Introduction and Outline of Navigating Past Deceptions: Science as Process

Science has a problem, or let us restate, science in North America has a problem.

50 years ago Science was regarded with a capital S as a source of trust legitimacy and wisdom. Today science is often viewed with a small S and as a source of potential distrust, questionable legitimacy, and falsely claimed expert knowledge.

Science is the foundation for the technological, medical, and informational advances that shape our modern life. We did not always have these things. It is the role of science to create the opportunities which allow for further advances. When science is under threat, or its legitimacy questioned, or its claims to wisdom misunderstood, then its role as a foundation begins to crumble.

America cannot afford that crumbling foundation.

This book looks at what has happened to science, not with the aim of retelling history, but to point the way to science his future. We call that future second order science.

First-order science is the science of exploring the world.

Second-order science is the science of reflecting on these explorations.

Second order science is both a toolset and an approach. As a toolset it can help both the general public and this practicing scientist repair the crumbling foundation. As an approach, second order science can restore the trust legitimacy and claims to wisdom which first order science needs if it is to flourish.

In our society the role of science is to provide the sagacity so that when serendipity happens we can take full advantage of the opportunities in our environs. Without sagacity, without wisdom and preparedness, fortunate opportunities maybe all around us -- but they will be overlooked. It is science that allows us to recognize the potentials in those opportunities and to work toward exploiting those potentials. It is science that gives us the tools to sort through the many false starts and dead ends among what seem to be promising leads – – so the progress can be achieved.

It took the launching of Sputnik in 1959 for America to place its priorities on Science. The very idea that another country – the Soviets no less – could "outperform" us was unthinkable. A national crisis of confidence in America's leadership resulted in a bold focus on advancing science as the means to advance America. And it worked.

The very technological marvels (or at least what our grandparents would have labelled as marvels) which give us our current life style are mostly the products of the post-Sputnik age. But, as our familiarity with, and dependence upon, technology has increased so too has public disdain for the foundations of that technology – Science.

In what can only be regarded with either irony or hyperbole, on the very same day that physicists were acclaiming the news that Einstein's long conjectured gravity waves had finally been proven, the US House of Representatives voted to restrict science funding from the National Science Foundation to projects which could be "proven to meet the national interest."

Much of the frustration expressed on the floor of the House was directed at studies in the "social sciences." Social interactions are increasingly being fueled by social media, mobile, and global Internet access. In this new world understanding social science means understanding how markets, economies, education, and every other social system behave. But that understanding, contrary to the beliefs of many US Congressmen, does not concern itself with finding "unquestioned facts." To study objects in this social science is not simply to find correlations and make predictions as if the act of observing and measuring provided no feedback to the system. Instead, by explicitly recognizing that observation, measurement, prediction and narrative are tools for shaping context as well as for describing context, social science is concerned with meaning. The models we use in social science are the language we use to communicate ideas and their associated prior and potential related actions.

In general, the pragmatic goal of applied science is to construct models which allow the observers and users thereof to better attune to context, such that they or other observers and users may make use of the model as a guide to next actions. Such applied science is successful when it reveals affordances (both good or bad) which were previously (i.e. before application of the science) unrecognized by the observer or the salience of which was understated. The science fails when it calls attention to false affordances - false because when contextually embedded the possibility for action is non-existent or infeasible - or overstates salience of affordances due to the imposition of overly restrictive boundary conditions or constraints on the context of the model. Thus applied science is always engaged in a process of learning and evaluation.

But the public perceives pure science quite differently. As Edgar Morin (2008) told us: "The distinctive quality of science up to the present was to eliminate imprecision, ambiguity, contradiction." Despite the simple truth that scientists cannot always apply ready-made terms, concepts or procedures to interpret new or surprising features of the world, the public expects otherwise. Traditional views of science have emphasized the established, accepted, finished product, [an] approach [which] hides the extent to which scientists invent and negotiate ways of representing aspects of the world they are investigating. "In science-as in everyday life-words and phrases often emerge from concrete situations in which participants jointly work out ways of describing what is going on. New terms, symbols or images are situated-they acquire meaning through collective use in real situations." (Gooding and Addis, 2008)

Science as traditionally understood by both the general public and scientists themselves involves an interplay amongst evidence, theory, and prediction which has as its goals the improvement of understanding and perhaps the explication of "truth." When theory and evidence combine to allow for successful prediction, both the scientist and the public find confirmation in the soundness of the scientific method and in the general concept of the "progress" of scientific understanding. But, predictions are not always successful and emergence all too often rears as an unexpected variable. When this occurs the practicing scientist may regard the failure as a learning opportunity, but the general public often takes such failures to be a black mark against "Science" (capitalized here to indicate some ephemeral concept) itself. Scientists have many tools at their disposal for limiting the occurrence of such failures – chief amongst these is the assertion of a set of assumptions which serve to bracket away ambiguity and its likely sources – including multiple meanings, the role of the observer or interpreter, emergence and more.

"The only meaningful thing is the usefulness of the model…. [Model-dependent realism] is based on the idea that our brains interpret the input from our sensory organs by making a model of the world. When such a model is successful at explaining events, we tend to attribute to it, and to the elements and concepts that constitute it, the quality of reality or absolute truth." (Hawking and Mlodinow, 2010)

While such model dependency is useful for scientific practice, it raises serious concerns re public acceptance. Predictions and explanations predicated on ceteris paribus demand interpretation if they are to have meaning once the ceteris paribus constraint is relaxed. And, often the public's understanding of inputs and variables differs from (without regard to correctness) the narrow ceteris paribus conditions assumed by the scientists' rigorous models.

The rigorous models may indeed result in successful predictions – but only within the narrow sphere or domain in which the ceteris paribus constraints hold. While the scientist may then assert (and it is critical to note that this is an assertion) that the results of the model so derived describe the “essence” of the issue at hand such that ambiguities do not matter, the general public is seldom willing to ascribe confidence in such an assertion.

Exploring causality, its inference, attribution, and ascription are some of the major tasks of the modern scientific endeavor. The reliance on statistics and probability distributions has given rise to rigorous standards and tests so as to distinguish the ascription of cause from either random occurrence or mere correlation. This domain in science tends to cause much puzzlement for the lay public, as an outcome that seems highly probably and discussed as a truth in public discourse, may well turn out to be completely false as more data becomes available.

A "habitable" planet (Gliese 581 g) is "observed" and then its existence is denied (Robertson, 2014). The inflation hypothesis of the "big bang" is confirmed to a "non-trivial standard" and then is dismissed as being nothing but evidence of dust (BICEP2/Keck 2015). The underlying assumptions regarding randomness (independence and identical distributions) which pervade the statistical models are seldom made explicit and even less frequently challenged. The obverse condition (items with a single cause are by definition correlated) is even less seldom addressed.

The existence of indirect causality is often questioned in many of the sciences. Yet, indirect causality can be looked at as the existence or creation of an environment where the conditions (including embodiment of the assumed values for the hidden uceps) afford/allow direct causality. Causality is also not just a "truth" statement, but also an acceptance of belief by the relevant community of practice. Lack of belief had much to do with the decades long gap between the observation that Helicobacter pylori "caused" ulcers and the acceptance of that observation as an explanatory theory.

In another example, it is common to assert that “addiction" is the product of direct causality - a craving for some brain chemical which is "relieved" by the supply of the addicted to substance. Yet, nicotine patches work less than 20% of the time and most medical patients given addictive narcotics do not end up as addicts. Recent research has suggested that addiction has multifactor causality where the conditions in the environment (indirect causality) play a far greater role than brain chemical cravings. (c.f. Hari, 2015)

"We often fail to allow for the possibility that evidence that should be critical to our judgment is missing. What we see is all there is." (xxx) "We therefore fail to note important items in plain sight, while we misread other facts by forcing them into preset mental channels, even when we retain a buried memory of actual events" (Gould, 2010). "We take up only those actions and solutions that have an immediate effect on the situation, and always as they have been framed for us" (Piattelli-Palmarini ,1996).

These frames are what allows for a seemingly infinite number of diet (fads) and nutritional supplements to be presented to the public as “scientifically proven.” In many instances the claims are just fraudulent, but the “legitimate” claims are seldom presented with the appropriate caveats of “within the narrow confines of this study, where we took as a baseline people with characteristics x, y and then studied the effects of z.” Instead, the framing is presented as “scientific study proves e, f, and g” without caveat, without context etc. Since the consuming public has been pre-primed to believe in (or at least to hope in) the veracity of such claims, the bulk of the cognitive work is done by the framing itself. That the federal government of the US participates in similar framing exercises does nothing to mitigate the doubts and ambiguities raised when the diet or supplement fails to perform as expected by its consumer – and now all of science is suspect. Substance e failed to produce effect f. Surely the attribution of causal effect was wrong (which may be the correct immediate conclusion) and all such attributions are suspect (a non-supported but common inference).

A 2015 study by the Pew Center suggested that there exists a serious gap between the perceptions of the average American and the average American scientist regarding the factual accuracy of scientific data in many fields. The gap relating to scientific claims regarding food was most striking. And is it any wonder given the marked variance in what the general public has been told?

For example, the basic American meat and potatoes diet was questioned in the 1960’s, which led to concerns of saturated fats, which then led to concerns over unsaturated fats, which was followed by concerns regarding trans fats. In 2015 the most highly recommended weight loss plan involved ingesting large quantities of protein and minimizing carbohydrates. Thus after fifty years the lesson is “we were wrong about meat and potatoes – eat the meat and forget the potatoes.” Oh and the second lesson is “we were wrong about vitamins too .. don’t take them as pills that is useless consume them as food.” Little effort goes in to explaining each of the suggested dietary changes other than to say “the latest scientific research claims…” The “trust me I am an expert” approach is failing.

"Scientists have earned the respect of Americans but not necessarily their trust, …but this gap can be filled by showing concern for humanity and the environment. From this view, scientists may seem not so warm. Their intent is not necessarily trusted and maybe even resented. Rather than persuading, scientists may better serve citizens by discussing, teaching and sharing information to convey trustworthy intentions." (Fiske, 2014)

"If you just call the public dumb, and try to set them straight about the facts, and don't understand where the resistance actually comes from …. well, then, the truth is that you're not being so perceptive yourself. … we have a lot of problems at the interface between science and society. But none of them are simple, and…, there's often a lot more going on than mere scientific illiteracy." (Mooney, 2015)

The past few years have also seen such high profile scientific scandals as the LaCour affair (where the research claimed to show that attitudes towards same sex marriage could be changed by having advocates ask the questions), the Obokata affair (where easy stem cell replication was claimed to herald a new age of medical interventions – except the replication method did not work), the Stapel affair (where a prominent Dutch psychologist thought it was "best" to "clean up data" so that it "better matched" the claimed to be supported theories – data which supported the awarding of more than four dozen PhD's), the California measles epidemic (where parents who believed that vaccines caused autism endangered the lives of many in their community by insisting that other children should be required to be exposed to their un-inoculated offspring), the Google Car affair (where it was finally acknowledged that "flawless" autonomous vehicles did indeed have accidents), and the Universe is Expanding affair (where it was claimed that the data unambiguously demonstrated the "proof" of the inflationary theory of the Universe only to be disproved months later as "noise caused by dust.") This list could be easily extended.

In each of these instances, the greater problem was not the underlying science but the claim to "truth" and "authority" for the results supposed based upon that science. If scientists can be wrong about so many things where they have made such unqualified claims, why should the general public believe them about the safety of food, or of vaccines, or of the need to take steps now to deal with climate change?

In short, the very success of science in the past two hundred years has laid the foundation for its becoming questioned now. Applied science has created technological marvels which simply "work" and are anything but revelatory about the tortured path of learning which birthed them. With the process of learning, experimentation, reflection, failure, and theorizing hidden from view, the general public has come to expect Science to be a fixed but slowly expanding set of certainty facts. It is those facts and their certainty which allows the technology to function. But the naked assertion of facts over process contains a hidden hubris -- that indeed the certain as claimed today will be just as certain tomorrow – and when that hubris is undermined, then the public's confidence in Science is undermined.

One goal of this book is to address that hubris and reclaim the uncertainty and processes on which Science itself must be based.

To do this we have an approach: second order science.

Second order science is a process for revisiting how science is practiced and communicated. That process has five key ingredients:

1. Question Uncritically Examined Presuppositions (UCEP's),
2. Add in Observers,
3. Be Reflexive,
4. Respect Pluralism, and
5. Do Meta-Analysis.

We will be developing the rationale and applications for these five steps throughout the book.

But first, we need to get you, the reader, in the right frame of mind.

A Hands On Thought Experiment

Indulge us if you will (after all we are only a few pages into the text).

Please gather a strip of paper – perhaps 10 or 11 inches in length and 1 to 1.5 inches in height, a pen, and a piece or two of scotch tape.

On one side of the paper please write: "CONTENT" and on the other please write "ASSUMPTIONS."

Now place the paper with the word CONTENT face up on a table. What you see is content, surrounded by some context (the table top) and a set of hidden assumptions underneath. Let us call this picture: frame #1.

Now pick up the paper and tape the narrow ends together so that the word CONTENT is facing outwards and ASSUMPTIONS is facing inward. We will call this picture: frame 2. What you see with frame 2 is a model of how we usually believe that frame #1 originates: namely that someone comes along and flattens the model so that all that is required is to deal with the CONTENT facing outward. Notice that in frame 2 the inner circle labelled assumptions is facing itself -- it is the model of consistency and coherence. The outward circle 'CONTENT' faces the world – the context. We usually believe that the way we produce frame 1 is to start with frame 2 and then cut it so that the model can lie flat.

So now we need you to try something different. Take your frame 2 model and break it back open where you taped it shut. Give one end a half twist so that one end thus has the CONTENT side face up and the other end the ASSUMPTIONS side is face up. Now tape the ends together. We will call this frame 3. Try running your finger around the inside of the frame 3 model – you will notice that your finger goes from the inside to the outside and then back again. With the frame 3 model there is no separating the ASSUMPTIONS and the CONTENT – they are both part and parcel of the same surface. But there is a more important observation to be made: the inner circle and the outward context have now merged. There no longer is a consistent and coherent space bracketed off by the assumptions which separates the middle of the frame model (as in frame 2) from the exterior context. It is all one and the same. Frame 3 is what is known as a Mobius Strip.

It is time to reveal the point of this hands on thought experiment: if you cut frame 3 and flatten it you get frame 1. Just like if you cut frame 2 and flatten it you get frame 1. So if we have the belief that the "source" of frame 1 is frame 2, we may be very wrong. Frame 1 represents the practical applied outputs of Science as we have come to know them over the past fifty or sixty years. Much of the public believes that frame 1 is produced by flattening frame 2 – that the Science which produced the applications is based on a consistent and coherent set of assumptions which is differentiated from an outer world of context. Science then consists of a set of nouns – each representing some element of knowledge. In the frame 2 world, to "do Science" is to acquire, find, and define those nouns – to identify the content along the outward facing circle. Applying Science is to flatten the circle. But what if this view is wrong?

If the world of Science is really the world of frame 3, then content, assumptions, and context are all intermingled. There is no coherent and consistent separation – no clearly defined outward circle – no neatly segregated inner set of assumptions to use as building blocks. Instead, EVERY time we see a frame 1 model which came from a frame 3 shape it was produced by someone MAKING A DECISION about where to cut the model and lay it flat. What was clearly CONTENT for one person may be ASSUMPTIONS for someone else. Applied Science in this world is arrived at by a process of trial and error, learning and negotiation. No one person holds the sole right to decide where to cut the Mobius Strip – each and every scientist has that right. Science is then the CURRENT consensus about where to make the cut and to lay the strip flat so as to best accomplish the applied or technological goal. Science in this view is a process and not a collection of nouns.

Our schools seldom teach our youth about the frame 3 world. But frame 3 is the world of almost every practicing scientist. Instead the public learns the simplification embodied in frame 2. We actually never lived in the frame 2 world, but we told each other stories as-if we did. Those as-ifs are now getting in our way – they are the prime cause for the misunderstandings which the general public and our political decision makers hold about how science works, what science consists of, and how science contributes to the way we live and function.

Your thought experiment is to think through the implications of frame 3. Leave the Mobius Strip you created in front of you as you read the book. Perhaps it will remind you of the "delusions" which come from believing that frame 2 describes the world. Perhaps it will give you a tactile model to ponder over as we describe these delusions and how science (using second order science) can overcome them.

We will return to the Mobius Strip model of frame 3 time and again in our journey, but it is time to move on.

The Plan of the Book

Following this introduction are two chapters which are intended to serve as a guide to our overall discussion. In Chapter 1 we revisit our statement of "The Problem namely that Science is no longer looked upon as trusted, reliable, a source of legitimacy, and as capable of meaningful predictions which inform public choices. In general, people do not understand the process of science because they have been taught that science is a collection of facts. When those "facts" prove to be wrong or merely temporary the foundation on which the public's trust has been built gets undermined. Science and scientists have no helped this situation both because biases have not been reflexively declared upfront and the professions have done a poor job of weeding out bad scientists. Finally, we observe that we are in the midst of a transition (thanks to the computer and the Internet) of moving from a several millennia old era of "curation" – where what was deemed "worthy" was filtered through suppsoed, Inadequate Curation, In Chapter 2 we attempt to explain where we are coming from by further developing the idea of science as a second order process. To do this we have a pictorial representation. Based on the idea of science as a second order process we ask “What are the tasks of Science?”. Our answers are a) Control, b) Explanation, c) Description, d) Classification, e) Prediction, and f) Attunement to Context. We expund on each of these.

PROBLEM

Chapter 3 highlights evidence of the “Problem” -- the erosion in the legitimacy the Public and political leaders associate with Science. We cite evidence of the Public’s Distrust and of funding issues. The chapter continues with evidence of first order causes: a) perceived quality control issues in both the doing of science and of the communication of results, b) the lack of publication and publicity regarding negative results, c) the decline in both the occurrence of and reliance upon “curation” as a means of helping to establish legitimacy, and d) the changing public perception about what the actual outputs of a scientific effort are due to the prevalence of technology over science. The next three Chapters 4-6 examine three cases where the “Problem” has made itself highly evident: 4) Climate Change, 5) Medicine and Food, and 6) Evolution.

ANALYSIS

The analysis section which follows highlights the role of key Distinctions which underlie our observations and then ties these distinctions together into a process. It begins in Chapter 7 with a discussion of the DSRP (distinctions, systems, relationships and perspectives) model. Chapter 8 looks at the idea of “as-ifs” versus things/events simply being or “is”. Chapter 9 looks at the differences between a model and a description with a focus on how models allow us to rehearse potential actions while descriptions do not. Chapters 9 and 10 look at the ideas of heterogeneity versus homogeneity (are we assuming that the things we are interested in are the same or different) and the particular versus the general. Chapter 11 examines the differences between making predictions and striving for better attunement to context. Chapter 12 looks at the sometime contentious debate between reflexive practice and claims of objectivity. While the ill numbered Chapter 13 wraps this section up by distinguishing between looking at Science as a collection of facts and the activities which produce or uncover those facts and Science as a process.

APPROACHING A SOLUTION

The next section summarizes the work of each of six writers in the field. Taken together their work has led to the Science as a Second Order Process described in Chapter 2.

Chapter 14 -- Question Uncritically Examined Presuppositions (Lissack), Chapter 15 -- Add Observers into the Mix (Umpleby), Chapter 16 -- Be Reflexive (Kauffman), Chapter 17 --Respect Pluralism (Friend), Chapter 18 --Do Meta-Analysis (Mueller), and Chapter 19 --Avoid Hubris (Maxwell),

DOING SOMETHING

The Conclusion and Next Steps Chapters (20 and 21) offer pragmatic advice to the practicing scientist, STEM educator and funders: Do More Meta-Analysis, Declare and vary UCEPS, Find a means to do transdisciplinary work, and above all Teach science as process.