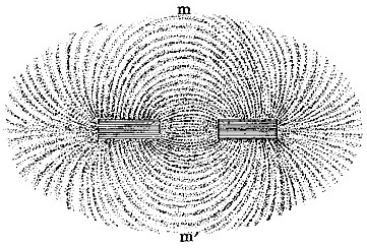
A TANGENTIAL SCIENTIFIC METHOD

ON THE NATURE OF SCIENCE WITH REFERENCES TO CHEWBACCA, STORK EATING ALIENS, A FEW STEVES, ONE INSTANCE OF THE WORD "FUCK," AND (QUITE POSSIBLY) TWO VERY LARGE CHILDREN.

by David Ng



1

For the last couple of years, when I'm speaking or lecturing to a larger audience, I would sometimes throw out the following question: "*Who is Chewbacca?*"

I do this because I'm curious on whether there are actually people in this world who have never heard of Chewbacca. Which, as a big fan of Star Wars, is a possibility that escapes me. Still, without fail, there are always a few. In fact, if I were to plot graphs around this question, I would notice that "Ignorance of Chewbacca" has been going up in a slow but steady fashion over the last few years. Furthermore, my small and caveat laden sample of data currently suggests that at least 5% of the world has no clue what this Chewbacca thing is [1].

Then, of course, things would get strange. Because usually at this point, I might ask those knowledgeable in the audience, to describe "Chewbacca" to those who are not. Here, the references to Star Wars specifically and science fiction in general come out. This includes discussions about co-piloting space ships, ripping arms off, and a description of a weapon that is a cross between a laser and a crossbow. The word "wookie" will inevitably surface, and then, remarkably you might say, someone will begin to make Chewbacca sounds – something best described as a long vibrating groan suggestive of yearning [2]. Indeed, if I give it a chance, the whole lecture hall might even begin making Chewbacca sounds, which is something that is both uniformly glorious and bizarre at the same time. Interestingly, none of this really seems to help the 5% who confessed to being Chewbacca ignorant. If anything, the 5%, looking at the strange proceedings around them, tend to look confused if not a little frightened.

I bring this up, because this silly idea of Chewbacca ignorance is a bit like asking people, "*What is science?*" It's one of those things where a proper answer is actually very rich in detail, and nuanced in ways that can be surprising. Furthermore, these details and nuances tend to be only obvious to those firmly embedded within science culture itself. And much like the Chewbacca example, if you explain this to a person who is not part of this culture, it would probably sound a little bewildering and frightening too.

To illustrate this, let's try something right now. Find someone you know who isn't into science.

This is probably pretty easy, since this is likely *most* people. Now ask them point blank, "*What is science?*" Undoubtedly, you will get all manner of responses - many of which will reference graphs, measurements and technology, perhaps with nods to things like physics, chemistry and biology. But if you listen carefully, I would bet that the responses are vague at best, and certainly not a reflection of the richness involved in what I consider a proper answer. Sort of like the injustice that goes with describing Chewbacca as simply, "a character in a science fiction movie."

To me, this is a shame. Not the Chewbacca part (which is a different kind of shame), but the bit about science. To me, the idea of the general public reacting to the fundamentals of science literacy, in a way that the aforementioned 5% might react to a wookie sound, is a very bad thing. In fact, I would suggest that this confusion or lack of familiarity over science is actually a dangerous thing. This is because, unlike wookies, science has an increasingly active and prominent role in real life.

As well, this lack of clarity is not about science literacy in the sense that we worry about citizens who do not know about greenhouse gases, or how DNA is replicated, or how differential calculus is done - in other words, it's not really about specific technical details (although this is important too). But rather, it is mostly about whether a person is literate of the *process*; whether they appreciate the steps and parameters which define how science is done. It is mostly about these points because they represent a framework that provides the world with a very powerful way of knowing things (epistemology for those who prefer big words).

Such parameters, of course, are often neatly laid out in what many would call "**The Scientific Method.**" Almost everyone will learn about this at some point in their lives, although it appears to be a topic that mostly presents itself at younger ages, at the elementary school levels for instance. However, one also finds that as the student gets older, its premise will be continually diluted by an increasing glut of science technical detail. This is an unfortunate reality of how science is taught in schools – there are information hierarchies that must be covered in order to get to the next level, and because the volume of that information is intense, there is simply little time for students to reexamine the basic principles of the scientific method and of science culture itself. Furthermore, this does not even include those young students who decide to avoid the sciences altogether.

Which brings us back to aforementioned mention of shame. After all, shouldn't we encourage *all* students and citizens to continually reassess the scientific method: more so, since an elementary student is hardly in the best position to fully appreciate its complexity? Isn't the scientific method an icon of rationality - something that you hope all decision makers, from individuals making small choices to leaders making large ones, would take time to appreciate fully?

Unfortunately, this isn't how the world currently works. Which is disappointing: because regardless of all this talk about society and danger and decisions, it would do us well to be reminded that through it all, the Scientific Method (and what it has produced) is, quite frankly, *awesome*.

So for now, we'll end this section with something basic. We'll end it with a flowchart depicting the scientific method. Perhaps something with steps like the below:

1. See something.
2. Think of a reason why.
3. Figure out a way to check your reason.
4. And?
5. Now, everyone gets to dump on you.
6. Repeat, until a consensus is formed.

But don't forget: this representation is, by no means, a complete picture or even necessarily a correct picture. Indeed, Sir Francis Bacon himself, a man often considered to be the "Father of Scientific Method," [3] may disapprove with the simplicity of this flowchart.

It is, however, as good a place to start as any: and hopefully sufficient to at least utter the sentiment, "Punch it Chewie."

2

"*You see something interesting…*"

This little phrase is often the start of the scientific process. In that it all begins when someone, possibly you, has noticed something intriguing. This doesn't mean that it has to be interesting to everyone – just as long as it's interesting to *someone*. In fact, sometimes, the science will stop right there. In other words, the act of just "observing" might be good enough – think about how everyone would feel if you were the first to discover a certain kind of creature.

Still, most conventional views of science would assume that you've seen something curious enough to merit the question "why?" And it is in that inspired act of asking a question, where arguably the most important part of the scientific method takes form.

We are, of course, referring to the notion of the hypothesis: which according to the Oxford Dictionary is defined as:

"A supposition or proposed explanation made on the basis of limited evidence as a starting point for further investigation"

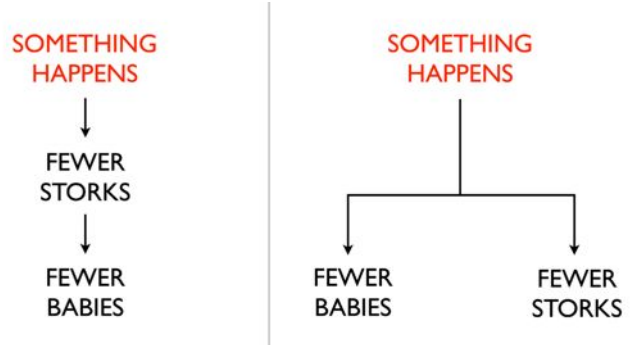
For us, in less eloquent terms, we say that this is the part where you try very hard to "**think of a reason why.**" Furthermore, when you do this, you inadvertently set the scene for the next stage of the method by defining how a person might "*figure out ways* to check your reason why." To a scientist, this last phrase is a colloquial way of talking about experiments.

For fun, let's explore these concepts by using an example. Here, we'll focus on some interesting observations that were noted in China during the early 1980's. Essentially, what folks observed was that there was a discernable decline in Chinese stork numbers [4]. As well, there was also a drop in fertility rates [5]. **In other words, storks in China were disappearing and the Chinese appeared to be having less babies.**

But why?

At one level, we might suppose that the two are not at all related. It could simply be a correlation and nothing more. But for the purposes of our discussion, let us suppose that we are trying to surmise whether the two are ultimately connected - whether there was truly a causative element involved.

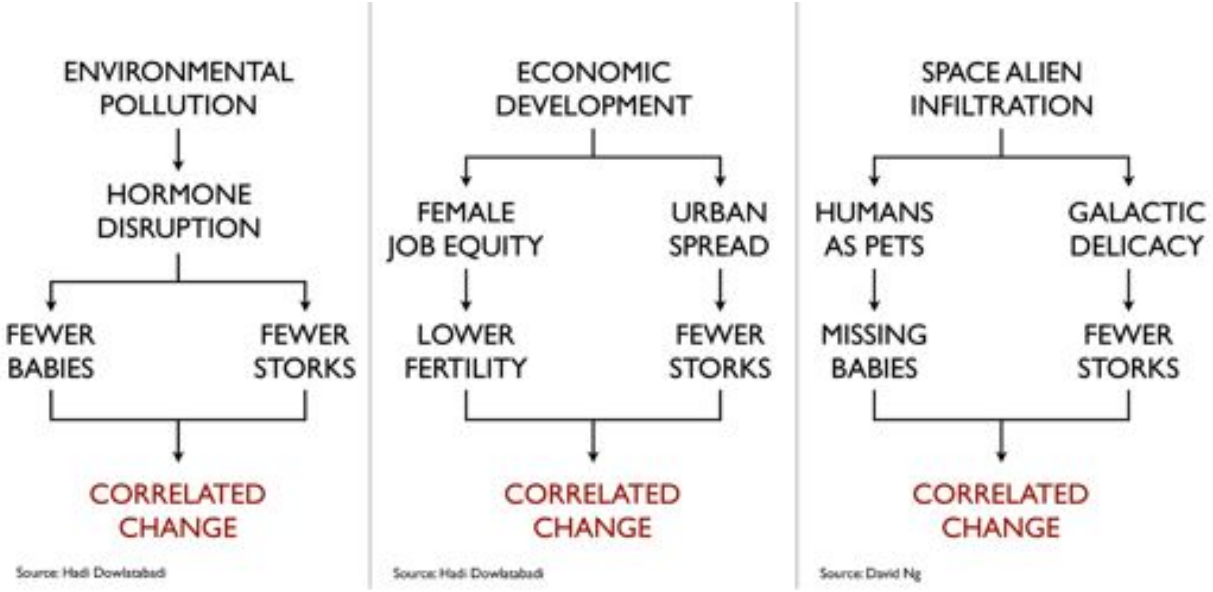
Here, some of the hypotheses might assume that there is a continuum involved, in that one of the observations is actually directly responsible for and logically leads to the other observation. For instance, if we play into the stork/baby mythology, where storks do indeed deliver babies, perhaps we can say that the decline in stork numbers was in turn causing the baby effect. Others, however, might ponder whether there is a more central reason for the two trends. In this case, we might talk about a hypothesis that suggests one prominent thing at play that is simultaneously responsible for both outcomes.



Here, we can try to distinguish the two scenarios by looking at the evidence more closely. Does the stork decline happen before or after the baby decline? What exactly are the numbers associated with the declines? Important, because even with the drop taken into account, the actual numbers of storks might still be more than enough to cover the number of babies born. In any event, as you can

see, a hypothesis can be quite nuanced and is really only a small step in a much longer path.

For amusement's sake, let's take this idea of nuance even further and look at three potential hypotheses presented below [6]. Here, they all focus on a core reason (environment, economics, or aliens) that could explain our observations.



Looking at these flowcharts more carefully, you can see that when accessed logically, they all work. Even with the somewhat interesting inclusion of aliens, the fact remains that all three could be considered acceptable, *worthy* even. However, this is very different from a hypothesis being valid.
Validity, which aims to make sure that what you say is indeed true, or at least true under every logical interpretation, is a much higher bar to meet. It is something that needs to be earned through the critical examination of **evidence**.

Now this is an especially important word, so once again we'll invite the gravitas of the Oxford Dictionary to provide a definition:

"Ground for belief; testimony or facts tending to prove or disprove any conclusion."

But such grounds can take several different forms, constituting strong or weak evidence. If we focus on the alien claim in particular, evidence might look a little like this:

1. We found an alien! And we have proof!

Here, we have important evidence from the point of view of addressing one critical question: are aliens real? It is crucial because it could be said that this detail is a major stumbling block in the alien hypothesis. However, proof of the existence of aliens isn't in of itself strong evidence to support the hypothesis. This is because it doesn't address any of the specific ideas and mechanisms put forth to explain our stork and baby narrative. Ideally, you would want to see data that demonstrated the involvement of our said alien with either storks or babies - actually, you would like to see both.

2. We found an alien eating a stork! We also found an alien with a baby on a leash! And we have proof!

This type of evidence is better, but it is still technically weak. This is because just having this data isn't necessarily conclusive. What if the stork you see is, in actual fact, American? What if the pet baby is not Chinese? What if it is Chinese, but not in fact, from China? What if it is a result of alien cloning techniques? As you can see, the scientific mind will take what might otherwise appear convincing, and deconstruct it skeptically. A scientific mind will continually probe, and continually look for flaws in the evidence.

3. We found an alien eating a stork, and we have biochemical proof that the stork is from China! We found an alien with a pet baby, and we even saw the alien take the baby from a family in China! And we have proof!

Now, we're getting closer, but now the issue is in the matter of whether this evidence represents an impactful occurrence. In other words, this particular data is really only good for showing the loss of *one* stork and of *one* baby. Obviously, this can hardly validate the observation that whole populations have dropped, which means that better evidence would also provide a better sense of the numbers involved. This particular stork and this particular baby could represent a simple coincident. Furthermore, what if this data was flawed for other reasons? Perhaps, if we had decided to observe the baby a little longer, we would have noticed that the baby was in fact being kept for food! This doesn't change the fact that aliens may still be responsible for the drop in numbers, but it does nevertheless alter the sentiment of the current hypothesis significantly.

Of course, this type of review can go on and on. And the thing is: *it does*. What we have here is this continual cycle of coming up with hypotheses, coming up with ways to address the hypotheses, coming up with evidence, and then reevaluating everything over and over and over again.

Hopefully, you can see why this can very easily become an arduously slow process, although that's not to say that it is always slow. More importantly, you should be able to appreciate how the process can lead to varying outcomes. It could lead to revisiting old ideas. It could naturally result in conflicting views. It could even cause your explanation (and also possibly the scientific discipline) to change directions dramatically. Imagine, if you will, that the real answer to our stork and baby scenario was a little bit about everything - a little mythology, a little environment, a little economics, and even a little bit about aliens. If this were the case, you could probably appreciate how difficult that complete story might be to tease out.

Here's another thing to note: if you think about this process carefully, you will soon realize that the continual acquiring of scientific evidence never actually proves anything to be one hundred percent certain. It can only **modify** or **support** an existing hypothesis, although by supporting it relentlessly, a hypothesis can get stronger and stronger and perhaps one day rise to the rank of a scientific theory or scientific law. But even there, there is no certainty that there won't be something that comes along to discredit that idea in a single stroke. This is Karl Popper's take on the philosophy of science: that at the end of the day, *you cannot prove something to be true*: you can really only prove something to be false. This might take a moment to ponder, but if you do so with our alien example, you'll note that this description does fit.

On the whole, our little alien discussion hopefully provides a window into how the scientific method works. But if we are honest with ourselves, we should also admit to glossing over something very important. Specifically, it's in the parts where we have very nonchalantly uttered the phrase, "And we have proof!"

This bit, we will spend some more time on in the next section, as it considers how we distinguish strong evidence from weak evidence. Which is all the more daunting these days, since it's quite likely you might not even understand the technical details of the evidence. Indeed, it might even be completely alien to you.

3

On a cold and miserable evening sometime during the fall of 2006, I found myself sneaking into a 4 star hotel and gate crashing an international science philosophy conference. Yes… I am *that* wild.

O.K. admittedly, this might not sound like the most thrilling of endeavours, and certainly not something that would beckon a Hollywood screen writer, but it was nevertheless quite exciting to me. Not the least of which was because this act of rebellion led to meeting a minor celebrity. This is someone, who if you took the time to google, you would discover in various photo-ops posing with folks as varied as Steven Pinker, President Jimmy Carter, and even Martha Stewart. As well, the word "posing" doesn't actually do these photos justice: rather, these well known individuals are literally *holding* him up.

Specifically, the celebrity I'm referring to goes by the name of Prof. Steve Steve, and the reason why he is always held is because he is, in actual fact, a small stuffed toy panda. True, he not necessarily a well known celebrity, but he is definitely an inspiration in certain scientific communities for reasons related to an interesting decade long battle of words.

Specifically, these words:

"We are skeptical of claims for the ability of random mutation and natural selection to account for the complexity of life. Careful examination of the evidence for Darwinian theory should be encouraged."

The above is a statement crafted by the Discovery Institute, a Seattle based think tank that primarily acts as a front to push the concept of "Intelligent Design" into public school science curricula. This is essentially the idea that elements of life were consciously "designed and/or created" by something with intelligence (for instance, a God or a tinkering alien, etc). It is more or less a supposed counterpoint to the science of evolution.

Since the statement's release in 2001, the institute has also maintained a list of signatories, who are collectively referred to as *A Scientific Dissent From Darwinism* [7]. In other words, this is a list of folks with advanced degrees who insist that evolution is a scientifically weak concept. As of December 2011, 842 signatures had been collected, and the Discovery Institute has often claimed that this exercise is evidence that evolution is, indeed, highly debatable as science; and that other views, specifically views that ultimately include intelligent design (and ergo creationism) should be entertained and validated within science education.

This, of course, is rather silly - if not altogether disturbing to those who are scientifically inclined. And so in response, the National Centre for Science Education (NCSE) decided to launch its own statement to counter this awkward pseudoscience babble. Released in 2003, this one read:

"Evolution is a vital, well-supported, unifying principle of the biological sciences, and the scientific evidence is overwhelmingly in favor of the idea that all living things share a common ancestry. Although there are legitimate debates about the patterns and processes of evolution, there is no serious scientific doubt that evolution occurred or that natural selection is a major mechanism in its occurrence. It is scientifically inappropriate and pedagogically irresponsible for creationist pseudoscience, including but not limited to "intelligent design," to be introduced into the science curricula of our nation's public schools."

And like the other statement, signatures were courted, where as of April 25th, 2012, the total number had reached 1208 individuals [8]. Apart from the empirically obvious fact that the *Scientific Dissent from Darwinism* has fewer signatures, it is also worth pointing out two other significant differences between the two opposing lists.

First, many have questioned the credibility of the Discovery Institute signatures. For instance, some

argue that over the years, the signatures have often been inconsistently attributed (many titles are vague, university affiliations may be absent, current involvement in scientific activity suspect), and often signatories were not necessarily aware of the agenda behind the vague statement [9]. In addition, one also notices that only a small proportion of them actually have relevant biology backgrounds. In fact, in an analysis done in 2008, this was calculated to be just shy of 18%. In contrast, the same analysis determined that the robustly labeled NCSE list scored a much higher 27% [10].

Still, it is the second difference that is most noteworthy (in fact, it's also brilliant). This is where every signatory in the NCSE list is named Steve... Or Stephen, or Stephanie, or Stefan, or some other first name that takes it root from the name "Steven." Yes, even Stephen Hawking is on the list. Put another way, the list would obviously be much much larger without this restriction [11].

This is why the NCSE list is also known as *Project Steve* (an affectionate nod to noted evolutionary biologist and author, Steven Jay Gould), and this was also why it was very exciting to meet with Prof. Steve Steve. You see - he is the project's official mascot, and he is a great reminder of why it is important to invalidate those who would be inclined to create controversy around the science of evolution, be it for political or religion reasons.

Prof. Steve Steve is also a lovely reminder of the importance of another aspect of the scientific method. Specifically, this concerns the part where **everyone gets to dump on you**, or perhaps more accurately, the part where everyone - *who's an expert* - gets to dump on you. It refers to the idea of how "proof" is accessed and validated. In science terms, we call this part of the method, "**expert peer review**."

This is important because it dictates that scientific knowledge gets to be critiqued in a very particular manner. It gets examined in such a way, where one is left with a scientific opinion that:

(1) is based on the examination of tangible evidence, which is not only made publicly available for all to see, but is also described in enough excruciating detail so that anyone has the option to try to reproduce it (hence the existence of peer reviewed journals);

(2) is formulated by those who actually know what the hell they are talking about;

(3) is backed by the most numbers of people who actually know what the hell they are talking about; and

(4) did I mention the bit about people actually knowing what the hell they are talking about?

In other words, this idea of expert peer review is really really a good way of critiquing evidence and thereby evaluating the claims and the hypotheses they contend to support. Moreover, it is especially important because it provides a mechanism for general society to check things out - since not everyone in society has the necessary background to evaluate scientific claims and evidence. For instance, a non-geneticist may be hard pressed to fully assess DNA sequencing data; a non-computer scientist may be hard pressed to appraise the relevance of a climate model - but that's o.k. since this is what expert peer review is set out to do. It sets out to gather the required community of scientists to check things out for you.

Such a review process is all the more pertinent because the reality is that it's not that difficult for anyone to be convincing and still disingenuously utter the phrase, "and we have proof!" *A Scientific Dissent From Darwinism* is a good example of this. Which is why the rational protect themselves from such scams by relying on these communities of experts, who are vested in the scientific method, and who strive to objectively and publicly analyze such sentiments for validity.

Which is to say, that clearly, the list of Steves win hands down.

4

About five years ago, a colleague (Ben Cohen) and I decided to conduct a little online experiment. Essentially, we thought it would be fun to host a puzzle. This would involve the sequential release of some fairly bizarre pictures. The goal, of course, was to see if we could entice the denizens of the internet to play along – in other words, could they figure out what was the unifying connection between all of these strange things that they were seeing?

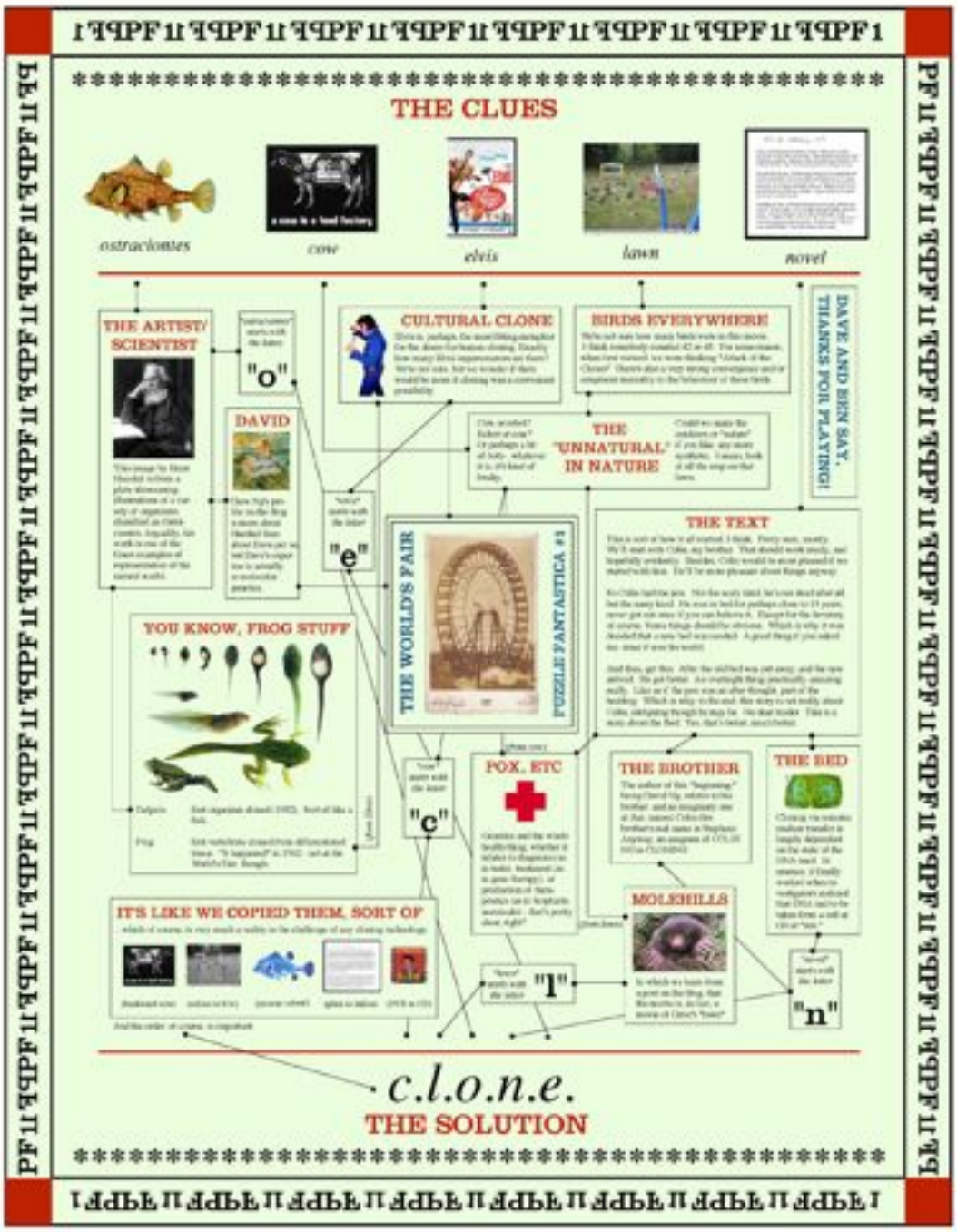
The formal start to this process involved the presentation of three images (shown above). This included: (1) a gorgeous picture of a fish, specifically one drawn by Ernst Haekel; (2) a picture of a robot masquerading as a cow masquerading as commentary on industry; and (3) the front cover of an Elvis Presley VHS tape (remember those?) called "It Happened at the World's Fair." We then gave this whole exercise the snazzy title, PUZZLE FANTASTICA, which was the sort of thing that precariously walked that strange line where it was simultaneously awesome and stupid. Next, we added the tag line, "Do not click unless you are of reasonable intelligence," and then we basically just sat back and waited [12].

What happened next was pretty amazing. Immediately, we got a lot of feedback and a lot of attempts at solving the puzzle. And, I should add, a lot of it was very sophisticated and, well, remarkable. But despite this ingenuity from our readers, Puzzle Fantastica did not get solved.
And so, we released another clue… and then another. The fourth clue was a short movie of someone's lawn covered with a few of those plastic climbing things that one purchases for small children, as well as about 100 European Starlings mulling through that same patch of grass. The fifth was some text, about a hundred words, which read as if it was the start of a strange children's novel.

For each of these new clues, we saw new wonderful attempts at solving the puzzle, which interestingly enough, were often modifications of previous attempts. We also saw a huge increase in the number of participants, significantly fueled by traffic from other websites [13]. By the end of the exercise, we had managed to court several hundred different answers for our puzzle. However, despite this outpouring, none of these fine attempts had found the "official" answer.

Still, we were so impressed with the effort and the diversity of what we saw, that we made a fancy graphic of the totality of solutions presented to us.

As well, at the time, Ben and I were a little worried. When all was said and done, we realized that when we put up our "solution" (a play on the word CLONE), we would also need to recognize the fact that many of the readers' answers were far more elegant.



Still, the whole process was sublimed. It was in many ways, a microcosm of the scientific method in action. What happened was that folks "saw something interesting" (our clues), and then they tried to fathom from these observations, a reasonable "reason why?" In other words, they were coming up with hypotheses: and their manner of testing them was waiting to see if the next clue would support or contest them. The participation was truly brilliant, and it was a testament to how creative a person's mind can be, especially when driven to the prospect of trying to understand something mysterious. It was also turning

into a great analogy that we could use for teaching purposes: "Look, it's like the scientific method!" we both said.

Except that the analogy had one completely mind boggling, over-the-top, truly delicous kink, which actually made it all the more richer. You see (and here's the thing): in truth, **there was no solution**.

That's right. The whole puzzle was, in actual fact, a complete ruse. We were simply interested in seeing how a community can seemingly find wonderfully intelligent ways to connect odd disparate observations. And it worked like a charm. Too well, actually: we hadn't expected such large numbers of participants which was a little stressful and also the reason why we decided to fabricate a answer that fitted but also one that hadn't already been mentioned. It was as if we were forcing ourselves into a paradigm of sorts.

Which is fitting given what paradigms are in the world of scientific discourse. Here, Thomas Kuhn, the American Historian and Science Philosopher, famous for the publication of "The Structure of Scientific Revolutions," says it best. He wrote that science "is a series of peaceful interludes punctuated by intellectually violent revolutions." Furthermore, it is during those revolutions where, "one conceptual world view is replaced by another."

What he was referring to was the idea that scientific discovery tends to work within paradigms. This is where there is an existing framework of knowledge that comfortably guides how observations are made, questions are asked, and how hypotheses are formed. However, history has also shown that on very rare occasions, these paradigms can change, and because they are so fundamental, such change can seriously rock the boat. We're talking the Sun being at the center of the Solar System not the Earth; Einstein's work on relativity over Newtonian physics; Darwin's Natural Selection over all of that God stuff.

Our Puzzle Fantastica, admittedly by accident, actually illustrated how consequential a paradigm shift can be. In that our participants would have obviously acted in a completely different manner and would have provided completely different responses, had they known that *there was never an answer in the first place*. That particular change in our framework of knowledge for the puzzle was, suffice to say, revolutionary.

I bring this up, because it is yet another part of the scientific method. It is in many ways, the ultimate example of why Popper's "You can't ever prove the Truth" statement is so important. You just never know. Paradigm changes are actually implied with our scientific method flowchart, except without the intensity. In fact, it might be worth changing our flowchart to reflect this:

1. See something.
2. Think of a reason why.
3. Figure out a way to check your reason.
4. And? (very very very rare chance of a WTF in font 100 times larger!)*
5. Now, everyone gets to dump on you. (people actually freaking out!)*
6. Repeat, until a consensus is formed.

(these grey bits refer to this paradigm business).*

So there you have it: The scientific method in all of its glory. Although, hopefully, after reading through

this material, you realize that this flowchart is still a gross simplification. Indeed, there are many who would prefer we not even call it the *Scientific Method* anymore. Instead, we should refer to it as the *Scientific Process* [14], as a way to highlight its fluidity and nuances, and that the flowchart should probably look a lot more busy and complicated with many criss crossing lines.

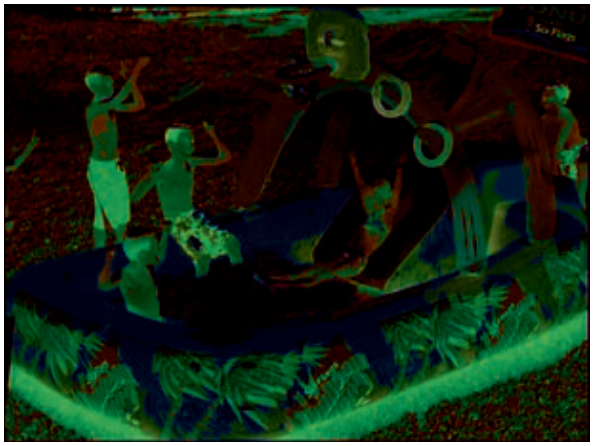
I personally like all of these , with maybe a secret desire to introducing a new term, Modern Baconian Method [15] - but that is just me. What might be most important from of all of this, is to just "get it." It is just for *everyone* to have a certain degree of familiarity on how science can provide us with knowledge, and how that knowledge came to be.

Why? Because when you do, you'll finally understand why the usual way we get our scientific information - that is, television, newspapers, the web and the like - is often completely fucked up.

5

O.K. so maybe my language was a little harsh in the previous section. But in many ways, it's true - let's just say that getting information via media, and getting information via science is best described as a complete and utter contradiction.

How so? Well, it's a bit like what you see when you look at this image:



If you are thinking that that is one kick-ass inflatable pool, then you would right: and that is partly the point. But first, a little context might help.

In the summer of 2009, my hometown of Vancouver experienced a small heat wave. It got very hot and humid, and not surprisingly my two young kids (Hannah and Ben) were quite miserable. Consequently, I had the brilliant idea of getting an inflatable pool for our backyard. This appeared to be a genius move; and to my kids I gained more than a few notches on the cool scale. So before we knew it, we were hunting for inflatable pools, which naturally led us to a local toy store, where lo and behold, marketing geniuses that they are, the store had conveniently placed all of their inflatable pools front and centre.

In this selection, we saw the pool that you see in the picture above. It looked, quite frankly, *awesome,* and, if you can believe it, it was also priced at only twenty dollars. Needless to say, we bought it immediately and full of excitement, took it home to set up. It was here that something odd happened. In essence, when the pool was inflated, it looked a little different from the box. In fact, this is how it turned out:

Of course, being a scientist and all, my rational mind was racing and trying its hardest to come up with hypotheses that could explain what was going on. Why did the pool look so tiny?

Was it because my children are *massive*?

Was the photograph on the box taken in a land of hobbit-like people?

Did I not blow hard enough and inflate my pool properly?

It was all very bizarre, but at the end of the day, the explanation was simple. Apparently, in the world of advertising, it is permissible to use misleading images as long as the object's dimensions are clearly printed on the box, and as long as a fallback statement, "object in box may not be as appears," is included.

For our discussion of science, the sentiment "object may not be as appears" happens to perfectly encapsulate how science is viewed by the general public. What one finds, is that what you see, hear, and read tends to be a modified version of reality. In other words, "science" reporting is often not altogether right, usually with a tendency to be exaggerated, sensationalized, and missing much needed context. More worrying, it can even be deliberately false, as any example of pseudoscience can attest to. However, when you look at how day to day media generally works and the caveats it has in place, it's really not that surprising that this is what happens. Indeed, let me repeat:

Getting information via media, and getting information via science is best described as a complete and utter contradiction.

Why is this? Well, to begin with, in the arena of media, time is of the essence. The soundbite is key. This means that in the world of audio and video, something that is quick and attention grabbing is paramount to attracting your audience. In the world of writing, this means that an over indulgence in space or word count is often a rare sight. Furthermore, strong loud voices are coveted. Unfortunately, when you think about it, how scientific research is done is neither quick nor generally dependent on loud strong voices. Science moves at a pace that is either wildly unpredictable, or just excruciatingly slow. The data speaks for itself. As well, most of the research is punctuated by things that aren't necessarily exciting to the average person - it's not at all attention grabbing - and yet those elements are often key to fully understanding and appreciating the merits and fallacies of a particular discovery. In other words, to fully understand the research, you need to look at the increments involved. It's like what Sir Isaac Newton might say: "You *are* standing on the shoulders of giants…" And in a perfect world, we would not place limits on how many shoulders we reference, despite the word count involved.

Another thing that makes media and science different, is that one prefers to have obvious endings, whereas the other technically never really ends. You can call this a form of narrative bias, where media prefers to express itself in friendly and familiar structures - like a story. Perhaps this is why we read about science in ways that suggest a finality. This is also why we see so many headlines that proclaim "Cancer is Cured!" so much so that we begin to distrust such proclamations and indeed become suspect of the science behind it. The thing is: the scientific method is a fluid process with a narrative that considers the gradual attainment of information in a continual twisty turny fashion. What occurs in the process of science is maybe closer to a *Choose Your Adventure* book that never ends badly or happily. It just never ends. Consequently, forcing an ending on acts of discovery doesn't really work, and further contributes to an inaccurate picture.

Then, there is the issue of validity. Is what you are hearing or reading actually reliable and trustworthy? With science you have the awesome power of expert peer review in your corner. It's very democratic, objective, and inclusive: or at least it sincerely tries to be. I say "try" because it's not perfect: it can be slow, it can still be influenced by various pressures, and it hardly ever reaches a complete consensus; but overall, there's probably not a better way to figure out whether a piece of knowledge is valid or not. In fact, when all things are considered, the process of expert peer review is just an incredibly sensible way to do things.

However, in media, things can be very different. With traditional media, where journalistic integrity and ethics is upheld, the writer may still be prisoner to the soundbite mentality. This is not necessarily the fault of the writer: but such a beat may mean that the writer has no time to be familiar with the science, meaning that they may miss important parts of the research that provide the context. They may also have to write in certain ways so that publishers and audiences are satisfied. Furthermore, objectivity is key in journalism in that there is always pressure to try to present "both sides of the story." However, this can also translate to equal billing for viewpoints that expert peer review would normally consider marginal, inconsequential or even discredited.

Worse, however, are "unconventional" forms of media. This is where journalistic ethics may be missing, either through ignorance or perhaps deliberately. This doesn't apply to all users of this medium, and it's not really fair to categorize them all in sweeping terms, but the existence of communicators that seriously harm scientific discussion is more common than you would think. More so, in today's world of social media, and portals of self expression. Nowadays, it's not inconceivable for anyone with the right delivery and a bit of luck to become a communicator of significant clout (as in numbers of readers or viewers) - this, irrespective of their credibility and their expertise. And without these credentials, their message could be inadvertently error prone, or in a more cynical take, their message could be distorted to fit within biased influences. Examples of this can be easily seen in some celebrity endorsements, in various cases of corporate lobbying, political discussion, or simply in the rantings of an influential but biased blogger.

Plus, with such voices in the media, and the ever expanding glut of these voices, more and more individuals (including you and I) become trapped in the path of corrective bias. This is where you inadvertently limit yourself to the "news" that you agree with anyway. You read certain newspapers, you like this television station, you follow the links of your like-minded friends, and so on. It's always easy to find someone who provides a viewpoint you agree with. Language is great at reworking any piece of information so that the *proverbial inflatable pool can always look kick ass*.

A lot of this has to do with the fact that most people really do have a problem with the idea of absolute "truth." In other words, if there are so many things that have yet to be discovered, then how do will really know that our current knowledge base is the "truth." Most people might surmise that because the scientific community is not 100% certain about anything, it is then, by default, deeply flawed in its thinking and perhaps not to be believed. You see this type of mentality in climate change discourse in particular, especially when future modeling is involved. Obviously, the science that attempts to predict the future for something as complicated as climate is not without a degree of uncertainty. But even with the smallest of margins, it's as if people assume that a paradigm shift is looming just around the corner. Worse still, it only takes a few phrases to entice these doubts.

Here is one of the more common ones: "*There are some scientists who are skeptical of the data*."

You see this a lot because of noble journalistic desires to be even handed, and because biased commentators are very good at twisting such statements around. Unfortunately, this type of messaging can easily be destructive to science. In short, this style of narrative would ask that we should ignore the scientific consensus, since there is always some doubt and therefore some chance that it could all be false.

But of course, there are skeptical scientists! This is why it is so important that everyone knows that such scientific skepticism and such reluctance to talk about "truth" is a normal facet of the philosophy of science.

In any event, let's end things here for now.

All of these considerations simply mean that it is worth being scientifically minded when you take

in your media. That there is value in the rational approach. It might take more effort, is possibly more boring, is often too complicated, is reliant on the expertise of others - but it is the process that will actually arrive at the best approximation of the truth, or at least the kinds of truths that relate to questions about the physical universe.

Awareness of this, I think, is what makes a true sciencegeek. A true sciencegeek understands that there is a great disconnect between how science is done and how it is represented. And a true sciencegeek is aware of how this can lead to a dangerous lack of scientific literacy, which in turn is negatively affecting our society. In short, we need more sciencegeeks: and I say this because without them, the hypothetical future is looking very bleak indeed.

(3rd draft – May 3rd, 2012)

NOTES

[1] If you happen to be part of this 5%, please refer to wikipedia for more on Chewbacca. (http://en.wikipedia.org/wiki/Chewbacca)

[2] The Chewbacca Soundboard might be handy here. (http://www.soundboard.com/sb/Chewbacca_Sound.aspx)

[3] Sir Francis Bacon (1561 - 1626) was incredibly influential in highlighting the importance of "inductive reasoning" through the accumulation of data (also sometimes called the Baconian Method). he was also buddies with the British Monarchy, and there exists many a hypotheses that suggests he may have written some of the works of Shakespeare.

[4] Ma, Ming; Dai, Cai. "The fate of the White Stork (*Ciconia ciconia asiatica*) in Xinjiang, China". *Abstract Volume. 23rd International Ornithological Congress, Beijing, August 11–17, 2002. p. 352.*

[5]. S Horiuchi. "Stagnation in the decline of the world population growth rate during the 1980s." *Science 7 August 1992: Vol. 257 no. 5071 pp. 761-765*

[6]. Pollution and economic scenarios via personal communication with Hadi Dowlatabadi.

[7] A Scientific Dissent from Darwinism. (http://www.dissentfromdarwin.org/)

[8] Project Steve Website. (http://ncse.com/taking-action/project-steve)

[9] Doubting Darwinisms Through Creative License. (http://ncse.com/creationism/general/doubting-darwinism-creative-license)

[10] Project Steve: 889 Steves Fight Back Against Anti-Evolution Propoganda. *Science Creative Quarterly.* (http://www.scq.ubc.ca/project-steve-889-steves-fight-back-against-anti-evolution-propoganda/)

[11] For instance, on quick examination of the December 2011 edition, there are 10 individuals on the Dissent list who names would fit under the Project Steve criteria (all Stevens or Stephens). Given that this represents 1.19% of all the names on that list, we could then, by analogy, project that the NCSE could have easily produced a list of close to 100,000 names, had they not included the name restriction.

[12] Puzzle Fantastica #1: "Fish-Cow-Elvis" [do not click unless you are of reasonable intelligence]. *Scienceblogs.com*. (http://scienceblogs.com/worldsfair/2006/07/puzzle_fantastica_1_fish-cow-e.php)

[13] Introducing Puzzle Fantastica. *Boingboing.net* (http://boingboing.net/2006/07/26/introducing-puzzle-f.html)

[14] Like these folks at *Understanding Science*. (http://undsci.berkeley.edu/article/howscienceworks_01)

[15] The Baconian Method, referred to earlier in part 1, is described on wiki (http://en.wikipedia.org/wiki/Baconian_method)

All links accessed on May 3rd, 2012