Agent Orange: Understanding the Science
An Easter Story

The Root Cause of Misunderstanding

Post Hoc Ergo Propter Hoc - Correlation is not causation

In springtime in Europe, around Easter time, hares gather in open grassy fields for the annual ritual of courtship and mating. The Jack Hares compete with each other for the favours of the Jill Hares. Such is the strength of their ardour that when humans venture into the same fields Jack stands his ground.

$$1 + 1 = 11$$

From time immemorial those human observers noticed that hares were often seen alongside nests of coloured or variegated eggs. Those naïve observers put the two together (correlation) and concluded that hares laid eggs. Don't scoff too soon. Today we celebrate Easter with bunnies, and chocolate eggs wrapped in coloured foil.

We celebrate a tradition based on faulty reasoning about cause and effect, confusing correlation with causation. The transposition of rabbits and hares is another matter, probably to do with marketing.

"It is human nature to see correlation and imply causation. The reason that correlation can occur between two things without there necessarily being a causal relationship is explained by something known as a confounding factor – the real, unseen cause of the correlation". [1]

In this case the confounding factor, or alternative explanation, is that at springtime in Europe the lapwing lays its eggs in nests on the ground in those same fields. The lapwing doesn't stand its ground when humans enter its domain, but quietly disappears, leaving its eggs to be observed in the care of hares (or rabbits if you don't know the difference).

Whilst that instance of faulty reasoning about cause and effect may now seem obvious, the modern human mind is still prone to the same error in attributing cause and effect. None more so than in matters of scientific inquiry, and especially so in the Agent Orange debate.

The mind leaps backwards from effect to cause without considering alternative explanations, or confounding factors.

The plural of anecdote is not data

In understanding that correlation does not equal causation we must also understand that even large numbers of positive examples of correlation (anecdotes) do not constitute proof. Anecdotal "evidence" in the absence of any exploration of possible and probable confounding factors (i.e. lapwings) is not necessarily evidence.

"The problem we face is that superstition and belief in magic are millions of years old whereas science, with its methods of controlling for intervening variables to circumvent false positives, is only a few hundred years old. Anecdotal thinking comes naturally, science requires training."[2]

Almost all of the "evidence" produced to promote and support the Agent Orange narrative over the last four decades has been based on correlation, repeated anecdotally over and over again until it becomes some sort of "truth". Easter bunny reasoning.

Uncertainty

The predominant characteristic of scientific knowledge in environmental health is uncertainty.

"The scientific approach is the enemy of certainty" [3]

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[1] Warner, Anthony. The Angry Chef: Bad Science and the Truth About Healthy Eating (Kindle Locations 153-155). Oneworld Publications. Kindle Edition. Anthony Warner is a chef with a strong interest in the science of nutrition (and a sense of humour). He has an undergraduate degree in chemistry that obviously informs his views, although he proclaims that he has forgotten all he learnt.

[2] Shermer, Michael. The Believing Brain: From Ghosts and Gods to Politics and Conspiracies---How We Construct Beliefs and Reinforce Them as Truths (p. 64). Henry Holt and Co.. Kindle Edition

[3] Taverne, D., The March of Unreason: Science, Democracy, and the New Fundamentalism, Oxford, 2005, p 282.

Toxicology experiments to determine the toxicity of various substances are conducted on laboratory animals and definitively prove cause and effect, based on a measured dose of a specific toxicant, administered either orally or by injection to a specific species of laboratory animal, of a specific gender, age and physical condition. The cause and effect relationship thus determined holds true for those unique conditions.

However the application of the results of those experiments to the human animal is an inexact extrapolation of the laboratory evidence. Given the marked and acknowledged difference in toxic effects from species to species (e.g., between guinea pigs and hamsters, or even between different breeds of mice or rats), and the ethical injunction on human testing, at best the extrapolation of laboratory results in non-human species to the human is an estimate, strongly influenced by the precautionary principle. The precautionary principle is used by regulatory agencies (like the Environmental Protection Agency) to set very low thresholds for exposure based not on the science, but on the remote chance of damage from exposure.

Epidemiology is the study and analysis of the distribution and determinants of health and disease conditions in defined populations. It is an inexact science that produces statistical associations that rarely prove cause and effect relationships; cigarette smoking and asbestos inhalation being two notable and rare exceptions. The size of the sample population has a direct effect on the reliability of the statistical association, as does the presence, known and unknown, of confounding factors (or lapwings). Nevertheless the public, including veterans, are wont to interpret epidemiological associations as finite evidence of cause and effect. They are however, correlations.

Epidemiology identifies the hares and the eggs, and sometimes a few birds that may have laid the eggs, but not necessarily the true culprit – the lapwing.

Agent Orange claim makers have for decades mistakenly interpreted those associations or correlations as scientific and medical evidence. They are however the basis of presumptive conditions in the absence of scientific or medical evidence.

Genetic and epigenetic science is still in its infancy in relation to environmental hazards and other factors that affect genetic mutation and genetic expression. It is an enormously complex science, almost always simplified and misinterpreted by the media and the public. Genetic science is discovering cause and effect relationships between specific genes, or groups of genes, and specific illnesses or disorders. But epigenetic science is still exploring how the expression or non-expression of those genes might or might not result in the expression of that illness or disorder, and the biological and chemical processes that influence that genetic expression.

The presence of a specific gene, group of genes, or genetic mutation does not necessarily result in the expression of the associated illness or disorder.

Cause and effect relationships in genetic and epigenetic science are still uncertain, although in the popular mind cause and effect is settled, once published in the media.

The scientific method and process

Neurobiologist Stuart Firestein is well known for his theory that ignorance and failure drive science forwards:

"It is very difficult to find a black cat in a dark room," warns an old proverb. "Especially when there is no cat."[4]

When most people think of science, I suspect they imagine the nearly 500-year-long systematic pursuit of knowledge that, over 14 or so generations, has uncovered more information about the universe and everything in it than all that was known in the first 5,000 years of recorded human history. They imagine a brotherhood tied together by its golden rule, the Scientific Method, an immutable set of precepts for devising experiments that churn out the cold, hard facts. And these solid facts form the edifice of science, an unbroken record of advances and insights embodied in our modern views and unprecedented standard of living. Science, with a capital S.

That's all very nice, but I'm afraid it's mostly a tale woven by newspaper reports, television documentaries, and high school lesson plans. Let me tell you my somewhat different perspective. It's not facts and rules. It's black cats in dark rooms. As the Princeton mathematician Andrew Wiles describes it: It's groping and probing and poking, and some bumbling and bungling, and then a switch is discovered, often by accident, and the light is lit, and everyone says, "Oh, wow, so that's how it looks," and then it's off into the next dark room, looking for the next mysterious black feline. If this all sounds depressing, perhaps some bleak Beckett-like scenario of existential endlessness, it's not. In fact, it's somehow exhilarating".[5]

It is also very difficult to find an orange cat in an orange room, especially when there is no cat.

The five steps of the *Scientific Golden Rule*, the Scientific Method are:

(1) Make an observation. Scientists are curious about the world.
(2) Form a question. After making an interesting observation, the scientific mind determines to find out more about it.
(3) Form a hypothesis.
(4) Conduct an experiment.

[4] Firestein, Stuart. Ignorance: How It Drives Science (Kindle Locations 63-64). Oxford University Press. Kindle Edition.

[5] Firestein, Stuart. Ignorance: How It Drives Science (Kindle Locations 68-78). Oxford University Press. Kindle Edition.

(5) Analyse the data and draw a conclusion.

Unlike the Agent Orange narrative process which makes an observation then draws a conclusion without bothering to ask the right questions and to test the answers.

The scientific method is, or ought to be, simple to understand. And it leads many to believe that the conclusions thus drawn represent a final understanding.

"One swallow does not a summer make".[6] Nor one research result a scientific fact.

For the scientific process does not stop there, with a conclusion from a single experiment or series of experiments being accepted as definitive evidence. Although the media and the public will often accept the conclusions of a single experiment as evidence.

"Science does indeed possess a lot of very interesting facts. But at the edges, at the coal face of science, there is always going to be uncertainty and doubt. The interesting parts of science are where the disagreements are, and when there are disagreements, the public is likely to be left confused. We are easily led by a disconsolate media to believe that science is broken. This doubt and ambiguity is likely to leave the instinctive brain unsettled, because if there is one thing it hates it is uncertainty". [7]

The willingness to be proved wrong, and an expectation that other scientists working in the same field will attempt to prove conclusions wrong, is an essential attitude in the scientific process. Disagreement is a positive sign that the scientific process is working.

It often takes years or decades of research and experimentation and disagreement by the global scientific community (the scientific "hive mind") to remove or even reduce the uncertainty. In the process there are many thousands of experiments that end up going nowhere. Research is peer reviewed and published in scientific journals. Other scientists will attempt to validate or invalidate the findings by replicating the research, or conducting other research. System reviews, or meta-analyses, are conducted to compare and analyse the results of all of the relevant research, world-wide.

An engineer puts the incremental process of reaching scientific consensus a slightly different way:

[6] From a remark by Aristotle (384 BCE – 322 BCE): "One swallow does not a summer make, nor one fine day; similarly one day or brief time of happiness does not make a person entirely happy."

[7] Warner, Anthony. The Angry Chef: Bad Science and the Truth About Healthy Eating (Kindle Locations 2437-2440). Oneworld Publications. Kindle Edition.

"Unlike mathematical theorems, scientific results can't be proved. They can only be tested again and again until only a fool would refuse to believe them."[8]

In the process the science remains contested and uncertain until eventually a scientific consensus is reached. Or not. In the case of Agent Orange and its effects on Vietnam veterans, their children and grandchildren – not, or at best, not yet.

We don't like uncertainty

How environmental and health science is understood is also culturally mediated:

"How harm is viewed is underwritten by a cultural script that informs communities about its meaning. Perceptions of harm, pain and suffering are mediated through cultural norms. In this respect, twenty-first-century Western societies have a uniquely low threshold for experiencing the anxiety that can emanate from uncertainty".[9]

The public, unable to grasp the reality of incomplete or unsettled evidence, and to deal with uncertainty and ambiguity, will often grasp at a media or claim maker's over-simplification of a single study or group of studies to form or confirm a belief, and to eliminate uncertainty.

In the absence of lapwings the public prefers to draw cause and effect conclusions from the statistical association (or correlation) of hares and eggs.

It has long been so in the case of Agent Orange.

Look for the Lapwings

In looking for the causes of the diseases, disorders, disabilities, defects and deaths of Vietnam veterans, their children and grandchildren we should

[8] Lloyd, S., in "What we Believe but Cannot Prove", Ed John Brockman, Simon and Schuster, UK, 2005. Professor Seth Lloyd is a quantum mechanical engineer, part scientist and part engineer.

[9] Furedi, Frank. What's Happened To The University?: A sociological exploration of its infantilisation (p. 37). Taylor and Francis. Kindle Edition.

accept that hares don't lay eggs, and search instead for the lapwings. Agent Orange didn't do it but there are a thousand and one other possible causes. And there still may not be answers. There is still so much about disease, disorder, disability, defect and death that we don't know. There is too the ever present element of pure chance.

As the human mind does not like uncertainty and ambiguity, neither does it readily concede the presence of pure chance. It craves certainty, and in the bad times, someone or something to blame.

But sometimes we just have to accept that what is, is, and to live without knowing why. And if we do need to keep asking why, look for the lapwings.