What is Empirical Science?

Science

'Science' comes from the Latin word `scientia` meaning 'knowledge'. Science as an activity is a systematic endeavour that builds and organizes knowledge in the form of testable explanations and predictions about anything in the universe.

Historically, the recovery and assimilation of Greek works and Îş̂âɱīc inquiries into Western Europe from the 10th-13th century saw a revival of "natural philosophy"[1]. This was later transformed by the Scientific Revolution[2] that began in the 16th century as new ideas and discoveries caused a departure from previous Greek concepts and traditions. The scientific method[3] soon played a greater role in knowledge creation and it was not until the 19th century that many of the institutional and professional features of science began to take shape, along with the changing of "natural philosophy" to "natural science".[4]

There are numerous branches of modern science. That is:

> *"Modern science is typically divided into three major branches that consist of the natural sciences (e.g., biology, chemistry, and physics), which study nature in the broadest sense; the social sciences (e.g., economics, psychology, and sociology), which study individuals and societies; and the formal sciences (e.g., logic, mathematics, and theoretical computer science), which deal with symbols governed by rules. There is disagreement, however, on whether the formal sciences actually constitute a science as they do not rely on empirical evidence. Disciplines that use existing scientific knowledge for practical purposes, such as engineering and medicine, are described as applied sciences."* [5]

Empirical Evidence

Empirical evidence is what is achieved through the senses to support a premise, hypothesis or theory which, to produce experiential knowledge. Empirical evidence is centrally important to the sciences and plays a role in other fields, such as law. It is the empirical nature of scientific experimentation which takes its findings out of the realm of conjecture and theory into reality.[6]

However, there is no general agreement on how the terms *evidence* and *empirical* are defined. Often different fields of study work with quite different conceptions of these terms. For example: In epistemology, evidence is what justifies beliefs or what determines whether holding a certain belief is rational. This is only possible if the evidence is possessed by the person. This has prompted various epistemologists to conceive evidence as private mental states like experiences or other beliefs.[7]

In the philosophy of science,[8] on the other hand, evidence is understood as that which *confirms* or *disconfirms* (contradicts) scientific hypotheses or the statements of competing theories. In this role, it is important that evidence is public and uncontroversial, like observable physical objects or events, and not like private mental states. This is how scientific consensus is fostered.[9]

Empirical Science

Scientific evidence is gained by experimentation which is real, logical and not derived from mental concepts or extrapolation from elsewhere. Mental concepts and extrapolation are actually non-scientific processes. They are examples of pseudo science, rather than genuine science, because the 'scientific facts' they result in are not totally factual. An example of this type of 'bad' science is a lot of the science behind

1 – en.m.wikipedia.org/wiki/Natural_philosophy
2 – en.m.wikipedia.org/wiki/Scientific_Revolution
3 – en.m.wikipedia.org/wiki/Scientific_method
4 – After: "Science" en.m.wikipedia.org/wiki/Science [Content is available under CC BY-SA 3.0 and free to use]
5 – "Science" en.m.wikipedia.org/wiki/Science
6 – After: "Empirical evidence" en.m.wikipedia.org/wiki/Empirical_evidence [Content is available under CC BY-SA 3.0 and free to use]
7 – After: "Empirical evidence" en.m.wikipedia.org/wiki/Empirical_evidence [Content is available under CC BY-SA 3.0 and free to use]
8 – en.m.wikipedia.org/wiki/Philosophy_of_science
9 – After: "Empirical evidence" en.m.wikipedia.org/wiki/Empirical_evidence [Content is available under CC BY-SA 3.0 and free to use]

Climate Change and the 'Hole in the Ozone Layer'[10]. The logical rejection of Stanley Miller's[11] proof experiment for the Primordial Soup theory of the origin of life on Earth,[12] is an example of where science overcame pseudo-science.[13]

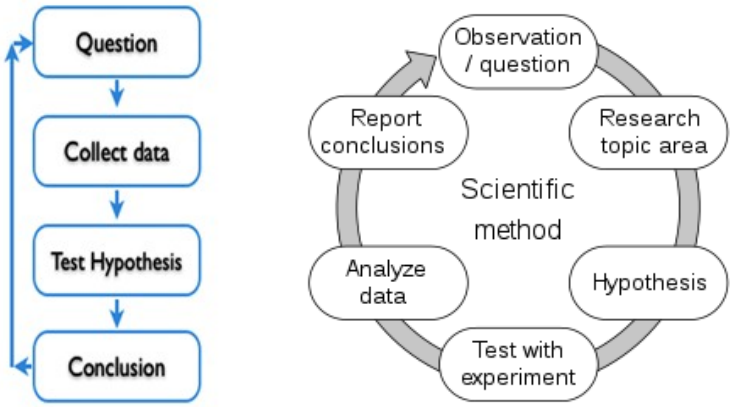
Scientific Method

To produce scientific empirical evidence, the scientific method was devised in the 19th century to establish clear boundaries between what was science and 'non-science' (non-sense). The method starts with conjectures from observations or thought activities which are tested by preliminary experimentation to gauge the veracity of the idea. The results of these initial testings produce more detailed, exact and accurate experiments which refine the results down to a single conclusion which provides the answer to the initial reasoning.

The method includes the following:

- Repeatability – The same results should be obtained when the same experiment is done over and over again.
- Duplicatable – The same results should be obtained any where in the world under identical conditions.
- Controlled – All sources of interference and bias are eliminated from the experiment so that only one factor influences the outcome.
- Tested – Appropriately suitable tests are applied to compare the results with what was expected. This is important as it determines whether the experiment needs to be modified or a new hypothesis formulated.
- Analyzed – All data is statistically analyzed to see if it lies between a 95%-98% probability of accuracy, etc., where it is then deemed acceptable. It is also analysed for margins of error to verify the accuracy of the results.

The scientific method is not a 'quick fix' as it goes through the following simple steps in a loop until the hypothesis is proven or it has to be discarded:[14]



The method was devised this way to eliminate chance, error, interference, bias, and much more that can influence test results. Although research results usually come out less than 100% accurate and totally free of external influence, when properly adhered to, the techniques involved in the Scientific Method have the greatest chance of producing what is truth, real and accurate, when compared to other investigative methods.

10 – SEE: en.m.wikipedia.org/wiki/Ozone_depletion
11 – en.m.wikipedia.org/wiki/Stanley_Miller
12 – en.m.wikipedia.org/wiki/Miller%E2%80%93Urey_experiment
13 – "The Sound of Miller-Urey and Prebiotic Chemistry Exploding" uncommondescent.com/evolution/the-sound-of-miller-urey-and-prebiotic-chemistry-exploding
14 – GRAPHIC #1: "Scientific Methods: What is Scientific Method?" byjus.com/physics/scientific-methods
GRAPHIC #2: "Scientific Method" en.m.wikipedia.org/wiki/Scientific_method#/media/File%3AThe_Scientific_Method.svg

Falsifiability

One item that's not in empirical science, but which is an essential add-on to it, is falsifiability.[15] This is a 'moral' tool which should be used by all scientists, in every scientific field, because it's at the heart of getting to the truth (i.e. what's reality) which scientists should be aiming for.

Karl Popper[16] proposed this technique to test hypotheses and scientific theories, as a cornerstone of finding solutions to problems.

> *"A theory or hypothesis is **falsifiable** (or **refutable**) if it can be logically contradicted by an empirical test that can potentially be executed with existing technologies. The purpose of falsifiability, even being a logical criterion, is to make the theory predictive and testable, thus useful in practice. "* [17]

Simply put, falsifiability in practice means that scientists who have developed a theory, or even a hypotheses, that is close to becoming a theory, should look to see how it could be dis-proven. However, this is counter-intuitive to modern scientists because their livelihood and academic prowess is dependent on their ability to develop a major theory or reveal a previously unknown fact.

Like a military strategist who plans a military campaign which includes contingency plans in the event of a failure, scientists should look for and welcome contradictory information. This is how we get to reality, rather than a pseudo-reality that someone is propping up for some reason or other. This is what falsifiability does.

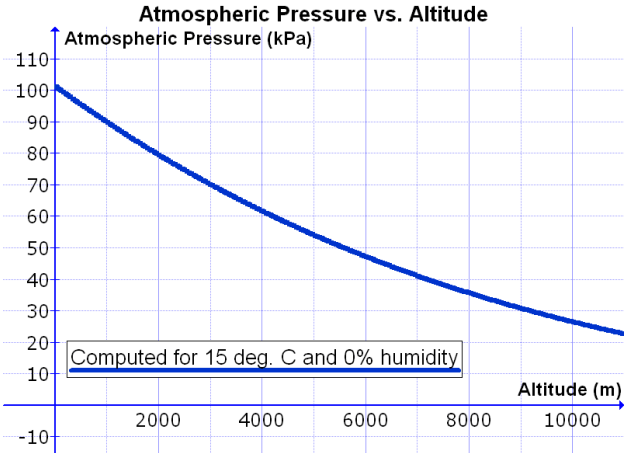
How Empirical Science Operates

(1) Empirical science takes every influencing factor into account and ensures that the statements, theories, results, etc., that are produced for public scrutiny are included in the report and taken into account in data analyses.

For example: Atmospheric pressure is known to change with altitude. This is the empirical mathematical formula for it:[18]

$$p = p_0 \cdot \left(1 - \frac{L \cdot h}{T_0}\right)^{\frac{g \cdot M}{R_0 \cdot L}}$$
$$= p_0 \cdot \left(1 - \frac{g \cdot h}{c_p \cdot T_0}\right)^{\frac{c_p \cdot M}{R_0}} \approx p_0 \cdot \exp\left(-\frac{g \cdot h \cdot M}{T_0 \cdot R_0}\right)$$

This is the observed effect of the change atmospheric pressure with increasing altitude:[19]



15 – SEE: "Why Scientists Disagree" canberraforerunners.org/wp-content/uploads/Why-Scientists-Disagree.pdf
16 – en.m.wikipedia.org/wiki/Karl_Popper
17 – "Falsifiability" en.m.wikipedia.org/wiki/Falsifiability
18 – en.wikipedia.org/wiki/Atmospheric_pressure#Altitude_variation
19 – GRAPHIC: "Atmospheric Pressure vs. Altitude" [FREE: Creative Commons CC0 1.0 Universal Public Domain Dedication] upload.wikimedia.org/wikipedia/commons/8/88/Atmospheric_Pressure_vs._Altitude.png

Knowing this, empirical research that is done above sea level would factor in these changes.

This is the case with the boiling point of water. At sea level it's 100ºC but it decreases with altitude.[20]

Boiling Point of Water at Different Altitudes

Altitude ft. (meters)	Boiling Point - Fahrenheit	Boiling Point - Celsius
0 ft. (0 m.)	212 ºF	100 ºC
500 ft. (152 m.)	211 ºF	99.5 ºC
1000 ft (305 m.)	210 ºF	99 ºC
1500 ft. (457 m.)	209 ºF	98.5 ºC
2000 ft. (610 m.)	208 ºF	98 ºC
2500 ft. (762 m.)	207 ºF	97.5 ºC
3000 ft (914 m.)	206 ºF	97 ºC
3500 ft. (1067 m.)	205.5 ºF	96 ºC
4000 ft. (1219 m.)	204 ºF	95.5 ºC
4500 ft. (1372 m.)	203.5 ºF	95 ºC
5000 ft. (1524 m.)	202 ºF	94.5 ºC
5500 ft. (1676 m.)	201.5 ºF	94 ºC
6000 ft. (1829 m.)	200.5 ºF	93.5 ºC
6500 ft. (1981 m.)	199.5 ºF	93 ºC
7000 ft. (2134 m.)	198.5 ºF	92.5 ºC
7500 ft. (2286 m.)	198 ºF	92 ºC
8000 ft. (2438 m.)	197 ºF	91.5 ºC
8500 ft. (2591 m.)	196 ºF	91 ºC
9000 ft. (2743 m.)	195 ºF	90.5 ºC
9500 ft. (2895 m.)	194 ºF	90 ºC
10000 ft. (3048 m.)	193 ºF	89.5 ºC

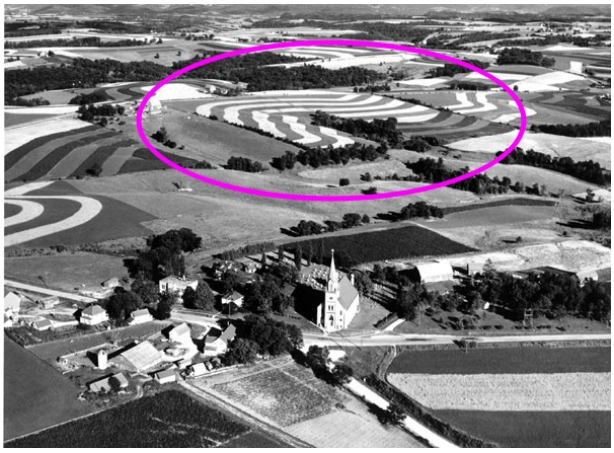
Temperatures have been rounded to the half degree.

Knowing this, any empirical statements about boil solutions must include a reference to altitude.

Chemistry scientists know about the fact that temperature and pressure affect chemical reactions. This is why the STP[21] (Standard Temperature and Pressure) system was introduced for accuracy. Empirical chemical results and statements include the temperature and pressure values so their influence on the facts is not hidden and can be accounted for in calculations.

(2) Influencing factors are also factored into the design of experiments by having them eliminated.

For example: Rather than comparing the productivity of wheat varieties in different paddocks which may have different soil, they are grown in alternating strips in the same paddock, like this:[22]



20 – "The Boiling Point of Water at Various Altitudes" www.thespruceeats.com/boiling-points-of-water-1328760
21 – en.m.wikipedia.org/wiki/Standard_temperature_and_pressure
22 – GRAPHIC: "Strip Cropping" en.m.wikipedia.org/wiki/Strip_farming#/media/File%3AStrip_farming_in_Wisconsin%2C_USA%2C_1957.jpg

Local Example of Empirical Science

How does the ACT's water board (Icon Water) know, that to test the quality of water around Canberra, water has to be run out of a tap for a set period of time before a sample is taken for analysis.

testing station

ICON Water employee testing the water

Initially, all over Canberra, water would have been drawn from testing stations for a long periods of time (probably 30 minutes) and a sample taken every 5 minutes, and repeated over a number of months. All the samples from every station would have been tested for water pipe impurities and an analysis done on the results. From the reading results, it would have been very straight forward to observe where the impurities stopped coming out and pure water was all that was collected. A protocol would then have been set in place where water station taps were to be turned on to expel any pipe impurities so that clean water could be tested for bacteria and soluble chemicals.

See how this was done empirically, with observation and the elimination of any influencing factors.

My Experience

I completed an agricultural science degree at Sydney University (NSW, Australia), graduating in 1972. My final year was an upgraded qualification where I trained to be an agricultural research scientist in the field of animal husbandry.

This was when I learnt about empirical science and how to properly follow the scientific method. I was taught experiment design, data analysis, statistical analysis, controlled experimentation, chemical analysis techniques, and a whole lot more.

The research work for my thesis was in experimenting how to improve the protein content of milk which is only around 3.1%. The experiment involved feeding 'protected protein' to milking cows and measuring the amount and types of protein in their blood and milk. Protected protein was quality protein that was harmlessly treated so that it went through the fermentation stomach (the rumen) and straight into acid and enzyme digestion in the other 3 stomachs and the small intestines. The aim was to have the high quality protein absorbed without it being transformed into low quality protein in the rumen.

Me taking blood samples from the jugular vein

The results of our research were published in one of the leading dairy science journals as a preliminary investigation into what could be achieved this way.

The need to isolate exactly what would produce a successful result (if there could be one) was the driving force to produce a high-fidelity design and achieve accurate results. These factors meant that we used empirical science and followed the scientific method – but only in the first cycle in our case.

It was this training and research experience which instilled in me the need for genuine science to be empirical.

Where Problems Come In

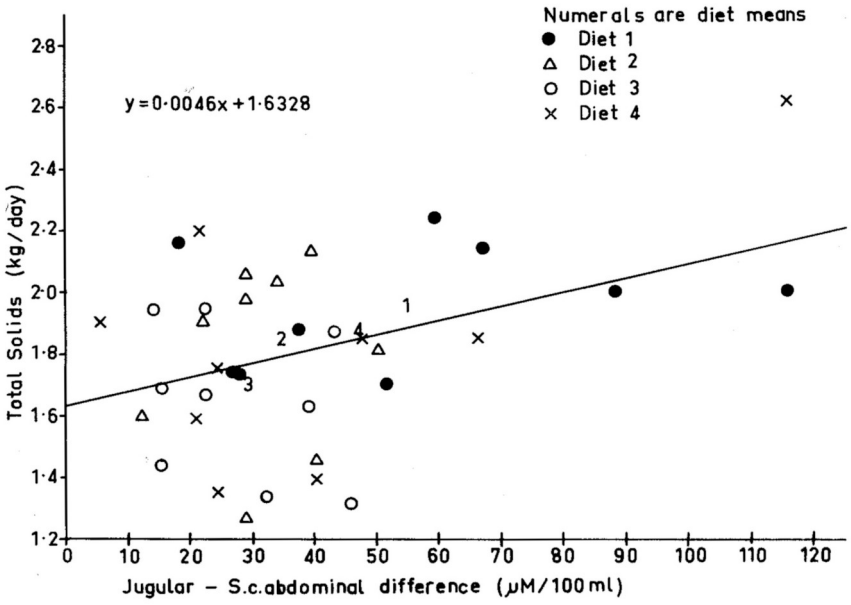
Problems in the fidelity of scientific experimentation arise in many ways. It's these problematic issues which cause myself and empirical scientists to reject the statement that "the science is in"[23] in regard to Climate Change. Climate Change science is not empirical and must only be treated as guides or possibilities, not factual. This 'science' should really fit into 'urban science', like not wearing shoes in the house,[24] even through reputable scientists have produced the knowledge for the public.

Here are few situations where problems come in and research 'drops out' of being empirical:

(1) Poor design – Experimental design is the foundation that good empirical science sits on. If the design is 'bad', the results will most likely be inaccurate, faulty or be misconceived. For example: My experiment was a switch-back design. The cows were fed a diet for a month, switched to a different diet for a month and then switched back to the original diet for a month. In this way the second diet could be compared to the first one and the switch-back took into account any changes in milk production during the lactation period. If a group of milkers were fed the normal feed and a different group was fed the protected protein diet, there's no way of telling if the two groups were identical. In a design like that, any changes in protein production with the special diet could have been because the cows in the second group were different to the first group.

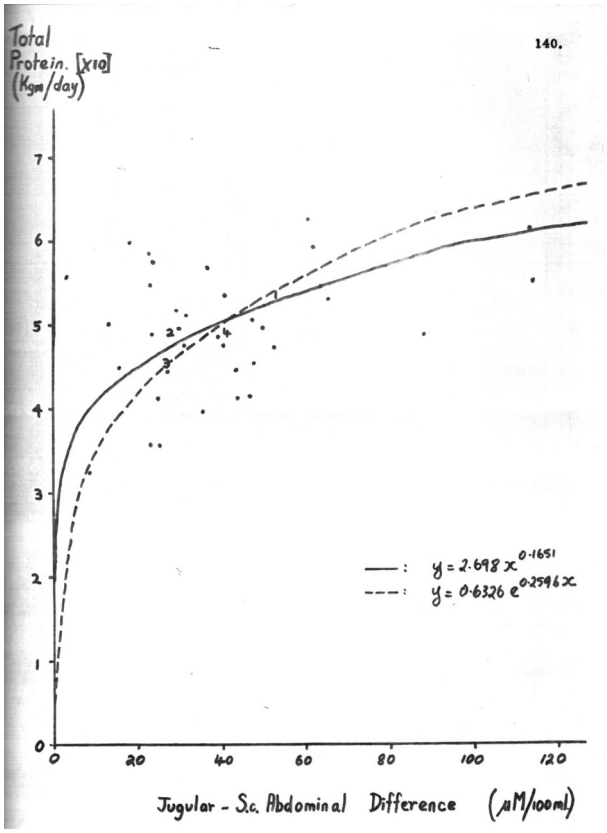
(2) Bias – Scientists are all biased. Never believe they aren't. They all have their worldviews and belief systems which are unconsciously used in their research analyses. The question is not whether scientists are biased or not, but what is their bias and how biased are they.

(3) Bad Interpretation – Research can be accurately designed and conducted, but the data can be badly interpreted. As an example, this happened in my research. Here's the graph that my professor created from our results. The correlation between the 2 factors fits the straight line y=0.0046x + 1.6328:



23 – e.g. "Be prepared: climate change, security and Australia's Defence Force" apo.org.au/node/57413
24 – "The science is in: wearing shoes inside your home is just plain gross"
www.theguardian.com/society/2022/mar/17/the-science-is-in-wearing-shoes-inside-your-home-is-just-plain-gross

I re-analysed the relationship between blood factors[25] and found that the following 2 relationships could equally describe the effects of our diet on milk production:



In my case the relationship is not linear, but logarithmic, described by different equations:

- $y=2.698x^{0.1651}$
- $y=0.6326e^{0.2596x}$

My analysis differed greatly from the professor's when looking at milk production outside of our testing zone. (See the graph between 0 & 20 on the bottom axis). All three relationships (equations) described what occurred in our experiment, but depending on which one was chosen to publish as the result of the experiment would produce different suppositions.

(4) Using Preliminary Investigations – Preliminary investigations are designed to test a hypothesis or to begin investigating a new discovery. Their results determine where the scientific method will be used to delve deeper and uncover the facts. Often these experiments are done in the laboratory, but they must then be fully researched 'out in the field' for the real research to uncover what are the facts.

Stanley Miller's[26] primordial soup experiment was one of these. It was conducted in the laboratory under hypothesised climatic conditions without being tested in the real world. Of course it couldn't be formally tested in reality because it was simulating the atmosphere back billions of years ago. When others checked the research later on they discovered that it was producing erroneous results and it was subsequently discarded. *(READ about it)*[27]

Often the results of preliminary investigations are released in scientific journals and treated with the same level of authority as complete research. This is not empirical science. Also, these results are released to the mainstream media and are taken up by the public as scientific fact.

25 – My graph above was for milk protein, whereas the professor's was for total solids. I don't have a copy of a total solids graph to compare.
26 – en.m.wikipedia.org/wiki/Stanley_Miller
27 – READ: "Chemical Evolution Debunked" My literature investigation into it
canberraforerunners.org/wp-content/uploads/Chemical-Evolution-Debunked.pdf
(From my textbook "Unmasking Evolution" canberraforerunners.org/wp-content/uploads/2021/02/Unmasking-resource-book.pdf)

Here's an example of preliminary research from laboratory experimentation that the researchers agree needs to be fully researched out on the land to be accepted as a technique to employ in environmental clean-up.[28]

So What?

The general public don't know what goes on in scientific experimentation, all they know is what the scientists choose to publish. To the public, scientists speak with authority, so they aren't questioned (as we saw from the medical 'experts'[29] that caused us to be locked down during the COVID pandemic). A lot of so-called science that we are forced to follow or cajoled into believing, is NOT empirical. These are often based on modelling which has 'best guess' or 'educated guess' for some or all of the inputs. Often they are extrapolations from laboratory to the natural realm (read, "real world").

Anecdotal evidence, surveys and questionnaires, written records, simulations, models, statistics[30] are not empirical science. They just show trends and are useful as a source for creating theories or hypotheses.

For example: 'Evidence-based Practice'[31] in health and the care sectors, does not mean it is based on empirical science evidence. Updates in this practice comes from any type of observed evidence from research or clinical situations, which has been reported in professional journals.

For example: In recent years we've found out that the failure of children learning to read was caused by teachers switching from phonics to word recognition some 20-30 years ago. The failure occurred because a long-term study following the Scientific Method did not take place before the state departments of education lauded the new method.

Conclusion

Not all science is empirical. So, don't use your knowledge of high school science lab experiments to cause you see science reports in the media having been done under the Scientific Method, and are to be trusted.

Even articles published in scientific journals can be 'off' because the authors used their biases to come up with their conclusions. In other words, don't expect climate scientists who support ACC[32] to produce reports from their scientific studies which repudiate it.

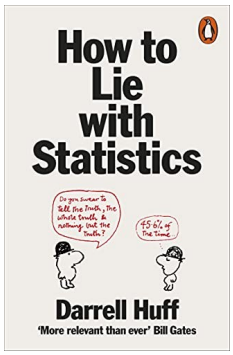
BE CAREFUL what you accept as being scientific

Laurence
29-3-2022
{updated 6-5-2022]
(www.CanberraForerunners.org)

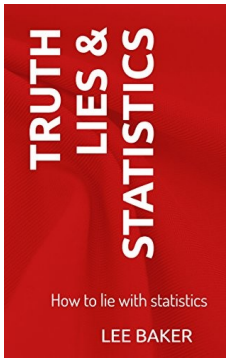
(Resource list over the page)

28 – "Hydroponic Australian Native Plants Found to Pull 'Indestructible' Chemical Contaminants From Water"
link.theepochtimes.com/mkt_app/hydroponic-australian-native-plants-found-to-pull-indestructible-chemical-contaminants-from-water_4442370.html
29 – Australian Gov. Dept. Health "Our response to the pandemic" www.health.gov.au/health-alerts/covid-19/government-response
30 – Darrell Huff (1991) "How to Lie with Statistics"
www.amazon.com.au/How-Lie-Statistics-Darrell-Huff-ebook/dp/B09HT1YRMF
Lee Baker (2017) "Truth, Lies & Statistics: How to Lie with Statistics"
www.amazon.com.au/Truth-Lies-Statistics-Bite-Size-Stats-ebook/dp/B077VRCVRL
Daniel Levitin (2019) "A Field Guide to Lies: Critical Thinking with Statistics and the Scientific Method"
www.amazon.com.au/Field-Guide-Lies-Statistics-Scientific/dp/0593182510
31 – "What is Evidence-Based Practice?" libguides.csu.edu.au/ebp
32 – Anthropogenic Climate Change – Humans cause all of the climate changes.

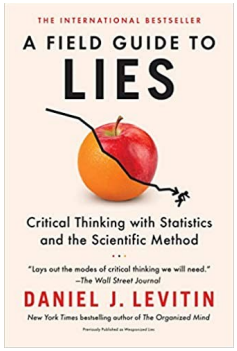
RESOURCES



www.amazon.com.au/How-Lie-Statistics-Darrell-Huff-ebook/dp/B09HT1YRMF



www.amazon.com.au/Truth-Lies-Statistics-Bite-Size-Stats-ebook/dp/B077VRCVRL



www.amazon.com.au/Field-Guide-Lies-Statistics-Scientific/dp/0593182510