

# In Search of Scientific Literacy

*How a supernova influenced Daubert;  
How a lawyer created modern science.*



The Scientific Process is actually recent in human history, and is the result of centuries of refinement. What are the hallmarks of that process? What event started the Scientific Revolution?

*And, how was a lawyer involved?*

by Jan Semenovff

## The Nova stella

There are very few pure “Eureka” moments in the development of science and technology, but this event is certainly considered one of them. On November 11<sup>th</sup>, 1572, then 26-year old Tycho Brahe (1546-1601) was gazing into the night sky when he noticed a new star, or in the Latin-educated language of the day – a *Nova stella*. A Danish nobleman who had studied law at the University of Copenhagen, Brahe had been drawn to the stars. Being pressed into a career as a lawyer and civil servant by his uncle, he was forced to study astronomy in secret. However, it was precisely his training as a lawyer and civil servant that provided the background necessary in rigorous study, record keeping, and systematic observation which would create the fundamental change about to occur. As with so many moments in our history, Brahe was the right person, in the right place, at the right time. (Wootton, 2015)



**Figure 1** - Tycho Brahe, circa 1585: Keen analytical mind; Poor swordsman skills; Brass nose, absolutely stellar mustache. He also had an odd choice of pets... *But wait until the end for that story...*

Imagine Brahe standing outside on that chilly Denmark evening (all astronomy was done outside in those days, using rudimentary optical devices) when the new star appeared before him. He must have been quite uncomfortable on that late fall evening. His artificial nose, made of brass, was undoubtedly rather cold. (He had lost most of his nose in a sword duel six years earlier in a quarrel with another nobleman, his third cousin, over who solved a difficult mathematical formula<sup>1</sup>.) But, to Brahe, the new star presented both a conundrum, and a mystery, and he was fascinated by what it offered.

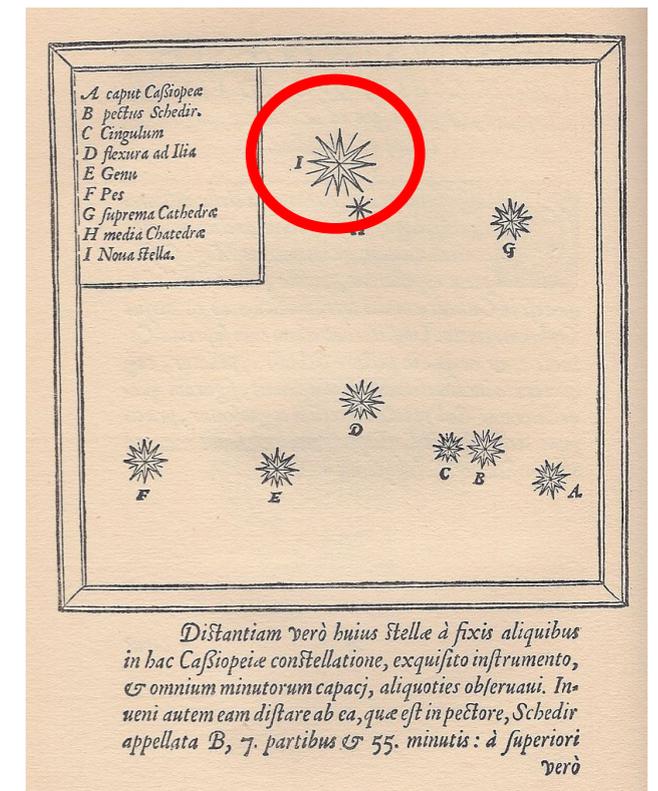
<sup>1</sup> Go ahead and complain, if you choose to do so, about YOUR next family reunion...

The conundrum was this; According to the accepted philosophy of the day, the Heavens were fixed and immutable. God had created the Heavens, so they believed, with the positions and numbers of the stars a fixed constant, all of which traveled geocentrically around the Earth in their own orbital shells. A new star could not *just appear*. To the devoutly Lutheran Brahe, the object therefore couldn't be a star. It had been observed a few days earlier independently by many other observers, and as such, conjecture surrounded the *Nova stella*. Aristotle's fundamental assertion in an “unchanging celestial realm” was now open to rigorous debate, and you simply didn't debate either the church or Aristotle... Still, the evidence was there, in the form of the star. The Heavens were no longer incorruptible.

The mystery came when he tried measuring the distance to the object, using the crude trigonometry of the day. The bright object was **not** located between the Earth and the Moon, as many suggested as a means of appeasing Aristotle's views. Rather, the *Nova stella* was as far away in the distance as the rest of the Heavens. *This was simply impossible!* The supernova of 1572 is often called *Tycho's Supernova* because he spent a number of years studying, measuring, recording and publishing about the phenomena.

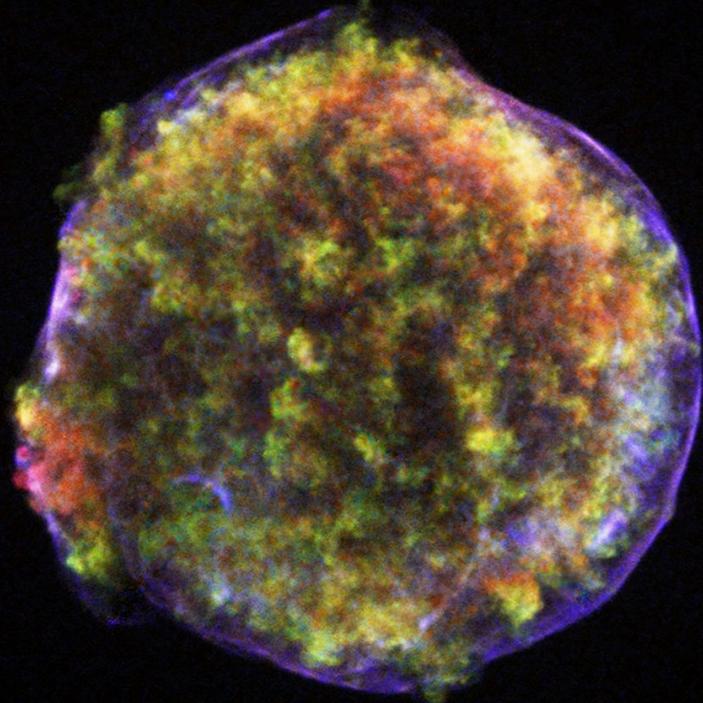
The appearance of that supernova changed the way humans think about the Earth, and indeed, about the Universe. Many believe it marks the beginning of modern Science.

*They needed a new way to conceptualize emerging evidence.*



**Figure 2** - Brahe's published work on the *Nova stella*, shown at position I in the diagram (red).

By the way, *Tycho's Supernova* – now known *B Cassiopeia* and cataloged as SN 1572 – was the result of a final and gigantic eruption of a dying white twin dwarf star in the constellation Cassiopeia, about 9,000 years earlier, when humans were still in hunter-gathering tribes using “*stone knives and bear skins*”. The light from that gigantic eruption took all that time to travel to Earth, making it, by definition about 9,000 light-years away<sup>2</sup>. It lit up the night sky, and became so bright for a while that it was visible during the daytime. It faded away by March of 1574, having been visible by the naked eye for about 16 months. Now, it is only “visible” by radio telescope in the X-ray band.



**Figure 3** - The *Nova stella* today, (SN 1572) visible only in the X-ray band, as shown on the front cover as well.

See the wavelength chart on **Page 148**

To this day it is still expanding, about 9,000 kilometres per *second*. It has a diameter of between 15-30 light years across. And regardless of how long ago it exploded, it is *still burning in space*.

I feel foolish even writing this, but our notion of modern science may have originated from an event that actually occurred “A long time ago, in a galaxy far, far away...”<sup>3</sup> They needed a new way to explain the new star... Enter, the *Scientific Revolution*.

<sup>2</sup> If you think there is measurement uncertainty in forensic sciences, know that the distance of SN 1572 has been measured alternatively between 6,500 – 16, 300 light years away, with more recent studies suggesting 8,000 – 9,800 light years. *That's a huge disparity...*

<sup>3</sup> Actually, a *Constellation* far, far away... *But how often have you had an opportunity to use that quote in a serious article? I've quoted Spock here, as well. But, hey, if you noticed, you're a geek, too!*

## The Scientific Method

### The Birth of Empiricism

The new explanation required a new way of thinking, a new way of empirically rationalizing the *Nova stella's* existence. Brahe and his contemporaries disengaged their intellectual exercises from the dogma of the day, and instead, applied critical thinking, reasoning and measurement in an attempt to understand the world around them. Up until that time, thinkers and scholars referred to themselves as *Natural Philosophers*. That is to say, they applied their reasoning skills, their philosophy, to the natural world. It was the only true academic discipline.

Until then, experimentation was purely a theoretical exercise, where the philosopher created the conditions, and reasoned through the exercise to draw out a logical conclusion. That conclusion would become the rational belief of the day, and would persist over time, absolutely unchallenged for the simple fact that someone learned had developed the conclusion. Unfortunately, this left the rest of us with notions that mice were spontaneously generated from the hay in the barn, and the absolute belief that a victim's body would bleed in the presence of the accused murderer. This is still the age of Witchcraft Trials. *Evidence to the contrary, indeed...*

Instead, a new *discipline*, and more importantly, a new *thought process* emerged – *Science*. It was based on empiricism, rationality, and measurable phenomena, that was reported and shared, discussed and debated - and as with Brahe, sometimes vigorously argued at the tip of a sword. The discipline was *knowledge based* (the word ‘science’ comes from the Latin *scientia*, meaning ‘knowledge’). Brahe, and those who followed, would inquire and try to understand everything from the orbiting of the galaxies around the Universe, to the orbital mechanics of an electron around its nucleus, and beyond, in both directions. As a species, we evolved from those content to accept the theories of the past into inquisitive beings, searching for new and more complex understandings. *Natural Philosophers receded, Scientists emerged.*

A fundamental paradigm shift occurred while humans developed, over the next few centuries, this *Scientific Method*. As Jacob Bronowski wrote in *The Ascent of Man*:

Man is a singular creature. He has a set of gifts that make him unique among the animals, so that unlike them, he is not a figure in the landscape, he is the shaper of the landscape. (Bronowski, 1973).

And to shape that landscape, you need the discipline and methodology of *Science*. From *Daubert* we get the notion that a conclusion – a shaping of the landscape - will qualify as scientific knowledge if the proponent can demonstrate that it is the product of sound scientific methodology that is derived from the scientific method. *Tycho's supernova* helped shape that scientific method.

## What is the Science Method?

Alan Gold discusses the merits of science in his book, *Expert Evidence in Criminal Law – The Scientific Approach*: “Science” is a process, not a product.<sup>4</sup> *What, therefore, makes science “good science”?*

1. Science is the ability to observe and describe phenomena and draw conclusions and inferences from what has been observed, measured, reported and thoughtfully considered.
2. Science integrates observations with data to draw conclusions that are confirmable.
3. Science formulates hypotheses based on results of verifiable data.
4. Science tests these hypotheses under controlled, observed, confirmed and repeatable conditions.
5. Science aims to minimize errors, either observational, computational or generated by measurement, technology or the testing process itself.
6. Science records the results without bias. The testing must be clear cut and free from interference from the observer, however unintentional.

<sup>4</sup> Gold, Alan D., *Expert Evidence in Criminal Law – The Scientific Approach*, Irwin Law, 2003, page 80..

7. Science must be transparent. Science does not hide its processes, technologies or methodologies.
8. Science invites criticism, the opposing view, and the opportunity to prove one's position, in the face of opposition, based upon a logical and clear interpretation of the observed facts. Good science welcomes cross-examination.

Regardless of these traits, I occasionally see opined views by experts completely disregarded based on the personal and scientific bias and of opposing experts. I accept as absolute that peer reviewed works should be considered authoritative. However, the onus this places on the authors of such works is to interpret their findings according to the results *obtained*, not the results *desired*. My advice is to read more than just the synopsis or abstract of any article presented. Occasionally, the reported data supports an entirely different conclusion than the one presented in the abstract, or by the expert. The duty of the unbiased expert should be to present the findings, materially, without bias or favor on the position of the author. To do any less is an affront to the scientific process, and an indignity to the court.



**Figure 4** - Astronomy was the first real science, and to begin with, it incorporated what we would think of as Astrology today. As an aside, another important astronomer, Galileo Galilei, was 6 years old when the *Nova stella* appeared. That supernova may have changed the way many profound thinkers of the day viewed the Earth, the Heavens, and concepts of critical reasoning.

## The Expert as Educator, Part 1:

Federal and state rules of evidence define the role and use of the expert witness. An expert witness or professional witness is a witness, who by virtue of education, training, skill, or experience, is believed to have knowledge in a particular subject beyond that of the average person, sufficient that others may officially (and legally) rely upon the witness's specialized (scientific, technical or other) opinion about an evidence or fact issue within the scope of their expertise, referred to as the expert opinion, as an assistance to the fact-finder.

In England and throughout continental Europe, the expert witness is seen to be totally independent. They are appointed by the court, with the parties unable to seek to influence or manipulate their views. They address their letters of opinion and expert testimony directly to the court, even though they are paid by the party commissioning their report and testimony. Their obligation is to “scientific truth.”

In the United States, an expert testifying in court must satisfy the requirements of Federal Rules of Evidence 702. Generally, under Rule 702 or its state law equivalent, an expert is a person with “scientific, technical, or other specialized knowledge” who can “assist the trier of fact,” which is typically a jury. A qualified expert may testify “in the form of an opinion or otherwise” so long as:

1. The testimony is based upon sufficient facts or data,
2. The testimony is the product of reliable principles and methods, and
3. The witness has applied the principles and methods reliably to the facts of the case.”
4. The expert is also constrained to testify to matters in a recognized scientific field of endeavor, and only then to matters that are generally accepted within the relevant scientific community.

## Science and the Law Intersect

### Daubert, Gate keeping and the “Scientific Method”

In general, there are two different legal paradigms that govern the admissibility of expert evidence: the older *Frye* standard (1923), and the newer *Daubert* standard (1995). The *Frye* standard is a test to determine the admissibility of scientific evidence before the courts. In the majority of jurisdictions in the US, the *Frye* standard has been superseded by *Daubert*.

The *Daubert* standard is a rule of evidence regarding the admissibility of expert witnesses' testimony during all federal and some state legal proceedings. In regards to this standard, a party may raise a *Daubert* motion, which is a special type of motion *in limine* raised before or during trial to exclude the presentation of unqualified evidence to the jury.

The *Daubert* trilogy refers to the three United States Supreme Court cases that established the *Daubert* standard:

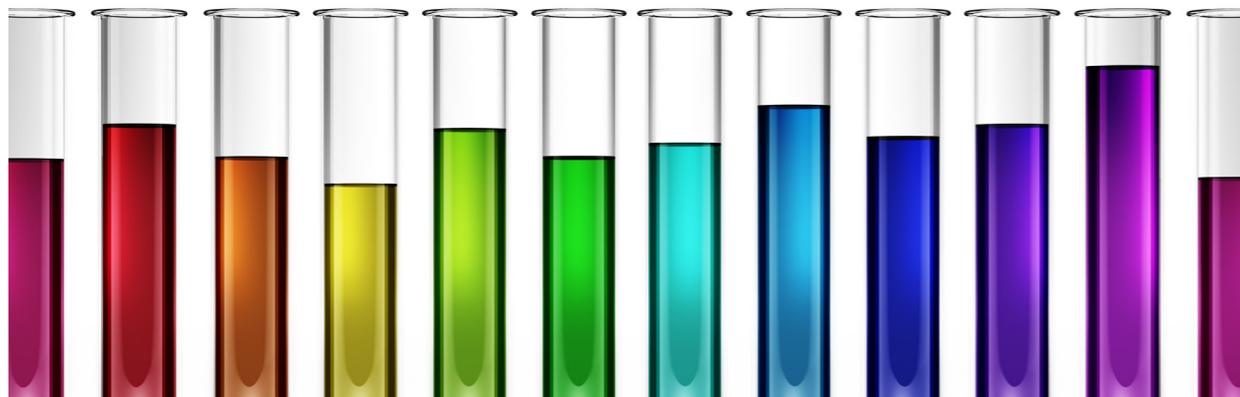
*Daubert v. Merrell Dow Pharmaceuticals*, which held that Rule 702 did not incorporate the Frye “general acceptance” test as a basis for assessing the admissibility of scientific expert testimony;

*General Electric Co. v. Joiner*, which held that an abuse-of-discretion standard of review was the proper standard for appellate courts to use in reviewing a trial court's decision of whether expert testimony should be admitted;

*Kumho Tire Co. v. Carmichael*, which held that the judge's gate keeping function identified in *Daubert* applies to all expert testimony, including that which is non-scientific.

In *Daubert*, the Court established the following guidelines for admitting scientific expert testimony:

- ***The judge is a gatekeeper:*** Under Rule 702, the task of “gatekeeping”, or assuring that scientific expert testimony truly proceeds from “scientific knowledge”, rests on the trial judge. This puts a great deal of weight on the judge’s decision, and requires implicitly that the judge is capable of assessing the veracity of a specific scientific opinion, often in light of conflicting testimony and dissenting opinions. *Can Judges or Justices really be considered valid scientific arbitrators? Do they possess the underlying scientific literacy to function as gatekeepers?*
- ***Relevance and reliability:*** This requires the trial judge to ensure that the expert’s testimony is “relevant to the task at hand” and that it rests “on a reliable scientific foundation”. Concerns about expert testimony cannot be simply referred to the jury as a question of weight. Furthermore, the admissibility of expert testimony is governed by Rule 104(a), not Rule 104(b); thus, the Judge must find it *more likely than not* that the expert’s methods are reliable and reliably applied to the facts at hand.
- ***Scientific knowledge = scientific methodology:*** A conclusion will qualify as scientific knowledge if the proponent can demonstrate that it is the product of sound scientific methodology that is derived from the scientific method. The proponent always has the burden of proof.



- ***Relevant factors:*** The Court defined “scientific methodology” as the process of formulating hypotheses and then conducting experiments to prove or falsify the hypothesis, and provided a nondispositive, nonexclusive, “flexible” test for establishing its “validity”, i.e. the “scientific method”:
  1. Empirical testing: the theory or technique must be falsifiable, refutable, and testable.
  2. Subjected to peer review and publication.
  3. Known or potential error rate
  4. The existence and maintenance of standards and controls concerning its operation.
  5. Degree to which the theory and technique is generally accepted by a relevant scientific community.

In 2000, Federal Rule 702 was amended in an attempt to codify and structure the “Daubert trilogy.” Rule 702 now includes the additional provisions which states that a witness may only testify if:

1. The testimony is based upon sufficient facts or data
2. The testimony is the product of reliable principles and methods, and
3. The witness has applied the principles and methods reliably to the facts of the case.”

As such, the gatekeeping role places an enormous burden on the court. Judges find themselves in the unenviable position of *Gatekeeper*. I respectfully suggest this necessitates a degree of scientific literacy among members of the court. A lack of scientific literacy allows a return to unchallenged pronouncements, devoid of true scientific merit. The only way to develop that scientific literacy is through education. And let’s be clear. This does not imply the a Judge has to be a Physician, Biologist or Chemist, but it does require a fundamental understanding of the scientific process upon which those disciplines rely, and the ability to separate good science from *junk science*.

## Scientific Literacy vs. Junk Science

Which brings us to *junk science*. Appropriate application of *Daubert* criteria leave us in a position where the only antidote to junk science is scientific literacy. There can be no doubt that the expert scientific evidence presented by some is little more than dogma, full of bias, and with intent to present, and worse, preserve, a one-sided view. This cannot be the position of the courts. Alan Gold writes:

Appellate courts in North America are recognizing that there is really only one relatively successful antidote for a system that has in recent times appeared to suffer a bad case of “junk science,” of inadequate, unreliable, and even worthless opinions that have managed to beguile their way into courtrooms disguised as expertise. That remedy is scientific literacy: a knowledge of science and its methods sufficient to distinguish good science from bad and expose the latter<sup>5</sup>.

He continues:

Scientific literacy is essential for justice to be done. It is essential if it is to be the case that only probative opinions are to be admitted and only valid inferences to be drawn by a trier of fact. The structured questioning of a well-briefed and scientifically opposing counsel can be a searching and rigorous examination of expert evidence, especially when accompanied by the quality logical reasoning of a scientifically literate fact-finder. There is simply no close contender for the task of successfully excluding junk science and bogus experts from the courtroom<sup>6</sup>.

The National Academy of Sciences recent study on the “health” of forensic science in the nation points out this issue with justifiable concern. Given the identified issues with education and training, best-practices and methodologies, coupled with a general lack of oversight in the forensic science labs across the nation, perhaps a greater emphasis should be given the Congressional Committee’s recommendations.

5 Ibid, Gold, page 17.

6 Ibid, Gold, page 18.

In *Melendez-Dias v. Massachusetts*, the late Mr. Justice Scalia commented on the National Academies’ report:

Nor is it evident that what respondent calls “neutral scientific testing” is as neutral or as reliable as respondent suggests. Forensic evidence is not uniquely immune from the risk of manipulation. According to a recent study conducted under the auspices of the National Academy of Sciences, “[t]he majority of [laboratories producing forensic evidence] are administered by law enforcement agencies, such as police departments, where the laboratory administrator reports to the head of the agency.” National Research Council of the National Academies, *Strengthening Forensic Science in the United States: A Path Forward 6-1* (Prepublication Copy Feb. 2009) (hereinafter National Academy Report). And “[b]ecause forensic scientists often are driven in their work by a need to answer a particular question related to the issues of a particular case, they sometimes face pressure to sacrifice appropriate methodology for the sake of expediency.” *Id.*, at S-17. A forensic analyst responding to a request from a law enforcement official may feel pressure--or have an incentive--to alter the evidence in a manner favorable to the prosecution.



**Figure 5** - Former Massachusetts Crime Lab Chemist Annie Dookhan admitted to falsifying evidence in up to 34,000 cases. She reportedly analyzed more than 500 samples per month - five times the lab average. The reason why remains unanswered. The havoc created is unfathomable, and brings about calls for third-party oversight.

In her sentencing, Judge Ball of Suffolk Superior Court wrote, “*Innocent persons were incarcerated, guilty persons have been released to further endanger the public, millions and millions of public dollars are being expended to deal with the chaos Ms. Dookhan created, and the integrity of the criminal justice system has been shaken to the core.*”

He went on to quote Tulane Law Professor Pamela Metzger's 2006 law review article:

Confrontation is designed to weed out not only the fraudulent analyst, but the incompetent one as well. Serious deficiencies have been found in the forensic evidence used in criminal trials. One commentator asserts that “[t]he legal community now concedes, with varying degrees of urgency, that our system produces erroneous convictions based on discredited forensics.” Metzger, *Cheating the Constitution*, 59 *Vand. L. Rev.* 475, 491 (2006). One study of cases in which exonerating evidence resulted in the overturning of criminal convictions concluded that invalid forensic testimony contributed to the convictions in 60% of the cases. Garrett & Neufeld, *Invalid Forensic Science Testimony and Wrongful Convictions*, 95 *Va. L. Rev.* 1, 14 (2009). And the National Academy Report concluded:

“The forensic science system, encompassing both research and practice, has serious problems that can only be addressed by a national commitment to overhaul the current structure that supports the forensic science community in this country.”  
National Academy Report P-1.

The same is true of many of the other types of forensic evidence commonly used in criminal prosecutions. “[T]here is wide variability across forensic science disciplines with regard to techniques, methodologies, reliability, types and numbers of potential errors, research, general acceptability, and published material.” National Academy Report S-5. See also *id.*, at 5-9, 5-12, 5-17, 5-21 (discussing problems of subjectivity, bias, and unreliability of common forensic tests such as latent fingerprint analysis, pattern/impression analysis, and toolmark and firearms analysis). Contrary to respondent's and the dissent's suggestion, there is little reason to believe that confrontation will be useless in testing analysts' honesty, proficiency, and methodology--the features that are commonly the focus in the cross-examination of experts.

## Juries: Possible Barriers to Justice

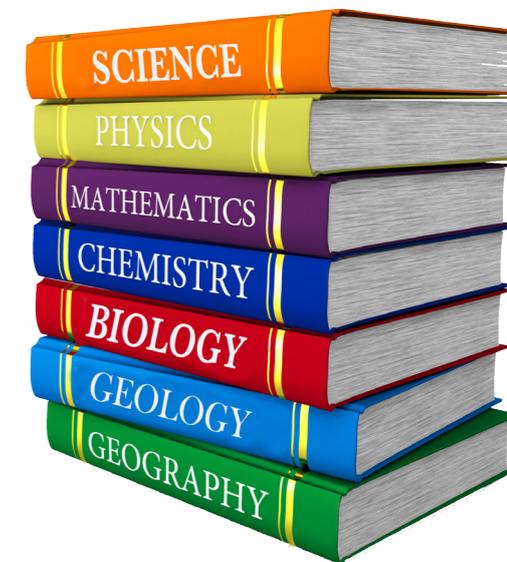
### Science and Adults

*“I can't understand the science, so I'm tuning out now... Wake me when its time to vote on the verdict...”*

According to Dr. Jon Miller, Director of the Center for Biomedical Communications, “70 percent of Americans cannot read and understand the science section of the *New York Times*” (*Science Daily*, 2009).<sup>7</sup> If this statistic is valid, how do we know that jury members understand the science intrinsic in any scientific testing? How can jury members make an informed decision if they do not understand the basic scientific concepts? Considering that juries are selected from the general public, a wide variety of backgrounds and experiences will come to play in their perceptions of the case presented.

Science literacy has become a target for educators in North America. Dr. Miller comments:

While science literacy has doubled over the past two decades, only 20 to 25 percent of Americans are ‘scientifically savvy and alert.’ ... Most of the rest ‘don't have a clue.’ At a time when science permeates debates on everything from global warming to stem cell research, people's inability to understand basic scientific concepts undermines their ability to take part in the democratic process. (Dean, 2005)<sup>8</sup>



Dr. Miller's assertion raises a number of issues for the courts, lawyers, and their expert witnesses.

<sup>7</sup> <http://www.sciencedaily.com/releases/2007/02/070218134322.htm> as of March 21, 2016

<sup>8</sup> [http://www.nytimes.com/2005/08/30/science/30profile.html?\\_r=2](http://www.nytimes.com/2005/08/30/science/30profile.html?_r=2) as of March 21, 2016.

## Explaining the Science

### The Expert as Educator, Part 2:

When giving testimony, experts must be sure to use clear and concise language. The jury must be taught the scientific concepts. No assumptions about previous knowledge should be made. If 70 percent of Americans do not understand the science section of the New York Times, simplistic explanations and demonstrative learning aids must be prepared. It is worth noting that newspapers tend to have the approximate reading level of grade six. Solomon (2002) states <sup>9</sup> :

Trials are about language. Word meaning, language perception and semantics ultimately dictate real understanding during jury deliberations and directly impact the completion of the verdict form! Our research demonstrates that jurors typically do not understand the real meaning of most case related language, and that this problem is magnified where the entire matter is foreign to them. Of course, these same terms are used by attorneys [and experts] with abandon! The result is confusion, or worse yet, misguided decision making. (p.6)

Jurors need to understand the language and the scientific concepts in order for justice to be served. As such, the expert must, at all times, be a good communicator, and an excellent educator in terms of their ability to effectively communicate complex ideas.



<sup>9</sup> [http://www.doar.com/apps/uploads/literature62\\_HowJurorsMakeDecisions.pdf](http://www.doar.com/apps/uploads/literature62_HowJurorsMakeDecisions.pdf) as of September 16, 2009.

### Recognizing Barriers:

According to Laurel Armstrong-Buisseret, an adult learning science practitioner, “probably one of the main barriers [to adult learners studying science] is fear of the subject. How many learners say they hated science (or their science teachers) at school?” <sup>10</sup> If jury members did not have positive experiences in science classes, they may instantly put up barriers to the information you are trying to impart. These barriers are even more difficult to manage in a courtroom setting, where jury questions are not easily addressed. If jurors do not understand the language or the science, they are more likely to tune out the information and rely on others on the jury, or worse, a “gut” opinion based on their understanding of the science from their exposure to the media in establishing a finding of guilt or innocence. Exploring ways to overcome this barrier will be necessary at trial.

This points to the need for the expert to create a positive “learning” environment. The explanations given, often of complex issues and ideas, must be presented in a manner that is both persuasive and realistic. “Talking-down”, “talking over the heads” and excessive use of jargon will only serve to frustrate and alienate the juror from the message being presented, thus accentuating the barrier, and reinforcing the notion that “science is too hard.”

**It may be helpful** for the judge or trial attorney to remember their own issues in understanding the complex scientific ideas the first time they were presented. I often teach lawyers and judges from across Canada and the United States on the fundamental principles and operations of breath alcohol devices. I’ve commonly heard the following type of statement, remarked privately during a break in an embarrassed whisper: *“I don’t think I will be able to do this course. I didn’t do well at (insert: biology, chemistry, physics, science here) in school, and that’s why I became a lawyer.”* The jurors, many with far less educational experience, have a similar sort of visceral reaction when it comes to understanding “science.”

<sup>10</sup> <http://www.excellencegateway.org.uk/162461> as of September 16, 2009.

## Perceived Jury Leaders:

If it is believed that jurors may have limited science background, and perhaps emotional barriers to this area of knowledge, how do jurors determine validity in an argument and therefore conclude guilt or innocence? Solomon (2002) suggests that jurors don't necessarily decide for themselves<sup>11</sup>. Faced with overwhelming jargon, or technical material, jurors may look for an "expert" within their group, and this person may not truly perceive the concepts either. He comments:

Jurors typically look to fellow jurors with perceived or real subject matter expertise. It may be a trivial relationship (and this has happened), such as a juror who worked as a typing clerk in a courthouse! More typically, it will be someone who works in an area that relates to the issue at hand. For example, in a contract case, this person will have an extraordinary influence during deliberations because the subject matter of the case is so foreign to other jurors.  
(p. 5)

It is important to recognize that those jurors who are perceived to have background knowledge in science or technology may be deciding the verdict for the entire group.

## The Conundrum of the Paradigm Shift

When an expert witness presents a contradictory view, or indeed a new view, the juror may experience a fundamental shift to their core beliefs. To many jurors, the notion of DNA, fingerprint or ballistic evidence, as a few examples, are an absolute one. Their core beliefs in these sciences are shaped by their exposure to its inner working through popular media. *If CSI Miami did it, it must be correct!* Now comes the expert, spouting complex terms, with charts and indecipherable diagrams in hand, to say that, *"No, it doesn't always work this way!"*

Who is the jury to believe?



The job of the expert, in concert with the attorney, is to incrementally shift these paradigms, identifying each fallacy, and educating both the jurist and the juror as to the science as really published in the appropriate peer reviewed journals. The focus must be on the methodologies used, variables with the instrumentation, and the accuracy, precision, reliability and specificity of the results obtained. The correct and legal focus should be on examining the offered evidence, *without* a presumption of truth for that evidence. Healthy skepticism, coupled with substantiated beliefs based on published peer-reviewed works is at the core in establishing the reliability of evidence offered, including expert opinion evidence.

## The Critical Nature of Scientific Literacy

Remember that all parties involved – lawyers, judges and juries are often illiterate or ill-informed to the science at hand, out of their element, yet with the power to create or render a decision of immense consequence. Regardless of the academic credentials of the expert, if they cannot convey their message effectively, their message will be lost in confusion, or open to misinterpretation. Worse, the jurors may be facing a fundamental paradigm shift similar to that faced by Tycho Brahe and his colleagues. Their world can be turned upside down. A jury needs to reach a *logical* conclusion based upon empirical knowledge rather than an *emotional* decision based on dogma.

The only rational way to combat this issue is with scientific literacy. Brahe and his colleagues were faced with a measurable dilemma – the *Nova stella*. Its appearance challenged beliefs dating back to Aristotle. Dogma failed them because it couldn't explain the physical evidence. In order to understand that evidence, they ended up creating a new world view. Science became the explosion equal to that supernova. This is a profoundly courageous moment in history. Without that supernova, and the "Scientific Revolution" it figuratively ignited, we would not have the benefit of growth from empirically challenged and validated ideas.

<sup>11</sup> Ibid.

*So, what happened to Tycho Brahe?* Well, history tells us that he probably had an affair with the Queen of Denmark, thereby providing the background story for Shakespeare's *Hamlet*. He was banished from Denmark as a result. Worse, his pet moose got drunk on a barrel of beer and fell down a flight of stairs, breaking its own neck. *Yes, you read that right.* He had a collection of noses – bronze, copper, or brass for everyday, and gold or silver for special occasions. *Sharp dressed man...*



Figure 6 - *Ya, it's a nose...*

He had a young apprentice and assistant named Johannes Kepler who advanced Brahe's work by absconding with all of his notebooks after his death, and used that painstakingly collected data to describe the *Laws of Planetary Motion*. (Kepler also discovered his own supernova in 1604. Kepler ended up providing the foundation for Isaac Newton's *Theory of Universal Gravitation*.) Kepler was apparently a better mathematician than Brahe. Science evolves...

But, unfortunately, poor Tycho died of a burst bladder while binge drinking copious amounts of wine and beer at a banquet because he refused to be so rude, according to the strict etiquette of the day, and leave the table to relieve himself.

He challenged Aristotle's fundamental principles, changed the face of science, and faced criticism and potential charges of Heresy from the church at a time when witches were being burned at the stake, but died early at age 55, because he wouldn't go pee.

*Tell me again how science is boring...* ▲

A special thanks to attorneys Mark Brayford, QC; Wayne Foote, Esq.; Bruce Kapsack, Esq.; and Justine McShane, JD, F-AIC, for their review and helpful comments in the original manuscript.

## More to Explore

**Author's Note:** If you are interested in learning more about science, start with some of these works that explain science as an evolutionary event. They breath some life into the subject, and more importantly, make the historical figures and events a little more interesting. *I highly recommend them all:*

Bronowski, Jacob, *The Ascent of Man*, BBC Press, 1973.

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Sagan, Carl, *Cosmos*, Random House, 1980.

Wootton, David, *The Invention of Science*, Penguin Random House, 2015.

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# COUNTERPOINT

The Journal of Science and the Law

*How Tycho's Supernova  
10,000 years ago helped  
establish Daubert criteria...*

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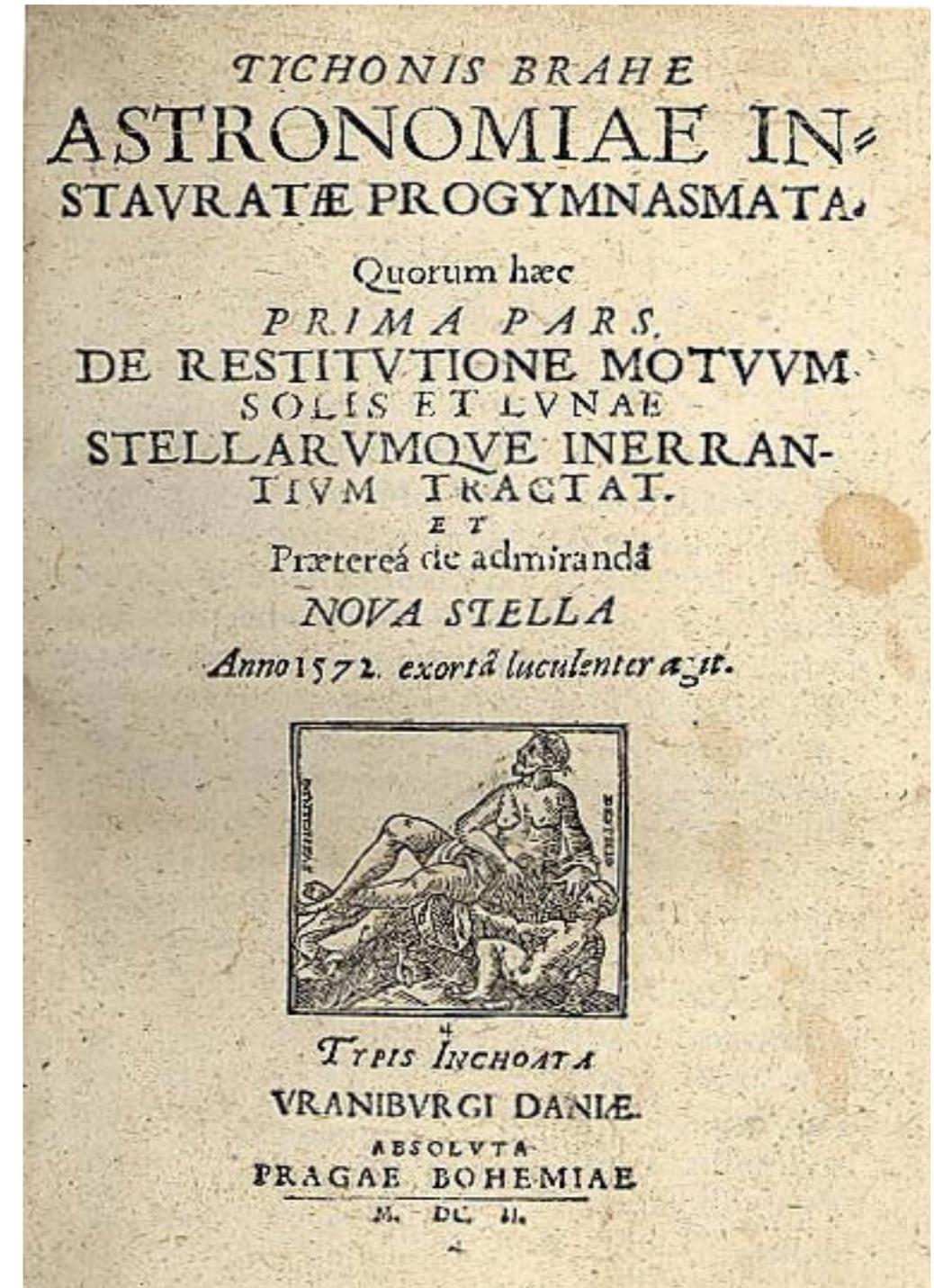
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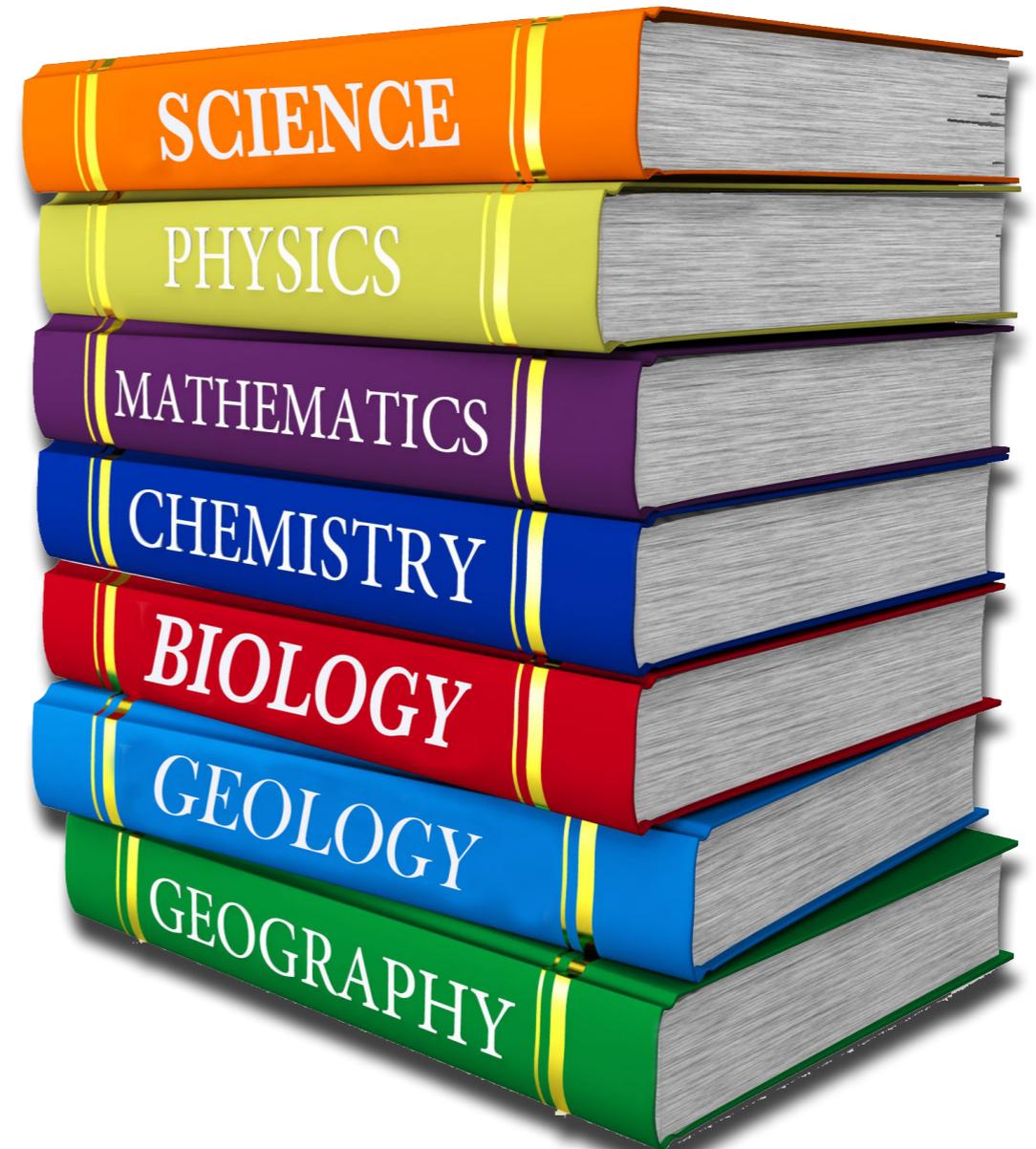
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## GM & EDITOR IN CHIEF:

[Jan Semenoff, B.A.](#)

## EDUCATIONAL CONSULTANT & ASSOCIATE EDITOR:

Susan Reschny, M. Ed.

## ART DIRECTOR:

Lesley Kerpan, B.F.A.

## DIRECTOR OF PHOTOGRAPHY:

Alexander Semenoff

## CONTACT US:

### GENERAL:

[info@counterpoint-journal.com](mailto:info@counterpoint-journal.com)

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