**Aangevallen door Pseudowetenschap (= wervende tekst voor de workshop)**

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*Karakter: actieve werkgroep/discussie*

*Niveau: havo/vwo bovenbouw (eventueel 3 vwo)*

*De docent deelt je klas in drie groepen waarbij iedere groep centraal zijn eigen opdracht krijgt, maar daarnaast krijgt iedere groep ook een geheime missie. Wat beleeft de leerling:*

*Je wéét hoe het natuurkundig in elkaar zit. Toch? Maar kun je jouw kennis ook verdedigen als die écht wordt aangevallen? Natuurkunde leren is ook leren omgaan met vaktaal, met verwoorden, redeneren, overtuigen van de ander, overtuigen van jezelf. Dat kan er levendig aan toe gaan! Als je ‘de’ waarheid in pacht hebt, dan is overtuigen toch een fluitje van een cent? Maar waarom lukte het in de geschiedenis dan zo vaak niet? En wat nu als je helemaal niet weet of jij wel degene bent die ‘de’ waarheid heeft? Is iedere redenering even valide?*

*De doelen: Natuurkunde verwoorden, het leren herkennen van hoe pseudowetenschap redeneert*

*Steekwoorden: Geschiedenis, NOS (Nature Of Science), gamification*

**Hoe werkt dit?**

Tijdens de workshop is er gediscussieerd over de stelling: de aarde is bol.

De workshopdeelnemersgroep is in drieën gedeeld:

- Groep 1 verdedigt dat de aarde bol is,

- Groep 2 verdedigt dat de aarde plat is,

- Groep 3 is de jury.

De workshoptijd is in drie stukken geknipt, van ongeveer 30 minuten:

1. Voorbereiding
2. Discussie
3. Nabespreking

*Centrale instructie*: Het doel is dat jullie gaan discussiëren over of de aarde bol is en dat de jury dit jureert. Iedere groep heeft echter ook een geheime ‘missie’.

Deze geheime missies zitten in de bijlagen. Groep 1 blijkt eerlijk te moeten spelen, groep 2 blijkt vals te mogen spelen, maar met name groep 3 krijgt een andere missie dan ze denken… Groep 1 en 2 denken op dit moment nog dat het doel van de discussie vakinhoudelijk is: de natuurkunde verdedigen/aanvallen.

*Verloop*

Tijdens de voorbereiding bereidt iedere groep zich voor. Bij de workshop gebeurde dit “in de les” zelf. Als je dit in een klas zou doen, kan de voorbereiding ook thuis plaatsvinden.

Tijdens de discussie vindt de discussie plaats en observeert de jury, maar zegt nog niets.

De aap komt pas uit de mouw bij de nabespreking. De jury beoordeelt namelijk niet de debating-skills of vakinhoudelijke argumentatie. De jury blijkt te beoordelen: welke pseudowetenschappelijke kenmerken (‘features of pseudoscience’) zijn er gebruikt. Tijdens de voorbereiding heeft deze groep hier informatie over gekregen. Deze informatie zit in bijlage 3, maar eventueel kan ook gebruik worden gemaakt van de Engelse Wikipedia-pagina over pseudoscience.

Het doel van de workshop is dat deelnemers eerst aan den lijve merken hoe lastig vakinhoud verdedigen kan zijn. Maar daarna vooral dat ze leren dat er ook oneerlijke technieken bestaan. Kennis over deze technieken geeft je handvatten om onwetenschappelijke argumentatie beter te doorzien.

*Mogelijkheden op school*

Ik heb deze discussie zowel op Woudschoten uitgevoerd als in mijn klassen over wetenschapsfilosofie, een vak dat ik geef op de lerarenopleiding NaSk. Het vaak heftige verloop van de discussie laat zich aardig vergelijken met het spelen van het spel Weerwolven 😉. Deelnemers bomen er in de pauze vaak nog flink over na, het gaat echt leven. Op een middelbare school kan deze discussie uiteraard wanneer je maar wil, maar het is beslist een tip voor een ludieke maar wel degelijk leerzame activiteit voor de laatste les voor een vakantie (het moment dat ze soms bij elke les film kijken (of gebeurde dit alleen op de VO-school waar ik jaren lesgaf?)).

**Bijlage 1 Instructie groep Bol**

Jullie verdedigen dat de aarde bol is. Gebruik in wat je bedenkt of opzoekt aan argumenten alleen instrumenten van tot 1610, dus tot en met de uitvinding van de telescoop.

Je mag dus wel een wetenschappelijk inzicht van na 1610 gebruiken, mits dat inzicht maar waar te nemen is met instrumenten die van voor 1610 zijn.

Wees erop voorbereid dat de ‘flat-earthers’ vals zullen spelen. Probeer zo goed mogelijk de wetenschap te verdedigen, probeer zo goed mogelijk de wetenschappelijke visie te verdedigen. Maar let op: jullie ‘vechten’ met één hand op de rug gebonden: jullie zullen altijd eerlijk moeten blijven en netjes in jullie argumentatie. Reken erop de jullie tegenstanders die beperking niet hebben…

​Nog een laatste opmerking: focus niet te hard op het winnen van de discussie. Een beetje onderlinge rivaliteit kan geen kwaad, maar zie de discussie ook als een uitwisseling van ideeën met mensen die anders denken dan jij.

**Bijlage 2 Instructie groep Plat**

Jullie verdedigen dat de aarde plat is. Gebruik voor wat je zelf bedenkt aan argumenten alleen wetenschap van voor 1610, dus van tot en met de uitvinding van de telescoop.

Je mag echter ook gebruik maken (en da’s juist de bedoeling) van -alle- argumenten van ‘echte’ flat-earthers. Als een flat-earther met argumentatie aankomt van na 1610, dan mag je zo’n argument dus alsnog gebruiken. Doe dus wat research, en daarmee mag/moet je dus ‘vals’ spelen (zal ik maar zeggen).

Je mag/moet verder ook ‘wetenschap’ zelf (juist!) hard aanvallen! En verdacht maken!

Maak er maar een smerig spektakel van 😉!

**Bijlage 3 Instructie groep jury**

Jullie moeten de discussie over flat earth jureren. Welke groep komt met de beste argumenten? Welke persoon is de beste debater?

Jullie opdracht gaat echter verder:

Je gaat bijhouden hoeveel pseudowetenschappelijke tactieken beide groepen gebruiken (en naar verwachting zullen de verdedigers van flat-earth dit meer doen dan de andere groep).

**Voorbereiding:**

-    bestudeer onderstaande tekst die vijftien ‘features of pseudoscience’ behandelt.

Na afloop van de discussie is het de bedoeling dat je van zoveel mogelijk van de gebruikte argumenten benoemt onder welk kenmerk van pseudowetenschap ze vallen.

In de tekst vind je 15 manieren, strategieën, om pseudowetenschappelijk zegmaar vals te kunnen spelen. Verdeel die 15 manieren over de mensen in de jury, dus bijvoorbeeld:

- persoon 1 focust op 1, 2, 3;

- persoon 2 op 4, 5, 6;

- persoon 3 op 7, 8, 9;

- persoon 4 op 10, 11, 12;

- persoon 5 op 13, 14, 15.

Jullie zijn met een aantal juryleden en er zijn 15 manieren: verdeel dat onderling. Ieder bereidt voor dat hij/zij de hem toebedeelde manieren turft en kort opschrijft.

Dus: als persoon 1 focust op manier 1,2,3,4 en flat-earther Pietje reageert alsof hij persoonlijk wordt aangevallen (manier 2)  dan zet persoon 1 bij manier 2 een turfje en noteert ook wat die Pietje (ongeveer) zei.

Het idee is: de flat-earthers zullen vast vals gaan spelen en de verdedigers van ‘bol’ zullen daar een flinke kluif aan hebben. Aan jullie als jury de schone taak om na afloop te duiden wat die flat-earthers nu precies voor tactieken gebruiken.

Mochten mensen van ‘Bol’ overigens (per ongeluk) een pseudowetenschappelijke tactiek toepassen: zeker ook die turven! Deze groep heeft weliswaar de opdracht gekregen ‘eerlijk’ te discussiëren, maarja, je weet maar nooit 😉.

Als je de features bestudeerd en onderling verdeeld hebt, en je hebt nog tijd:

- verzin van jouw features vast een voorbeeld dat een flat-earther kan gebruiken;

- bedenk zelf nog een extra feature.



Features of Pseudoscience, afkomstig uit bovenstaand boek.

**1) Working Backward from Conclusions**

The fundamental feature that separates the process of science from pseudoscience is that science is a genuine search for what is true, regardless of what that might be, whereas pseudoscience begins with a desired conclusion and then works backward to verify only that conclusion.

Scientists, of course, have their preferred hypotheses, but they need to act as if they were dispassionate toward the findings of their investigations, with no vested interest in the outcome one way or another. They also need to design their experiments so that any bias they might have will not influence the outcome. Scientists should be their own most dedicated skeptics: They should work hard to disprove their hypotheses, seeking out disconfirming evidence, thinking of alternative hypotheses, and criticizing their own work.

Pseudoscientists, by contrast, are overwhelmed by their own bias. They seek to confirm their hypotheses and often design experiments to guarantee that confirmation. They make a lawyer’s case for their beliefs, dismissing skepticism and alternatives, explaining away faults, and generously interpreting their results.

​**2) Hostility Toward Scientific Criticism, Claims of Persecution**

Criticism is a necessary and healthy part of the scientific process. Anyone who has ever submitted a paper for publication in a scientific journal has been the target of such criticism. It’s the primary mechanism by which standards are maintained and an important source of the self-corrective nature of science. Scientists, therefore, learn to be thick-skinned. They also learn how to focus their criticism on the logic and evidence of an issue, rather than making personal attacks against those proposing a view different from their own.

Pseudoscientists, by contrast, display clear hostility toward any such criticism. They view criticism as a personal attack, even when it’s not. They tend to characterize criticism from mainstream scientists as supporting the status quo, hostility toward new or innovative ideas, or even a full-fledged conspiracy to suppress their ideas. They’ll often dismiss the content of criticism by denouncing the philosophical basis of science altogether, or they’ll deny the ability of science to pierce their arcane knowledge.

In short, they view the criticism of their ideas as a problem with science and scientists, not with the evidentiary or logical basis of their claims.

Jacques Benveniste, who published studies claiming to show evidence for water memory, didn’t respond well when Nature magazine reviewed his laboratory procedures and concluded his controls were inadequate. He rejected the criticism as a “witch hunt.”

Rather than accepting constructive criticism as a necessary part of the process, the pseudoscientist feels persecuted. In fact, it’s so common for pseudoscientists to compare themselves to Galileo (who was persecuted and turned out to be correct) that this phenomenon has its own name, the Galileo syndrome.

Some pseudoscientists will complain about a scientific “orthodoxy” that unfairly rejects any ideas that are too radical. They may also claim that the world is just not ready for their genius, or that their claims are too disruptive. Some begin to believe in an elaborate conspiracy to suppress their ideas: It’s the only explanation for why the scientific community isn’t fawning at their feet, granting them accolades and awards for their genius. In the end, these are all excuses for the fact that they haven’t done the rigorous science necessary to convince the scientific community of their ideas.

**3) Making a Virtue out of Ignorance**

Some pseudoscientists lack formal training in science. In centuries past, this wasn’t a serious obstacle to performing cutting-edge science. Many scientists were independently wealthy gentlemen who made major scientific discoveries in basements or cottages that had been converted into laboratories, or by making basic field observations. Darwin, Galileo, and Newton all fit this mold. Today, the gentleman scientist is a rarity, although his image persists in the lay consciousness.

Cutting-edge science is too advanced for anyone to have a reasonable chance of making a significant contribution unless they first have sufficient education in science. The pace of change in any active field of research is so rapid that a researcher must keep in contact with the community of scientists through journals, meetings, and seminars, just to keep up.

This modern status of the practice of science is a double-edged sword. It’s a testimony to the success of institutionalized scientific research and the progress that has been made so far. However, it also tends to alienate the amateur scientist and the public. The lay, or amateur, scientist must be content to sit on the sidelines and learn about exciting scientific discoveries in those books, journals, and lectures that are designed to distill this information for the public. No matter how great the interest, the private citizen can’t just fire up a particle accelerator in their backyard and make important discoveries in particle physics. Professional scientists understand that even for them it’s difficult to contribute meaningfully to a field even marginally outside their areas of expertise.

There are, however, citizen scientist projects in which interested people can participate. You can classify galaxies, find Kuiper Belt objects, and fold proteins. Trained scientists are responsible for maintaining a rigorous procedure, however.

Some amateur scientists aren’t content to sit on the sidelines or be citizen scientists. They weave hypotheses and sometimes even carry out experiments in highly specialized fields. Often their conclusions are somewhat naive and betray their lack of formal training. Perhaps keenly aware of this potential shortcoming, the pseudoscientist is quick to turn a lack of training into a putative virtue by arguing that this is actually an advantage. The argument frequently put forward is that formally trained scientists are “brainwashed” into a narrow view of reality. They are, in effect, pawns of the status quo, unable to think outside the box. The untrained scientist, by contrast, is free to conceive of unique and truly innovative ideas. The truth becomes obvious to them, while trained scientists can’t see the forest for the trees.

On my blog, NeuroLogica , I had a detailed debate with comic book artist Neal Adams. Adams believes that the Earth is hollow and growing, gaining matter over time. The full debate is amazing to behold, and the excerpted tidbits below are phenomenal interactions and classic examples of pseudoscience.

First, Adams is unfazed by the fact that his wild speculations aren’t generally accepted by scientists. He wrote:

“Of course, I’m going to be dismissed by most educated scientists. For me, I’m not quite as impressed by formal education. I can read and there are no books forbidden to me in the end. I can think, and I use many aspects of science in my work.”

The flaw in this argument is that knowledge isn’t necessarily constricting. It can also be liberating. The more one knows, the easier it is to learn more information. Knowledge provides intellectual tools that can be applied to the process of discovery. Also, knowledge of what is already known helps in evaluating the plausibility of new ideas.

I admit it’s easy to understand how this view can be interpreted as elitist, and pseudoscientists often take great rhetorical advantage of this fact. Keep in mind, however, that I’m not making the argument from authority that scientists who hold advanced degrees are always right simply because of their training. I’m not even saying that someone without a degree can’t be correct in a scientific claim—their claims should be judged solely on the basis of their logic and evidence. What I’m saying is that ignorance isn’t an advantage, nor is it a virtue to be touted. It’s a hindrance.

**4) Reliance upon Weak Forms of Evidence While Dismissing More Rigorous Evidence**

There is no way to remove the need for judgment from the process of science. You can’t apply a mathematical formula to a claim to determine if it’s valid (although people try). You have to weigh evidence, decide which kind of evidence is most significant, and determine which explanations are most likely.

It is with these kinds of judgments that scientists need to be most careful and pseudoscientists run into deep trouble. They can be so biased that they will casually dismiss conclusions based upon mountains of rigorous evidence, while citing the flimsiest of evidence to support their alternative claims.

In order to read and appreciate the technical literature, scientists must know how to evaluate the quality of an experiment, look for flaws in the design, and determine if the study has the power and sensitivity to detect what the experimenters are trying to detect. Reading original scientific research is highly technical and requires detailed knowledge of methods and statistics. This skill is critical, as many—if not most—published studies are in fact wrong in their conclusions. Most studies are preliminary and not very rigorous.

Pseudoscientists, by contrast, will tend to accept any testimony or anecdote that supports their desired belief. They will sometimes present large volumes of low-quality evidence, implying that a large amount of poor-quality evidence equates to high-quality evidence. Alternative medicine guru Andrew Weil, for example, supports the use of “uncontrolled clinical observations” in determining whether or not a treatment works. Such observations have a history, however, of being contradicted by later well-controlled and more reliable experiments. This is a lesson that good scientists have learned and that pseudoscientists deride.

A classic example of this can be seen in the field of UFO research. Believers often tout the great number of UFO sightings as compelling evidence that we’re being visited by aliens. Skeptical scientists, however, are more compelled by the fact that there is not one single piece of high-quality evidence to support the alien hypothesis.

**5) Cherry-Picking Data**

Closely related to the use of poor data is the selective use of data. Scientific experiments are designed to take a complete look at a sequential set of data. Anecdotal evidence is by definition selective, because it is limited to self-reporting and is not a thorough analysis of all outcomes. Patients who die receiving a specific treatment, for example, aren’t around to give anecdotes about their experience with that treatment. (This is called the survivor bias.)

There are many ways to cherry-pick data. Early ESP research is infamous for finding ways to select the data the researchers want. They introduced the idea of “optional starting and stopping,” because, they claimed, psychic individuals need time to warm up before their powers work, and their powers will then work only until they become too fatigued, then they will stop working again. Therefore, researchers could look at a sequence of data (like guessing what cards a target was looking at) and decide when to start and stop counting the data. They could essentially mine the data for sequences that were statistically significant. They were simply cherry-picking the data they wanted and discarding the rest. There’s a more conventional term for this procedure—it’s called cheating.

**6) Fundamental Principles Are Often Based upon a Single Case**

This is really just an extension of the overreliance upon testimony and anecdote as a feature of pseudoscience. Some entire belief systems that pretend to be scientific base their fundamental underlying principles on a single uncontrolled observation. Any good scientist, before launching into a research career investigating some principle, will first make sure that the principle in question is correct, lest he risk wasting an entire career on a false idea. Certainly, before applying a basic principle to the real world—by, for example, using it to treat patients—it should be verified with repeatable experiments.

Some pseudosciences, however, have extrapolated an entire elaborate belief system around a single observation that was never verified. My favorite two examples are chiropractic and iridology. D. D. Palmer, the originator of chiropractic, reported that he “discovered” the primary underlying principle of chiropractic when he cured a janitor of his deafness by manipulating his neck, thereby relieving (he believed) the pressure on the auditory nerve. Palmer conducted no experiments of any kind to verify his assumptions, but rather extrapolated all of classic chiropractic theory and practice from this single case. D. D. Palmer was apparently unaware of the fact that the auditory nerve, and in fact the entire neurological pathway responsible for hearing, at no point passes through the neck.

Iridology has a similar history and is based upon the observation of a single owl. Apparently, Ignatz von Peczely, a Hungarian physician, noticed that an owl that had injured its wing had a particular fleck of color in the iris of its eye. He set the owl’s wing, which later healed well. Dr. Peczely then noticed that the fleck of color in the owl’s iris had disappeared. From this single observation, Dr. Peczely developed a system of diagnosing all human disease by the pattern of colors in the iris. (In truth, the story of the owl may be apocryphal and Dr. Peczely made up iridology out of whole cloth.)

**7) Failure to Engage with the Scientific Community**

Science is hard, and getting harder. We’ve picked most of the low-hanging fruit, answered all the big and easy questions, and we are now engaged in complex research to address more and more sophisticated and subtle scientific questions.

For this reason, it’s difficult for any one person alone to make significant advances in our understanding. It’s generally too challenging to address all possible flaws and errors, consider all possible alternatives, and look at a problem from multiple perspectives by oneself. The scientific community has a better chance of doing this as a whole. That’s why scientists publish their data in peer-reviewed journals and discuss their ideas at meetings. They’re testing their ideas, addressing criticisms, and accounting for new ideas.

Pseudoscientists tend to be disconnected from this process (or perhaps exist in a protected echo chamber of similar-believing pseudoscientists). They ferment their ideas by themselves, which often allows them to drift further and further from reality.

**8) Claims Often Promise Easy and Simplistic Solutions to Complex Problems or Questions**

One of the primary reasons for the psychological appeal of pseudoscience is that it provides a putative easy answer to a complex problem. Classic chiropractic, for example, states that all human disease is caused by spinal subluxations, and therefore spinal manipulation can be used to cure all human disease. Nutrition guru Gary Null, by contrast, claims that all human disease is caused by nutritional deficiencies, and therefore all disease can be prevented or cured by taking nutritional supplements.

In a broader sense, this feature relates to the psychology of belief. Pseudosciences all tend to have a particular psychological appeal, of which providing easy answers is just one example. Others include alleged evidence of a supernatural or spiritual world, confirmation of deeply held religious beliefs, illusion of personal empowerment or control, or simply the appeal of the fantastical or unusual.

**9) Utilizing Scientific-Sounding but Ultimately Meaningless Language**

All sciences have their technical jargon. The purpose of jargon is simply to express complex technical concepts in precise terminology. Subtle distinctions can often be very important, and colloquial language may not have the precision necessary to unambiguously convey the necessary meaning. Moreover, as new concepts and entities are discovered, new words must be invented to refer to them. There’s also a tendency to render the resulting cumbersome terminology into a more convenient shorthand, which can add an additional barrier to understanding for the public. The most challenging aspect of popularizing science is often translating technical jargon into everyday language while minimizing the loss of precision and accuracy.

For example, as a neurologist I may describe a patient as having cerebellar ataxia instead of just saying they are clumsy. This is because clumsiness is a general phenomenon that may have many causes, while cerebellar ataxia is a specific neurological phenomenon that correlates with specific structures in the nervous system.

Pseudosciences often imitate real science by cloaking themselves in pseudojargon. The result is the frequent use of scientific-sounding terminology that lacks a precise definition (much like the technobabble in a typical episode of Star Trek ).

For example, Gwyneth Paltrow’s lifestyle brand Goop sells “Body Vibes stickers” they claim will promote healing:

“The concept: Human bodies operate at an ideal energetic frequency, but everyday stresses and anxiety can throw off our internal balance, depleting our energy reserves and weakening our immune systems. Body Vibes stickers come pre-programmed to an ideal frequency, allowing them to target imbalances. While you’re wearing them—close to your heart, on your left shoulder or arm—they’ll fill in the deficiencies in your reserves, creating a calming effect, smoothing out both physical tension and anxiety. The founders, both aestheticians, also say they help clear skin by reducing inflammation and boosting cell turnover.”

Translation—“magic stickers.”

**10) Lack of Humility—Making Bold Claims on Flimsy Evidence**

Successful science must intelligently combine almost giddy speculation with harsh conservatism. Scientists must invent hypotheses, which extend the limits of human knowledge, introduce entirely new concepts, or invent new aspects of nature. At the same time, they must not accept any conclusion unless it’s rigorously supported by solid evidence and all other reasonable alternatives have been eliminated. In this way science attempts not only to move forward but also to build on a solid foundation.

For this reason, technical literature tends to utilize very conservative language and is careful not to endorse or promote any conclusions that cannot be rigorously supported. Those scientists who make premature claims are typically harshly criticized by their colleagues for doing so. The premature announcement to the press of the achievement of cold fusion by physicists Stanley Pons and Martin Fleischmann, for example, did great damage to their professional careers.

Part of this is also being humble. If you find a result that contradicts well-established scientific conclusions, your first thought should be that you made a mistake, not that you just overturned an entire field of science.

Pseudoscientists, by contrast, make use of bold claims, superlative descriptions, and unrestrained self-serving accolades. Their discoveries are often touted, for example, as being world-altering in their scope and their implications for humanity.

Getting back to our friend Neal Adams, he wrote:

“Imagine being me and seeing these unexplained ridge complexes EVERYWHERE and being the (almost) only person on Earth who knows what they all are, pull-aparts. The ONLY THING they can be.”

He thinks he has a unique insight that allows him to look at geological formations and the map of the Earth and see the Truth. When it’s pointed out to him that his ideas conflict with entire areas of science, he simply overturns them. The Earth grows by gaining matter, so gravity doesn’t work like scientists thought, and neither does particle physics. He also wrote:

“Know how fast the moon goes over the face of the Earth? 1,000 miles per hour. I think the water compresses. Got some textbooks wanna be rewritten!”

and

“There is no standard model. It is in fact all a little math game of where the densities are and it’s all theorising. This is a very big topic and without exposing you to several papers and long involved discussion—let me simply say, at the end of the day… densities evolve to when and where iron is.”

The standard model of particle physics is in my way? Gone!

**11) Claiming to Be Years or Decades Ahead of the Curve**

One dramatic red flag that someone is making claims that go way beyond the evidence is that the breakthroughs they are claiming would require years or even decades of supportive research, and yet there is little or no scientific paper trail to support them.

For example, starting in 2013 when writing his book Immortal: Why CONSCIOUSNESS is NOT in the BRAIN , and through 2017, Italian surgeon Sergio Canavero claimed he was close to performing the world’s first “head transplant.” (We can argue about whether or not this should be called a “body transplant.”) In an interview with Newsweek , he said:

“I can only disclose that there has been massive progress in medical experiments, which would have seemed impossible even as recently as a few months ago… The milestones we have reached will undoubtedly revolutionize medicine.”

This is a bold claim. In order for such an operation to be considered successful, Canavero must have found a way to regenerate the spinal cord. Otherwise the head would be attached to a completely paralyzed body.

Canavero is claiming not just that he has perfected the surgical technique of removing a head from one body and attaching it to another, but that he has solved the problem of spinal cord regeneration. This is more than impressive, given that labs around the world have been working on this problem for decades with only incremental advances, nothing really clinically useful.

Even more impressive is that Canavero and his colleagues apparently did this in secret, without publishing a single paper or earning a single grant to conduct the needed research. They did all the basic science, animal studies, and clinical trials without leaving a single word of evidence in the scientific literature.

The fact is, modern science is complex and requires significant infrastructure and collaboration. Before we figure out how to actually regenerate spinal cords, scientists will need to put a hundred pieces of that puzzle together. There will be hundreds, maybe even thousands, of published studies leading up to the clinical trials that eventually show success.

It’s simply not feasible to have leapfrogged all this necessary science, making decades of progress in a few years, all from nothing.

**12) Attempts to Shift the Burden of Proof Away from Themselves**

It is generally accepted within the scientific community that anyone making a claim to any truth bears the burden of proving their claim. The more out of sync such a claim is with accepted reality, the greater this burden of proof becomes.

Pseudoscientists, often because they cannot prove their claims, frequently attempt to shift the burden of proof to those who are skeptical of those claims. They maintain that their claim must be accepted as true because it hasn’t been proven false.

This shift in the burden of proof often takes the form of our logical fallacy friend known as the argument from ignorance, the one that says that if we don’t yet know the cause of a phenomenon, it must be paranormal. For example, ghost hunters will often present photographs containing blobs or wisps of light and claim that because these photographic artifacts can’t be precisely explained, they must be ghosts.

Neal Adams again, after I asked him for a bit of evidence to support his hollow-growing-Earth claims:

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“Are you suggesting that I provide a new invention, or show you a discovery of some magic thing that no one else has ever made before, like a flying mechanical donkey?

I don’t have one, I have all the same things that are known by many people, like Darwin. Darwin didn’t have to go to the Galapagos to observe what he did. He simply went THERE. The evidence was and is everywhere. It was his eyes and his brain that drew the conclusions. The question is, will you take the chip off your shoulder long enough to see what I see and think with me?”

**13) Rendering Claims Non-Falsifiable**

Sometimes the pseudoscientists not only shift the burden of proof away from themselves, they also attempt to make their claims immune to refutation. Often this is done through inventing reasons why the expected evidence doesn’t exist or experiments are negative.

For example, homeopaths sometimes say that their products can’t be tested against placebos because they only work as part of an entire treatment program. This makes it impossible to isolate homeopathy as a specific variable. Of course, when you do isolate homeopathic products, they don’t work.

At times the claim is formulated in such a way that it cannot be falsified even in theory. Creationists, for example, are fond of saying that we cannot know the mind of God, therefore we cannot say why nature looks the way it does. God just happened to make a creature that looks halfway between a dinosaur and a bird for his own unimaginable reasons. Ironically, doing so doesn’t rescue the claim from being pseudoscientific but makes it more so. A scientific hypothesis must be falsifiable. If it isn’t, then it’s “not even wrong.” Being wrong in science is useful; it still helps us move toward the answer. Being not even wrong is worthless and is by definition not scientific.

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**14) Violating Occam’s Razor and Failing to Fairly Consider All Competing Hypotheses**

One critical step in the process of scientific discovery is to consider all possible explanations for any observation or phenomenon. Often a scientific hypothesis is considered to be probably true because it’s the best and simplest current fit for all available data. If all reasonable alternatives haven’t been considered, however, this conclusion is likely premature.

Pseudoscientists, because they are invested in a desired conclusion, will give only perfunctory consideration to competing hypotheses. Often one or two token alternatives will be put forward and summarily shot down, leaving the desired belief as the only possibility. UFOlogists are most notorious for this behavior: The classic “unidentified light in the sky” cannot be a plane or a star, therefore it must be an alien spacecraft.

As part of this, pseudoscientists routinely violate Occam’s razor by dismissing simpler explanations for more complex or implausible ones that fit their beliefs. Remember Arnold and SHC—he casually dismissed simpler explanations for alleged cases, even when there were obvious external sources of flame. Perhaps the most dramatic example is a 1980 case from Chorley, England. The charred remains of an elderly woman were found in her apartment. Here’s the kicker—her head was in the fireplace. She’d clearly fallen and hit her head on the grate.

The corollary to this shortcoming is the failure to reject a disproved but desired hypothesis. This is often the ultimate test of a scientist’s objectivity—can they discard a cherished hypothesis when it’s confronted with incontrovertible disconfirming evidence? For the pseudoscientist, no amount of disconfirming evidence will result in such rejection.

**15) Failure to Challenge Core Assumptions**

What often passes for research within pseudosciences addresses questions about the alleged phenomenon but isn’t designed to test whether or not the phenomenon exists. This is what fellow science-based medicine writer Harriet Hall called “Tooth Fairy science.” Imagine you perform a “scientific” study in which you carefully collect data on the amount of money the Tooth Fairy leaves behind and run sophisticated statistical analyses correlating the amount given with the type and size of the tooth and the age and gender of the child. This type of study would have all the trappings of serious science but would never address the key underlying questions: Is the Tooth Fairy real, and who is actually leaving the money?

We often find these types of studies within alternative medicine—how is a particular alternative treatment being used, by whom, and what are their attitudes toward it? Such studies don’t address the questions of whether or not the treatment works and the underlying philosophy is valid. Once efficacy studies start to come back negative, we find that proponents stop doing them in favor of more “Tooth Fairy” type studies.

In a famous speech at Caltech in 1974, Richard Feynman referred to such practices as “Cargo Cult Science.” He made an analogy to the preindustrial Melanesian tribes who, after World War II, would build grass huts and fake runways hoping to attract the supply planes that delivered goods during the war. Their rituals had only a superficial resemblance to actual landing strips and lacked the necessary technology and infrastructure.

Similarly, pseudoscience may superficially resemble the ritual of doing research, but it lacks the true essence of real science—rigorously testing hypotheses with evidence capable of proving them wrong. In short, pseudoscientists engage in motivated reasoning. They’ll commit endless special pleading to explain away experimental failures (like the presence of skeptics causing psychic ability to stop working).

By keeping in mind the characteristics outlined above, one can make a reasonable judgment about a claim or theory and determine where along the spectrum it lies from solid science to absurd pseudoscience.

Evolutionary science, for example, pulls together multiple independent lines of evidence, has been debated transparently for decades, and has stood the test of multiple observations that could have potentially disproved it. It remains the only viable scientific explanation for the life we see in the world.

At the other end of the spectrum is poor Neal Adams. He desperately wants to be taken seriously as a scientist, but he has done none of the actual work. He has nothing except wacky ideas based on his own superficial observations, and he blithely suggests a cascading transformation of virtually all of modern science to accommodate his wild notions.

Somewhere in the middle is Daryl Bem and his ESP research. He is following standard scientific protocol, to an extent, but is overwhelmed by his own biases. In the end he’s created a great example of pseudoscience, with all the trapping of science but failing to rigorously prove his main hypothesis.