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The Ingredients of Scientific Illiteracy

The National Academies defines scientific literacy as the knowledge and understanding of scientific concepts and processes required for personal decision making. However, in recent decades this important and necessary term has been transformed into its notorious antithesis: Scientific Illiteracy. A progressing society requires the advancement of science, technology, and medicine. Without making milestones in these crucial areas, a civilization would not be able to adapt to the constantly changing environment. The United States specifically has made tremendous advancements in the name of science, but with all new things comes a slew of apprehension and anxiety. When discussing issues such as vaccination, climate change, and evolution, there tends to be quite an amount of push back from the general public. Why? The culprit strongly appears to be scientific illiteracy. People are unable to understand the science behind these issues, thus creating a cloud of mistrust toward the experts that release their findings to the world. There is not just a lack of knowledge to blame, but the overwhelming amount of media and politics that contort these issues affects the viewpoints of constituents. Along with this, there are the personal beliefs that these issues threaten, creating a society that lashes out at science that challenges these pre-dispositions. The specific issues previously mentioned are ones that are most prevalent in the recent decades. Scientific illiteracy is dangerous for our society, and will create many obstacles for future scientific advancement. In all, scientific illiteracy not only deals with a deficiency of scientific education, but people's religion, politics, core beliefs, and emotions come to play in this phenomenon.

The first example of scientific illiteracy includes the anti- vaccination movement. Vaccines were first introduced in the late 1700's hundreds by Edward Jenner. This new method was designed to treat smallpox, a deadly disease that wiped out much of the population. Ever since this breakthrough in the 16th century new vaccines have paved their way into the

medical field. However, in the 1990's, a now discredited doctor named Andrew Wakefield proclaimed that vaccines were dangerous. The specific vaccination that Wakefield denounced was the MMR vaccine, one that fights measles, mumps, and rubella. He unethically stated that this vaccine causes colitis and autism, which sparked outrage and most importantly fear. This fear was the driving force behind the anti-vaccine movement that still haunts society today. To be fair, the initial fear was warranted, considering Andrew Wakefield was considered a medical professional at the time he made his reports. However, since then his "scientific research" has been debunked by majority of the medical experts in his field. The issue with this however, is that these new and accurate studies have not been able to replace the fear with confidence over vaccines. Scientific illiteracy is largely to blame in this case. The ability to distinguish between good and bad science is an art many people have not mastered. On the Skeptical Raptor blog, writer Brooke Fotheringham describes her journey with vaccines. Initially she was not on board with the idea of vaccinating her child. She says, "The problem was, most of what I was reading was misinformation designed to exploit my fears" (Fotheringham, 2018, August 17). This misinformation is widespread, being fueled by the media, and influencing venerable new parents. With so much information circulating, it could be difficult to weed out the bad and latch onto the good. Recognizing logical fallacies is a step in the right direction. Logical fallacies are defined as, "errors of reasoning in making an argument" (Fotheringham, 2018, August 17). Fotheringham offers her advice and says, "Ask for citations, if none are provided, you can be relatively certain you are being manipulated or talking to someone who is misinformed and pushing bad science" (Fotheringham, 2018, August 17). Considering this, if people were able to recognize the major faults in Wakefield's reports, it's possible that more people would have vaccinated their children. So how does one scout out the reputable science? Fotheringham offers a guide to use in one's pursuit of factual science. Some of the attributes are: "it demonstrates actual clinical, not just statistically significant findings, there is a lot of editorializing, colorful language, and opinion mixed in, that can also be a red flag, and it is genuinely hypothesis-driven and created with the understanding that the results should be found to be reproducible by other researchers before being accepted with confidence" (Fotheringham, 2018, August 17). Another

aspect of scientific illiteracy in relation with vaccines, is the lack of basic scientific knowledge. In an article by “The Logic of Science”, the author describes five basic chemistry facts (many of which involve vaccines) to show how little the public knows of science. One reasoning for not vaccinating, includes the distaste people have toward chemicals. The author says, “So, when someone says something like, “I don’t vaccinate because I don’t want my child to be injected with chemicals,” they have just demonstrated how truly uninformed they are, and you can be absolutely certain that they don’t know what they are talking about because all matter is made of chemicals”(5 simple chemistry facts). The specific chemical in vaccines that the public fears is mercury. However, this type of mercury, due to its other components, is safe for the human body to be injected with. The author concludes, “Thimerosal in vaccines makes an excellent illustration of how little anti-scientists actually understand about chemistry” (5 simple chemistry facts). In full, the fear Andrew Wakefield caused, the difficult task of discriminating between good and bad science, and the plain lack of knowledge is the epitome of the anti-vaccine movement.

Next, we have climate change. Climate change is not a new concept. In fact, climate change has existed since the Earth was forged (i.e. the ice age millions of years ago). No one denies this period of climate change, however today when the term “global warming” was introduced, a mass amount of the population was convinced it was a hoax. Some people even reasoned their doubt with the statement “it is snowing where I live, so how could the earth be warming?” The understanding of global warming, requires the knowledge of understanding that temperature and climate are two different things entirely. The backlash against the term global warming was so incessant, a new term was coined that is less offensive in wording: climate change. However, even with this new way of describing global warming, much of society still resented and ignored what scientists were saying. Again, scientific illiteracy is the driving factor in this distrust. But is it just a lack of knowledge? Ken Miller, a biology professor at Brown University offers his insight on the issues concerning climate change, and why there is such a large amount of denial. He blames media and politics. His reasoning includes the wide spread of misinformation, and the political agenda. Miller states, “These groups have managed to persuade

a majority of Americans that any move away from traditional fossil fuels will cost jobs and depress the economy” (Miller, 2017, February 16). Generally, the Republican party (in recent years) is not focused on the environmental issues facing our society. President Donald Trump has even denied the issue of climate change exists. His actions and opinions, have led to much of his supporting party to follow his lead. This is detrimental, because it involves people choosing to listen to someone with no scientific background- no expertise in the area. Ultimately in the world of politics and scientific literacy, it is blind leading the blind. Miller weighs in on this, and says, “This is where conservative and liberal ideas about regulation, taxation and the role of government should be competing — not on the validity of science itself” (Miller, 2017, February 16). Politics are often fueled by emotions. Politics and science author Chris Mooney says, “Broadly speaking, political views are elaborate, emotionally rooted manifestations of divergent psychological identities” (Mooney, 2015). When invested in a party, often emotions dictate much of how someone thinks. This sort of scientific illiteracy pushes science away, due to the persons inability to think logically. Mooney states, “Conservative individualists have come to see dealing with climate change as a fundamental threat to a value system that places a premium on the individual’s ability to thrive, free of government interference...” (Mooney, 2015). With this mindset, it is easy for one to be outraged by the idea that tackling climate change means sacrificing some sort of freedom. But it also means ignoring an impending issue to our planet, making this emotionally charged scientific illiteracy dangerous.

One of the most sensitive topics that exists is the evolution theory. This concept in sum, states that all animals and plants have adapted to their environment, and even humans fall under that category. The Bible states that God created the world in seven days along with two Homo sapiens, Adam and Eve. Young children attending Bible school are most likely taught this creation story. However, as they age and enter grades K-12, a different less fantastical story is presented to them as the truth: evolution. The idea scientists have about evolution no longer includes uniformitarianism or unilineal construction, but micro and macro scales of decent with moderation. This “radical” idea is one that all scientists and anthropologists accept as fact. However according to John D. Miller, the Director of Biochemical Communications at

Northwestern University, a steady amount of the population do not accept the evolution theory. Statistics show, “One-third of Americans think evolution is “definitely false”; over half lean one way or another or aren't sure. Only 14% expressed unequivocal support for evolution—a result Miller calls “shocking.”” (Gross, 2006). One could conclude that the reason for these statistics is religion. To say that just a lack of scientific understanding is to blame is incorrect. From speaking with John D. Miller, author Liza Gross says, “It's not that Americans are rejecting science per se, Miller maintains, but longstanding conflicts between personal religious beliefs and selected life-science issues has been exploited to an unprecedented degree by the right-wing fundamentalist faction of the Republican Party” (Gross, 2006). As previously mentioned, politics has great sway in the minds of party followers, especially when mixed with religion. Because Christianity (or any religion with a creation story) encapsulates some people's lives, the idea that their creation story is not reality genuinely scares them. Chris Mooney states, “Basically, a lot of people are afraid that if they accept the science of evolution, life becomes meaningless, morality collapses, and death becomes just the end” (Mooney, 2015). Considering many people believe America was founded with religion being the base for law and liberty, science is offensive due to the ways it seems to clash with religion. Shawn Otto, a national Merit Scholar, wrote a book called *The War on Science: Who is Waging It, Why It Matters, What We Can Do About It*. In his chapter about religion he covers the history of religion and science. He concludes, “(We are) A nation whose authority was instead based on the underlying principles of liberty, reasoning, and science” (Otto, 76, 2016). However, Otto's views prove to be vastly different than much of the population today. To some, science may never come above religion, or even exist as separate units of measurement peacefully taking different courses.

A strong relationship with mutual respect is required during every argument or debate. When presented with polarizing information, both sides must present themselves transparently and directly. The relationship between the public and the scientists who endorse things like vaccines, climate change, and evolution is quite weak. This presents another factor as to why scientific illiteracy exists. The level of distrust exists mainly because these scientists appear far removed from the public. There hardly ever seems to be direct communication from scientists to

the population. Rather, their ideas are presented through the media, a source that has little understanding of the science being provided to them. This creates all kinds of issues regarding the deliverance of the science, and this can have a negative effect on the perception of facts by the public. Two notable scientific authors, Hank Campbell and Alex Berezow, composed a book called *Science Left Behind: Feel Good Fallacies and the Rise of the Anti-Scientific Left*. In this, they discuss what the public desires of the experts. They state, “When it comes to scientific issues and policy, the public craves context and explanation. People want trusted guides to help them through incredibly complex issues” (Berezow & Campbell, 196, 2012). When speaking about journalism, Campbell and Berezow state that a lot of times, the journalist is not an expert when writing about scientific issues. They say, “You can become an “expert” in political journalism circles just by becoming popular. In science, you will become popular only if you know your stuff, which is hard and takes a lot of time” (Berezow & Campbell, 196, 2012). When science filters through journals and media, it can often be warped, widening the gap between the public and scientists even more. But is it just the media’s fault? The scientists themselves could even be considered a problem in regards to the gap. Once again, Christopher Mooney weighs in on this issue. He states, “They found that, hey, it takes two to tango in the science-society relationship, and scientists might, if anything, be more down on the public than the public actually was on them” (Mooney, 2015)! This presents the idea that scientists present themselves as superior towards the public, which in turn leads people to resent them. Mooney refers to evolution and climate change, and points out that many more scientists support the two issues than U.S. adults. He concludes, “In both of these cases, if you just call the public dumb, and try to set them straight about the facts, and don’t understand where the resistance actually comes from....well, then, the truth is that you’re not being so perceptive yourself” (Mooney, 2015). When the public feels as if they are being talked down to by the people who deem themselves superior, they are less likely to engage in the dialogue of the people “above” them. In order to educate, the educator must not teach from a pedestal to be received. In the case of scientist and the public, they must stand as equals for any progress to be made in lessening the gap, in turn lessening scientific illiteracy.

Finally, after exploring all the inner workings of scientific illiteracy, we reach how to start mending the cut it has left of society and the world of science. Considering how complex this issue is, there proves to be no concrete solution to this problem. Besides having a lack of scientific education, the motivational aspect of scientific illiteracy, will be the hardest to overcome. Josh Pasek, a researcher at the University of Michigan, has done extensive research on the motivations people have for choosing to disagree with science. He says, “Results suggest that motivational processes are capable of leading individuals to reject either the presence of a scientific consensus or its relevance to their personal beliefs. Whether one or both processes occur appears to vary depending on the issue under examination. Hence, motivational factors appear to operate via both theorized pathways” (Pasek, 2018). When science rejects someone’s personal belief, they tend to ignore it. This part of scientific illiteracy is the hardest to crack, considering the emotional attachment said person has on towards belief. No educational angle will be able to overcome pre- dispositions for people whose minds are set in their ways. However, a more tangible solution is better scientific education. The National Academies of Sciences, Engineering, and Medicines concludes that a good scientific education is beneficial. They report, “According to this rationale, people are confronted with a range of decisions, such as those about health, their consumption of materials and energy, and their lifestyle, in which an understanding of science (or an ability to interact with science) might help them to take informed actions and lead richer, healthier lives” (NASEM, 24, 2016). The Academies conclude that a better scientific education leads to “healthier lives”, thus fixing a portion of scientific illiteracy. People can make changes as well. Individuals who believe in science, and that are concerned for the future of our society and planet, can take a stand. Bringing awareness to the epidemic can result in positive change. Sean Otto, the author of *The War on Science: Who’s Waging it, Why It Matters, What We Can Do About it.*, concludes that there is something to be done. He says, “One of the most important things a concerned citizen can do it organize, which means taking a public stand against the war on science, staging or participating in events that dramatize their concern, inviting local policy makers and media, and asking friends and family to join in” (Otto, 372, 2016). By taking a stand, drawing attention to, and involving people who could make change is a

step towards bettering the relationship between science and society. Overall, there is a challenge with overcoming scientific illiteracy, mainly due to the emotional reasons people reject science. However, there are things to be done regarding better education and organizations dedicated to irradiating scientific illiteracy.

In conclusion, scientific illiteracy is made up of the following: the rejection of science in accordance to lack of education, personal beliefs and emotional connection, a distrust of scientific institutions, political followings, and the mis informative media. Science can only be understood when the individual is willing to try to understand. Even when faced with a theory or fact that goes against a belief, one must be open to change and accept facts as they are. When society achieves this mindset, we build a stronger, healthier, smarter, more productive system. Until then, issues such as the anti-vaccine movement, rejection of climate change, and disbelief in evolution will still prevail and cause harm to the nation. However, getting educated and bringing awareness to the issues mentioned is an honorable step in producing more scientific literacy, and the beginning of scientific illiteracy's downfall.

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