

## The Lifelong Learning of Science\*

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### Abstract

The lifelong learning of science is actually becoming harder and harder to avoid. We can expect that there will be fewer and fewer adults who are truly uninterested in science and technology. What will happen is that people will periodically be interested and periodically uninterested. The rising impact of science and technology on lifelong learning, with the constant flow of information through the media, Internet and 24 hour news cycle, will make some interest in science some of time unavoidable for most people. Thus, the question is not *whether* adults will learn science throughout life, but *what* they will learn. What people learn will be complicated by that fact that science is not always completely objective and unproblematic; and that the public will follow its own instincts with respect to who they trust and on what topics. The real challenge for the lifelong learning of science is learning to be a savvy consumer of scientific information and alleged scientific claims in a world awash in all sorts of information and information sources.

**Keywords:** Lifelong Learning, Science

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### 1. Introduction

This article is about the “lifelong learning of science.” There is a sense in which I feel quite qualified to write on this topic. This coming January 2016, I will turn 67 and from my earliest memories I have always been interested in science. I grew up in California along the Pacific coast and one of the things that amazed me was the flight of seagulls. I remember daydreaming about being a seagull – but aside from such childish playful imagining, I was always interested in how flight was possible. To this day I remain curious about all forms of flying contraptions and organisms.

Of course when I was five years old what I was interested in was the natural world around me but I was too young to know that the knowledge I wanted to acquire was called science. My point is that I’ve had a lifelong interest in science and I think I have been learning more and more about science all these many years. However, I am what John Ziman<sup>23</sup> referred to as a science “insider.” I am a member of the science community in that I hold appointments in an Institute for Science Education and a Department of Biological Sciences. Of course, I would have a lifelong interest in the sciences. Thus, my approach to the topic of the lifelong learning of science, and which is organized into five parts, begins with insiders and outsiders:

Part I: Insiders and Outsiders

Part II: The Rise of the Internet and the 24 Hour News Cycle

Part III: The abuse of science

Part IV: Who do you trust?

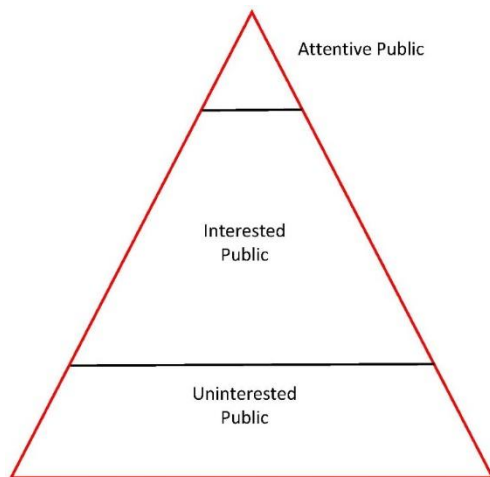
Part V: Parting Comments and Advice

#### Part I: Insiders and Outsiders

But what about science outsiders? “Outsiders,” according to John Ziman,<sup>23</sup> are those who are not within the community of science – which is the majority of all people. Outsiders vastly outnumber insiders when it comes to the sciences. Those outsiders are not necessarily interested in science which means that the

whole idea of the lifelong learning of science is going to be complicated. Shortly I will attempt to unpack some of the complication but first it will be helpful to consider a model that represents science outsiders.

The pyramid below is adapted from the work of Jon Miller who studies the American and European public's knowledge of science (see Layton et al., 1993). The levels in this pyramid are not specifically proportioned by data but are qualitative estimates of how much of the science-outsider public is attentive to science. I make the assumption that the more attentive one is to science the more likely one is to participate in the lifelong learning of science.



What the pyramid indicates is that only a small proportion of the public is attentive to science (NSF data suggests about 16% of Americans); but the good news is that data suggests that many people are least interested in science. For example, data from the National Science Foundation suggests that 80% of Americans are interested in “new scientific discoveries,” though they might not be particularly attentive to what is happening in science.<sup>14</sup> Similar data from European countries suggests about the same level of interest. A majority of both Americans and Europeans say that they visit zoos, aquaria, natural history museums, or museums of science and technology. On a nine-item test of science factual knowledge, both Europeans and Americans answer about six questions correctly – about a 64% correct response rate. On the other hand about 20% of the American and

European public appears to be uninterested in science.<sup>10</sup>

But, these pyramid levels are unlikely to be static. While some people are probably permanent residents at one of the three levels, other people move up and down the levels. We can begin to understand the fluidity of the pyramid and what motivates people to move up and down these levels by considering the characteristics of adult learners. Adult learners are what we have in mind when we talk about lifelong learning. Malcolm Knowles argues that generally speaking there are four characteristics specific to adult learners.<sup>17</sup>

1. Self-concept: As a person matures his/her self-concept moves from one of being a dependent personality toward one of being a self-directed human being.
2. Adult Learner Experience: As a person matures he/she accumulates a growing reservoir of experience that becomes an increasing resource for learning.
3. Readiness to Learn: As a person matures his/her readiness to learn becomes oriented increasingly to the developmental tasks of his/her social roles.
4. Orientation to Learning: As a person matures his/her time perspective changes from one of postponed application of knowledge to immediacy of application, and accordingly his/her orientation toward learning shifts from one of subject-centeredness to one of problem centeredness.

These four characteristics track well with what we know about adults learning science.

- Adult learning of science is self-directed;
- Self-directed learning of science is grounded in personal experience;
- Because adults have personal experience leading to self-directed learning they are ready to learn science;
- And finally – and something that is very important – adult learning is motivated by application. As Knowles put it, their learning is problem-centered not subject-centered.

Going back to John Ziman's notion of insiders and outsiders, the outsiders' view of science and the learning of science is “overwhelmingly instrumental” while the insiders' view emphasizes discovery and the validation of discovery. Put another way, the lay public or outsiders' view of science tends to be problem-centered. This perspective is sometimes referred to as: Science for Specific Social Purposes.

Sir Arthur Condon Doyle's detective Sherlock Holmes provides a humorous 19<sup>th</sup> century example of interest in science based solely on the applicability of science.<sup>3</sup> We think of Sherlock Holmes as somebody who was absolutely brilliant, yet Dr. John Watson, his friend and accomplice, notes that Sherlock's “ignorance was as remarkable as his knowledge...” We learn the extent of Sherlock's ignorance when we read Watson saying:

My surprise reached a climax, however, when I found incidentally that he was ignorant of the Copernican Theory... That any civilized human being in this nineteenth century should not be aware that

the earth travelled round the sun appeared to be to me such an extraordinary fact that I could hardly realize it.

We then read that Sherlock responds to Watson, saying:

"You appear to be astonished..."

It is what Sherlock says next that bears close attention. Watson briefly describes the Copernican theory for Sherlock to which Sherlock responds:

"Now that I do know [Copernican theory] I shall do my best to forget it."

"To forget it!" Exclaims Watson.

"You see," Sherlock explains, "I consider that a man's brain originally is like a little empty attic, and you have to stock it with such furniture as you choose... Depend upon it there comes a time when for every addition of knowledge you forget something that you knew before. It is of the highest importance, therefore, not to have useless facts elbowing out the useful ones."

"But the Solar System!" I protested.

"What the deuce is it to me?" he interrupted impatiently; "you say that we go round the sun. If we went round the moon it would not make a pennyworth of difference to me or to my work."

Sherlock simply doesn't care about the Copernican theory because it is not applicable to his work. What this fictional character is expressing is the very attitude that many adults have toward science. As Knowles and Ziman both note, adults are interested in *useful* knowledge.

The difference between the 19<sup>th</sup> century and the 21<sup>st</sup> century is that now in the 21<sup>st</sup> century, for much of the world, science is inescapable because we are surrounded by the applications of science. We hear about science and medicine, science and health, science and the environment, science and the economy, and unfortunately science and weaponry.

What we can say then about the lifelong learning of science is that the public's interest in learning about science is motivated by personal experience and is directed towards solving personally important problems. People move up the pyramid toward being attentive to science when they decide that science is relevant to some problem that they face.

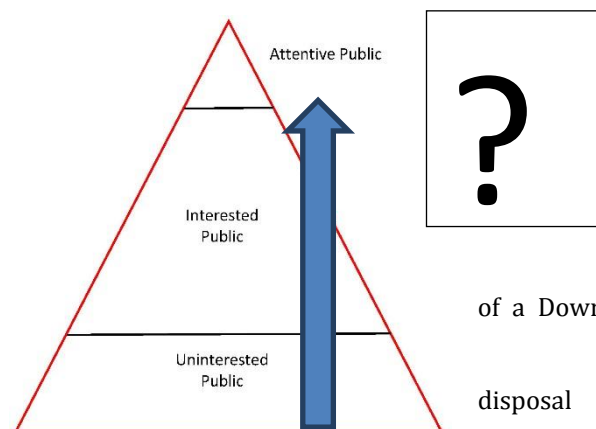
There are some very good examples of this phenomenon in the research literature such as the Leeds' Case Studies that were conducted by researchers from the University of Leeds, Britain, in the early 1990s.<sup>12</sup> The Leeds' researchers began with an assumption that would have made great sense to Sherlock Holmes. The researchers assumed that no matter how important these ideas are for professional scientists, that there was no good reason why most members of the general public should quest after knowledge such as the thermodynamics of non-equilibrium systems, the origin of cosmic radiation, the age distribution of air bubbles in polar ice or the electron spin resonance spectra of free radicals. (p. 27)

Most of the public would probably be thinking what Sherlock said to Watson: "What the deuce is it to me?"

To determine whether or not science-uninterested persons became science-attentive, the Leeds' researchers, therefore, studied people who had found themselves in situations where scientific knowledge could be very helpful. In terms of our pyramid, did the people in those situations move up the pyramid?

There are four case studies:

1. Parental challenges due to the birth and raising syndrome child.
2. The domestic energy needs of elderly citizens.
3. A local municipality dealing with waste problems.
4. A controversy over rising incidences of childhood leukemia in the area of a spent nuclear fuel



of a Down  
disposal

reprocessing plant.

In each of these situations scientific knowledge should have been helpful for the citizens dealing with each of the particular problems. In each case, the scientific community however was of little help. In some cases citizens found the scientific community to be condescending and unsympathetic with their concerns. In other cases the scientific community was found not to understand their concerns and simply did not answer the questions of importance to the community. Moreover, the public found that the information provided by the scientific community can change. For example, the initial claim from the scientific community was that the rising incidences of childhood leukemia would not be linked to a nearby spent nuclear fuel reprocessing plant. But later, that opinion was reversed.

Rather than turning to the science community for information, the Leeds Case Studies<sup>12</sup> reported that people were more likely to,

turn to their usual sources of information, opinion and comment – the media, prominent local figures such as trade union officials or medical practitioners, whom they worked, occasionally specialist reports and, most significantly, their husbands, relatives and close friends. (p. 116)

Parents of Down syndrome children found experts to be unsympathetic, lacking compassion, unhelpful with respect to how the parents perceived their problems - leading to parents ignoring them even though they had potentially valuable information to share with the parents. Parents relied on what they could learn on their own. The Leeds researchers concluded that: “the representation of science as a coherent, objective and unproblematic entity characterized by certainty and direct applicability to everyday life received little support.”

But this lack of attention to the scientific community does not mean that people in those situations did not become more attentive to science. I would say that they became attentive but only to the sources and the people that they trusted. And both tended to be local-- but much has changed in our world since the 1980s and early 1990s.

## Part II: The Rise of the Internet and the 24 Hour News Cycle

Interestingly, a 2009 study that examined evidence of change in the British public’s understanding of science between the 1940s and the 1990s looked for data in the British press but not the Internet or the 24 hour news cycle.<sup>1</sup> But such a study would have to be done differently today because sources of information are vastly more available now than what was available prior to the 1990s through print news media.

Why? First of all, the personal computer was invented in 1975 and then five year later in 1980 TIME magazine named the personal computer “Machine of the Year.” And then in the early 1990s, the Internet went public.



Print media had been losing ground to television for quite some time but the advent of commercial communication satellites led to the 24 hour news cycle, which meant that nobody had to wait for the 6 o’clock news let alone the morning or evening paper to get the news. Fast forward to 2015 and we are in the age – not just of PCs and the Internet – but of Google, search engines, laptops, tablets, smartphones, and even smartwatches. Now, as noted by media expert Richard Sambrook, former director of BBC global

news: “satellite TV has now been overrun by innovative digital technology in news consumption methods.”<sup>22</sup> Thus while the people in the 1980s Leeds studies were approached by experts with scientific knowledge and had access local sources of information, today the public is virtually awash in information.

Moreover, the public today is constantly faced with scientific and technological innovations that impact our daily lives. Of course there has always been an intersection between science and society, but the rise of Internet-based media and personal communication devices seems also to have come hand-in-hand with the rising impact of scientific and technological innovations on our daily lives. It is no exaggeration to say that science and technology have changed the world in which we live.

Of course the presence of information does not mean that the public will take an interest; and one must recall that adult learners pay attention to what interests them. However, the almost ubiquitous presence of information coupled with the increasing impact of science and technology on our daily lives, I can only conclude that most of the public today will find it difficult to have no interest at all in science. Indeed, a relatively recent poll of the British public found that 82% of the public agree that “science is such a big part of our lives that we should all take an interest.” The same poll found that 67% of the British public think “it is important to know about science in... daily life.”<sup>10</sup>

Data collected by the National Science Foundation<sup>14</sup> in the United States and the Eurobarometer<sup>5</sup> in Europe suggest that the British public is not alone in these views. Examples of science related information that catches the public eye are easy to identify, such as:

- Stem cell research
- Climate change
- Energy sources
- GMOs (genetically modified organisms)
- Public health

In each case, many in the public are engaged and thus one can assume that they are learners as they arrive at their personal opinions on the relevant issues. Note that I say they arrive at their personal opinions on the relevant issues; because “many policy makers and scientists assume that increased public understanding of science will lead to increased public support” which is not born out by the data.<sup>15</sup> In each of the above examples, there has been rising public awareness and knowledge concerning the issues and yet opinions are divergent.

#### Stem Cell Research

In 2014, a German scientific organization reported that 92.5% of the public were aware of stem cells. The organization reported that this figure was up from 82.2% that the same survey reported in 2008. Moreover, the same organization reports that 78% of the public opposes any bans on stem cell research.<sup>6</sup>

Similarly, a 2010 Harris poll conducted in the United States found that a majority of Americans approve of some forms of stem cell research. The figure however is 73% in contrast to the German figure of 82.2% for the year 2008.<sup>8</sup>

The German poll did not disaggregate data by groups as was done in the American polls. Thus for example, disaggregated American data indicates that persons who identified themselves as Catholic or born-again Christians were significantly less accepting of stem cell research.<sup>8</sup>

The point I wish to make is that it would appear that the public has learned some science with respect to stem cells but they do not have a uniform opinion as to the implications of that knowledge. The best guess as to from where the public has gotten its information on stem cell research is the Internet and the 24 hour news cycle. Whatever significant scientific events are reported in one part of the world, the rest of the world will know within hours because of the 24 hour news cycle. And, all one has to do is type “stem cell research” into a search engine and literally tens of thousands of Internet sites pop up. Anyone who gets news through the Internet will find information about significant scientific events popping up, especially when they have social and political significance. If you have a TV and if you have the Internet, I’m not sure it’s possible to be completely ignorant about stem cell research.

#### Climate change

In 2015, one would be hard-pressed to find anyone in the Western world who has not heard about “climate change,” “global warming,” or “environmental pollution.” The public has learned about these ideas, and just as with stem cell research, the public’s conclusions about these ideas are far from uniform.

Data in the United States indicates that Americans have divided opinions. According to a 2013 poll, “A majority of Americans worried ‘a great deal’ or a ‘fair amount’ about climate change.”

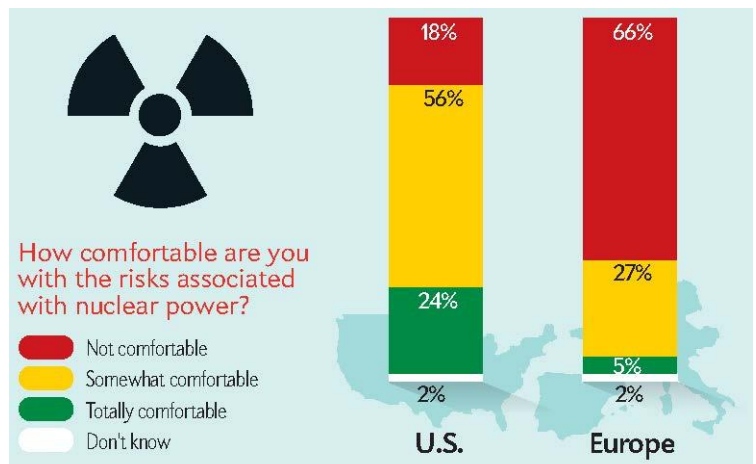
National Science Board.<sup>14</sup> On the other hand, data from many other countries suggests that the American citizenry is much less concerned about problems such as global warming.

Americans remain divided on views about climate change and hold views that are different from those of citizens of other countries. “Americans are more likely than residents of other countries to say they believe that any apparent change in temperatures is the result of natural rather than man-made causes” (Executive Summary).<sup>13</sup>

Again one sees that citizens have learned some science but what they have learned differs as do their conclusions. And again, one asks where the public gets its information: the Internet and the 24 hour news cycle.

Nuclear Energy

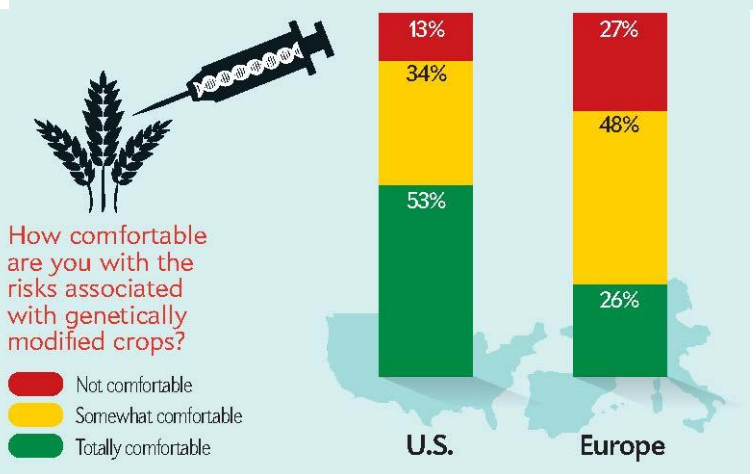
What citizen has not heard about nuclear energy and has at least some idea of what that term means? Again, one would be hard-pressed to find anyone who has TV and Internet access and who is also completely ignorant about nuclear energy. And again, the views of the public are different. And again, the American public is a little bit different from the European public. Even after the 2011 Fukushima nuclear accident, most Americans continue to support the use of nuclear energy as one method for providing electricity.<sup>14</sup> The graphic (right) illustrates the difference between Americans and Europeans on the matter of nuclear energy – specifically in terms of the risks associated with nuclear power.<sup>21</sup> Note that in this study Europe includes Belgium, France, Germany, Italy and Spain, but not Britain. British opinion on nuclear energy (as well as a number of other science – related issues) is closer to the opinions of Americans than to other Europeans.



GMO (genetically modified organism)

I have made the point that I wonder if anybody could really claim ignorance of stem cell research or nuclear energy. That claim should probably not be made as strongly when it comes to knowledge about genetically modified organisms, or the more commonly used term, GMOs. But where there is awareness, one finds again that awareness and knowledge does not lead to the same conclusions.

As one can see in the graphic (above), Americans are not as concerned about the risks posed by GMOs as are Europeans though they still have concerns. Curiously, the citizens of Belgium are less concerned about risks posed by GMOs than Americans.<sup>14,21</sup>



There is an interesting indicator in the commercial world that the rising awareness of GMOs is leading to concerns about health risks. The American fast food company, Chipotle, as of April of this year announced that it would no longer use any GMO ingredients in the food that it serves.



This is not a move that a food company would make it less and thought that the public knew something about GMOs and had opinions based on that knowledge. However, not everyone appreciated Chipotle's response to the public's knowledge of GMO. Within days, Chipotle's new policy was derided as irresponsible. The Washington Post ran two critical articles: "Chipotle's GMO gimmick is hard to swallow" and "Corporate irresponsibility over GMOs."<sup>4</sup>

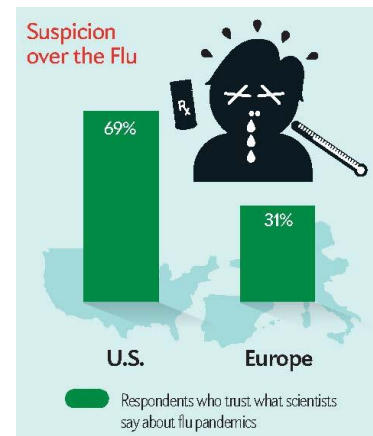
Both articles suggest agreement with Chipotle that the public has knowledge about GMOs. In both cases (i.e., Chipotle and the two Washington Post columnists), the problem was not that the public had not learned anything about GMOs. The problem was that the public had indeed learned about GMOs and had developed concerns about risks – that Chipotle was now exploiting to the dismay of GMO supporters.

In Germany, there was another interesting reaction to the public's adverse view of GMOs. German scientists who support the use of GMOs actually came out in favor of GMO labeling. They came out in favor of requiring "anything that contains or has been produced with the help of GM organisms" to be so labeled.<sup>11</sup> This is their gambit: the public's dim view of GMOs will lessen once the public becomes aware of how widely GMOs are actually used.

My point is simply that neither the Post nor the German scientists would have any reason for concerns if the public had not learned anything about GMOs. The public has learned something – and at least for some persons, that ironically is the source of the problem.

### Health

I have one final example and this example is somewhat related to what was learned in the Leeds case studies: scientists are not always trusted. In 2004, the World Health Organization, purportedly concerned about pandemic flu outbreak, recommended that governments stockpile antiviral drugs; and as it turns out this stockpile was used during the 2009 flu pandemic. However, the 2009 pandemic was not as bad as expected, which of course was a good thing. The problem is that within a year two European studies concluded that members of the WHO committee that made the recommendation to stockpile were affiliated with the drug companies that manufactured the antivirals. The controversy was picked up in the European press. For example, the Daily Mail of Britain charged that drug companies had "encouraged [the] world health body to exaggerate swine flu threat." Fair or not, scientists in Europe found their reputations tarnished. On the other hand, these two critical studies got little press in the USA. Not surprisingly then one finds that European suspicion regarding what scientists say about flu pandemics is much stronger in Europe than in the USA.<sup>21</sup> This particular example highlights the impact of news that is widely available. The impact on learning that comes from the Internet and the 24 hour news cycle depends on what actually appears in the news.



### **Part III: The abuse of science**

Unfortunately the high profile of science and the general public aware of science has led to abuses. The name of science is invoked for commercial reasons whether the use of science is justified or not. For example, there is a memory aid called PrevaGen widely advertised at least in the USA.<sup>19,20</sup> The product carton clearly claims that the product has been "clinically tested"—in other words, science is invoked. The manufacturer claims that with PrevaGen one will "Experience improved memory, a sharper mind, and clearer thinking by choosing from our three options for healthy brain function." The keen eye consumer would note that this claim is followed with an asterisk that leads to this disclaimer: "These statements have not been evaluated by the Food and Drug Administration." The American Food and Drug Administration (or FDA) is the arm of government that validates food and drug efficacy and safety. Consumer beware if something is not FDA approved – and PrevaGen is not. Not surprisingly a quick Google search turns up many critical articles about PrevaGen claims. And yet this product sells very well.

In an attempt to draw attention to how easily the public can be fooled by bogus scientific claims John Bohannon fabricated a scientific study yielding results indicating that eating chocolate can help one reduce weight. This bogus study was



reported in newspapers as if it were the real thing and even made its way into a health magazine.<sup>2</sup> The magazine claimed:

When German researchers put dieters on a low-carb plan and gave some of them a daily dose of 1 1/2 ounces of super dark chocolate, those who ate chocolate lost more weight steadily over time and state happier throughout the process than those who didn't get treat.<sup>2</sup>

The trickster later published an article titled, "I Fooled Millions into Thinking Chocolate Helps Weight Loss. Here's How." While I have doubts about the ethical nature of the Bohannon's fabrication, it does draw one's attention to something important: one must bring a skeptical eye to what is reported in the media, Internet or on the 24 hour news cycle—perhaps especially when claims are made in the name of science.

And this brings me to an important question: who do we trust? This question is important because we believe what we hear from those trust.

**Part IV: Who do you trust?**

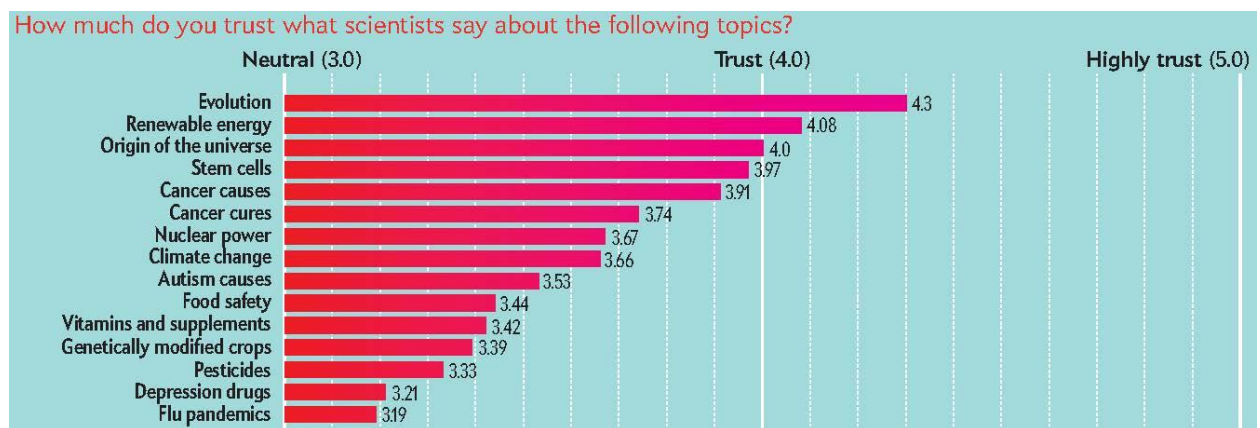
The public gets its information about science from different sources but the Internet and social media and the 24 hour news cycle have become commonly used sources. The problem is that not all of the information is valid. Actually, I think that the public knows that and makes its decisions on what to believe according to who they find trustworthy. Recall that in the Leeds studies, people got information from *trusted* sources. We believe who we trust. In terms of the lifelong learning of science, who do you trust is the key question.

The good news for science is that when it comes to scientific information, the public is more likely to trust scientists than anyone else. The following graphics represent responses on a scale of 1 to 5 with 5 being trustworthy. This data is from the USA. Similar studies would suggest that the British public is very close to the American public with the European public perhaps leaning more towards trusting scientific opinion.<sup>21</sup>



scientists ranges from a high of 4.3 to a low of 3.19.

However, as is often the case, it is important to disaggregate data. In the following graph one sees the public's trust in scientists broken out by different topics. Broken out by topic, trust in



What we learn from this data is that while scientists are trusted they are not always trusted more than others and they are not equally trusted across topics. Which brings me to my concluding comments and advice.

**Part V: Parting Comments and Advice**

In terms of the lifelong learning of science:

- As noted by the Leeds researchers, science is not always completely objective and unproblematic.

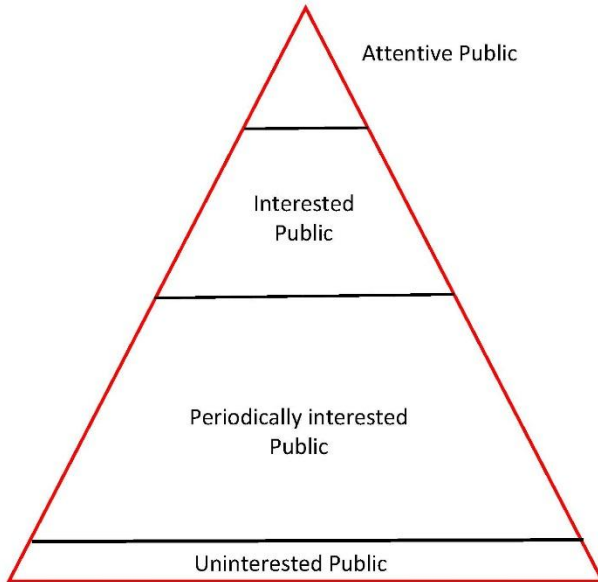


- The public will follow its own instincts with respect to who they trust and on what topics.

And, given the vast amount of scientific and technological information that is available to people today the question is not *whether* adults will learn science throughout life, but *what* they will learn.

It bears repeating: the question is not whether adults will learn science throughout life – because they will – the question is *what* they will learn.

Thus I suggest that the pyramid of interest needs to be modified:



We can expect that there will be fewer and fewer adults who are truly uninterested in science and technology. What will happen is that people will be *periodically* interested and *periodically* uninterested. The rising impact of science and technology on life along with the constant flow of information through the media, Internet and 24 hour news cycle will make some interest in science some of time unavoidable for most people.

That being the case people must be encouraged to examine who it is they trust and ask questions even of those whom they trust. Most people would not buy a car based solely on the opinion of a trusted neighbor. They would seek more information before buying. That consumer savvy attitude is exactly what the public needs to bring to science.

Thus I would say that the real challenge for the lifelong learning of science is learning to be a savvy, discriminating consumer of scientific information and alleged scientific claims.

Let us all learn to be smart shoppers!

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