

What a Friend We Have in Science

(Last in a series of four sermons on heeding the guidance of reason and the results of science)

Tom Ward, Ph.D.

Member, High Plains Church Unitarian-Universalist

Readings

1. From the five smooth stones of James Luther Adams, as presented to us by Roger Butts, we learn that “Religious liberalism depends on the principle that ‘revelation’ is continuous.” Our religious tradition is a living tradition because we are always learning new truths.
2. From an essay by Stuart Feinstein in *Scientific American* entitled “What Science Wants to Know”: “...ignorance will always grow faster than knowledge. Scientists and laypeople alike would agree that for all we have come to know, there is far more we don’t know. More important, everyday there is far more we *know* we don’t know. One crucial outcome of scientific knowledge is to generate new and better ways of being ignorant: not the kind of ignorance that is associated with a lack of curiosity or education but rather a cultivated, high-quality ignorance. This gets to the essence of what scientists do: they make distinctions between qualities of ignorance.”

Introduction

In the first three talks of this series, which began last fall, I explored how science works, in contrast to religion, and some of the findings of science related to the brain and to the multiverse. My intention was to offer you the opportunity to expand your thinking about why humans tend to be religious and whether or not it makes sense to embrace the Part A of religion, namely, the supernatural. Today, I’d like to get more specific about how the findings of science can actually be put to good use in shaping your everyday lives, concentrating on some of those things that Part B of religion tries to provide.

A good place to start might be drawn from the readings we just heard. That is, perhaps it is worthwhile to ponder what we don't know, and from this derive a subset of things we would like to know and are hopefully learning, all in the spirit of helping us lead more satisfying lives. Of course, this implies that our most noble goal is to lead a satisfying life, and what is meant by "satisfying" is certainly open to debate. You and others can easily think of other words that could take its place, such as "happy" or "rewarding" or "pleasurable" or "luxurious" or "stress-free" or simply "long". But let's stick with "satisfying" for now, but I certainly invite you to think and talk more about just what would make your life ideal. People have been doing this for millennia and have come up with some real duds! Maybe you can do better!

Getting back to science, let me acquaint you with a list of modern scientific topics so you are aware of the breadth of current scientific endeavors. It comprises some items that have jumped out at me from many years of reading scientific books and magazines and others from a listing of lectures by Professor Jeffrey C. Grossman of MIT offered on DVD under the title of "Understanding the Science for Tomorrow: Myth and Reality" under the umbrella of "The Great Courses". Then we can pick a few of the topics from this list and briefly explore how additional distinctions between qualities of ignorance or, said another way, higher qualities of ignorance might prove useful as we make our way through our all-too-brief lives...

Here's the culled list:

1. Quantum Gravity—Seeking the Theory of Everything (addressed earlier)
2. Cosmology—How Did It All Begin and Where Is It All Going? (addressed earlier)
3. Genetics and Epigenetics—Blueprints and Change Orders (genetics addressed earlier)
4. Paleoanthropology—How Did Humans Evolve and Populate the World?
5. Computers—Trillions of Bits per Second
6. Artificial Intelligence—Thinking Machines (addressed earlier)
7. Communication—Transcending Time and Space

8. Robotics—Living with Machines
9. Nanotechnology—The New Science of Small
10. Synthetic Life—Making Life from Scratch
11. The Brain—Your Body’s Supercomputer (addressed earlier)
12. Energy—Production and Conservation
13. Climate Change—a political hot potato for no good reason
14. Personal Pharmaceuticals
15. Food or Famine—Science Holds the Key
16. Prediction—From Storms to Stocks

Let’s talk about the last item first – prediction. Today’s supercomputers allow us to model phenomena with more detail than ever before, but this can be a two-edged sword. We can easily develop a false sense of knowledge, putting more faith in our models than they deserve, simply because they’re complex and take a long time to run, relatively speaking. The old adage from the computer world, “garbage in, garbage out”, sometimes applies, where the raw data fed into the model isn’t as good as might be assumed. Then there’s the problem of hidden variables, where some key factor is overlooked and rears its ugly head when the model ventures into new territory. So the lesson here is the same as for scientific discoveries in general – let the findings prove themselves over time through repetition and persistent scrutiny. Another adage comes to mind, “If it seems too good to be true, it probably is.” I’m from Missouri. Prove it. Show me. But after time has passed and different researchers seem to converge on the same outcome, it’s time to say they’re probably right. Climate change is a perfect example, where, after many years of intense observation and modeling, the conclusion that the Earth’s climate is warming due to mankind’s influence is virtually inescapable.

Another concept from the world of prediction is captured in a simple phrase that has profound implications: “Dice have no memory.” Carry that with you. What does it mean in practical terms? It

means there is no such thing as “I’m about due.” I’ve been buying lottery tickets for ten years and haven’t won a thing – I’m about due. No you’re not. What happened or didn’t happen in the past with matters of probability has no bearing on what will happen in the future. Speaking of the lottery, notice some of the recent deception that’s been going on? One hears that the big jackpot is worth, let’s say, \$750,000. Wow you say! But then you learn that three people have come up with winning numbers, so your share is now only \$250,000. Then the tax man cometh, and you only get \$110,000, if you choose the lump sum. So the jackpot you get that excited you enough to buy that ticket is less than one sixth of what you thought! We all know that lotteries are ways for governments to make money, so there are only two real justifications for playing: (1) you want to give the government some extra money because you believe in the things the money goes for, like better education or more parks, or (2) it’s pure entertainment, like paying \$10 to see an exciting movie. It’s definitely not a way to turn your financial fortunes or misfortunes around!

Let me offer one last item in the realm of prediction before we move on – the age-old question of “why”. Humans have this strong urge to ask why a particular event occurs. Why did that school bus carrying 34 children home from a church camp run off the road and into a ravine, killing 11? Why did the loving grandparents caring for their two grandchildren all die in a sudden house fire? Why did my neighbor’s house get swept away by the tornado and mine was hardly touched? One can search for answers, like faulty brakes on the school bus or bad electrical wiring in the grandparents’ house, but these turn up more whys, and in the end, we have to conclude that it was either just bad luck or part of God’s plan. In scientific parlance, some events are stochastic, meaning they occur by chance, and others are deterministic, meaning they occur predictably as a result of some earlier event or events. That’s the way nature works. Not unexpectedly, many events are a mixture to the two, such as winning a golf tournament. Deterministic skill plays a large role, but in the end the winner is the one who rolls in a few more 50-foot putts than the others, where stochastic fortune has smiled on him or her. Take the recent Masters tournament – the pundits were talking about Rory McIlroy and Tiger Woods, but the victory went to Bubba Watson. Rory and Tiger finished way back. It just wasn’t their

day. So accept life for what it is – a mixture of events we can control or influence coupled with those we can't. It's important to acknowledge the latter and avoid too much debilitating hand-wringing. The pithy adage here is "Stuff happens." There's a pithier version, but I'll leave that up to you to recall...

Speaking of hand-wringing, let's move on to the next topic – you and your pre-frontal cortex. What's the connection you say, or non-connection, as we will see. Here, I'm drawing largely from an article in April's Scientific American by Amy Arnsten, Carolyn Mazure, and Rajita Sinha from Yale University titled "This is Your Brain in Meltdown". This is more about the brain, one of the topics in my earlier list, and one I addressed in my talk about the God gene and about the number of neurons it takes to create a soul (or not).

The pre-frontal cortex is the forward third of the human brain, located just behind the forehead. It was the last part of the brain to evolve, and is mainly what distinguishes humans from other creatures. It is this part of the brain that acts as a control center that mediates our highest cognitive abilities such as concentration, planning, decision-making, insight, judgment and the ability to retrieve memories. It also keeps our baser emotions and impulses in check. Comparing humans to animals we are familiar with, it is just this array of abilities they largely lack, though not completely. Not only did the pre-frontal cortex evolve last, but it is the last part of the brain to develop as humans mature. In fact, the circuitry that hooks up this part of the brain to the rest isn't fully in place until an individual reaches his or her early to mid-twenties. This is a very important fact that was the subject of a highly informative article in National Geographic last year called "The Teen Brain". Educators are benefitting from research of this nature as they search for better ways to impart knowledge to young people across the spectrum.

For adults, whose brains are as fully developed as they're likely to get, fortunately or not, there is the matter of using them properly, and brain research has some useful things to say in this regard.

Lurking deeper in the brain are the parts that evolved first and that serve mainly to keep us alive, parts that we share with so-called lower animals. These include the hypothalamus, which regulates

basic appetites such as hunger, sex and aggression, the amygdala, which controls emotions such as fear, and the striatum, which moderates our habits. Now, as we learned when I was talking about the so-called God gene, a way to think of how the brain operates is to visualize it like the telephone network of networks, with networks of neurotransmitters and their corresponding receptors intertwined throughout the organ. You'll recall the names of two of these neurotransmitters – serotonin and dopamine. Three more are norepinephrine, acetylcholine, and glutamate, and researchers are finding how various concentrations of these chemicals correlate with the many different types of mental disturbances, very important among them being depression. Well, a key point about all this I want to share with you this morning has to do with the disengagement of the pre-frontal cortex. The Yale researchers I cited earlier described a mechanism whereby acute stress causes an upset in the balance of neurotransmitter concentrations, which, in turn, alters the communication networks in the brain. More specifically, elevated levels of norepinephrine and dopamine stimulated by the amygdala block the pathways to and from the pre-frontal cortex, and we “lose it”, in common parlance. This phenomenon manifests itself in many different situations such as taking a feared examination, confronting a threatening adversary, or getting pulled over by a cop. For soldiers on the front lines, one can imagine it as being extremely commonplace and leading to highly unpredictable actions, including acts of barbarism. Here one can see the importance of this kind of research, in that it could lead to better ways of dealing with these adverse effects of stress. For now, however, we can see how important it is for each of us to cultivate our own personal mechanisms for recognizing when our pre-frontal cortex is shutting down and slowing or even reversing the process. What are some of the common practices? Well, counting to ten is one. Another is to take slow, deep breaths. For some, Religion Part B might help, calling forward an inner peace built on loving thy neighbor and eschewing violence. Based on what you now know about your brain, maybe you can now add the thought “I've got to keep my pre-frontal cortex engaged!” “Don't let my inner brain take over!”

The last topic I want to introduce this morning is epigenetics, meaning “outside the genome”.

Epigenetics is a rapidly growing field of research that explores the activity or non-activity of genes due to external factors beyond their mere presence or absence. Much of what I’ll be sharing with you came from an article in my favorite magazine, Scientific American, specifically the December 2011 issue, titled “Hidden Switches in the Mind” by Eric Nestler who’s at the Mount Sinai Medical Center in New York. We are learning more and more that having one or two copies of a particular gene is not always enough for it to do its job. Heretofore, a great deal of genetic research has involved identifying genes and learning what role or roles they play under normal circumstances, often by the use of so-called knockout mice. Everyone knows what a knockout mouse is, right? It’s a mouse whose genome has been artificially stripped of a particular gene before gestation. Epigenetics research, on the other hand, looks at how existing genes may be suppressed or stimulated by external factors such as environmental influences and experience. We’re not talking here about the sequential expression of genes controlled internally during the growth of an embryo, for example. To understand how epigenetics works, we need to spend a moment or two understanding just how our DNA is stored in a cell’s nucleus. It’s not just a tangled ball of string like something the cat got hold of. Rather, strands of the double-helix DNA are carefully wrapped around protein spools called histones, and the spools are then laced together in a multi-sided strand something like a woven whistle lanyard you made in craft class during summer camp. The resultant strand is called chromatin, and it is what chromosomes are composed of. So these long strings of DNA containing all our genes are actually stored in a very compact manner, and this is where epigenetics comes in. Stick with me now as we dig a little deeper. Proteins known as writers, erasers, and readers, which, very importantly can be influenced by external factors, attach, detach, and read small chemical tags such as methyl and acetyl groups that can hook up to the DNA on the spools or the spools themselves. When readers sense a preponderance of methyl groups, for example, they can cause the DNA wrap in that vicinity to tighten up and thus restrict the expression of the genes located there.

Conversely, when these readers sense a concentration of acetyl groups in a particular region, they loosen up the structure and promote gene expression in that region.

Now that we understand this new mechanism for gene regulation, let's examine two ways it manifests itself and how this knowledge can be put to good practical use. Firstly, it provides a mechanism whereby chronic exposure to certain chemicals can cause symptoms of disease thought to result only from inherited genetic factors or from mutations during cell replication. Research into cocaine addiction took researchers deep into epigenetics, where they learned that drug use and interestingly chronic stress can change the way the brain reacts to future experiences over a long term, rather than for just a short period, like getting drunk. With some individuals, reactions can be positive, such as stimulating resilience, and in others the reactions can be negative, leading, for example, to addiction or depression. The fact that identical twins, naturally having the same genomes but different exposures and experiences, were seen to exhibit different responses to similar stimuli proved that some mechanism affecting the genome without actually changing it was at work. The epigenetic writers and erasers were influenced by these different external factors, causing them to alter the chemical tags on the chromatin, and stimulating or suppressing gene activity, all the while the genes themselves remained unchanged.

The second illustration of the epigenetic phenomenon has to do not with chronic exposure to drugs leading to long-lasting epigenetic changes in the brain's reward center, but with a behavior pattern that can be handed down from one generation to the next as though it were part of the genome itself but actually isn't. Researchers studied the nurturing behavior of mother rats and noted that mothers that were aggressively nurturing to their pups – nuzzling them, licking them, etc. – produced female pups who were similarly nurturing when their time came to have offspring. In contrast, those mother rats less interested in their offspring produced female pups that later showed the same nonchalance toward their own pups. Looking deeper, the scientists established that epigenetics was at work. They found methyl inhibitors attached to the chromatin where genes existed whose purpose was to

produce proteins that enhanced the animals' ability to deal with stress. Attentive mothering by the female rat caused these inhibitors to gradually melt away, thus enhancing the pups' ability to deal with stress and predisposing themselves later in life become the same kind of loving mothers. And so the behavior was perpetuated, just as if it was a matter of the presence or absence of the genes themselves.

Let me conclude, then, with some suggestions for living having roots in epigenetics, which I'm sure we'll be hearing more and more about in the years ahead:

1. Be mindful of chronic exposures to stressful situations and unnatural substances. There is now a proven way they can affect your brain, in some cases virtually for the rest of your life. While you're busy keeping your pre-frontal cortex engaged, as I encouraged you to earlier, also try to avoid those situations where it is a struggle to do so.
2. When you encounter people who you know have gone through rough times, be especially kind to them as they may be living with serious mental scars as a result.
3. As we UU's say, the Divine is Love. Now whenever you hear that, I don't want you necessarily think about how divine the mother rats were who nuzzled their pups, but I do encourage you to think about where research of this nature might lead five, ten or twenty years in the future and consider the possibility that we will discover true epigenetic benefits to humans conferred by many of the Part B behaviors the world's religions have offered us.

Thank you.