That's how the light gets in

Tyler J. Jarvis

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An important problem that arises in many settings is the *Traveling Salesman Problem*.

A traveler must visit many destinations to sell her goods or make her deliveries. Her problem is this: what route will be the fastest way to get to all the destinations? A poor choice could mean she travels many times farther than she would if she made a good choice.

Obviously, this problem is important to companies like UPS, the US Postal Service, Walmart, and Amazon. For example, according to *Wired* magazine, UPS has roughly 55,000 delivery trucks running each day. If each driver could choose a route that shaves just one mile off the daily trip, that would save the company $30 million each year.[*]

And this problem is not only interesting to companies involved in delivery. The Traveling Salesman Problem also has applications in computer chip manufacturing, DNA sequencing, and many other areas.

Figure 1 shows a diagram of the situation for 3 destinations. One of the possible routes our traveler could take would be to first go to city *C*, then to city *B*, then to city *A*, and then home again. This is depicted in Figure 2.

Altogether, there are 6 possible routes in this situation, so to solve the Traveling Salesman Problem with 3 destinations, I need only compare the 6 routes and see which is shortest.

With 4 destinations, I must check a bit more: 24 possible routes. I can do that. With 5 destinations, we have 120 routes. I am too lazy to check all those, but it is not hard to write some computer code to do it for me. You may have noticed that the number of things to check is growing rapidly. For 10 destinations, we have 3,628,800 possible routes to check. A lot, but not impossible.

For 20 destinations, it grows to 2,432,902,008,176,640,000. This is a little too big for my laptop to check in any reasonable time. In fact, if my computer could check a billion routes per second, it would still take 77 years to check all the possible routes. At current energy prices, just the electricity for the computation would cost roughly $675,000.

Now, let me reassure you. It may look like I am going all mathy on you, but don't worry—I won't make you compute anything, you don't need to remember any of these numbers, and there won't be a quiz at the end. So stay with me for just a bit longer.

The point is, even for just 20 destinations, we have way too many

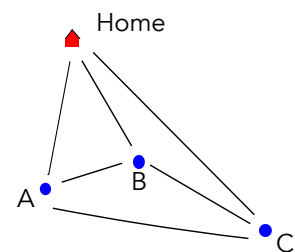[*] `http://www.wired.com/business/2013/06/ups-astronomical-math`

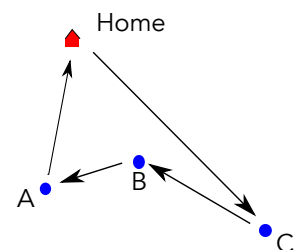Figure 1: Traveling Salesman Problem with three destinations.

Figure 2: One possible route for the traveler.

possible routes to check in any reasonable amount of time. The bad news is that in many real life situations, we have a lot more destinations than just 20—for example, a UPS driver makes an average of 120 deliveries each day.[*]

For 120 deliveries, there are so many possible routes we couldn't store them all in the memory of any computer in existence, not even if our computer's memory comprised all the atoms in the universe, or even all the atoms in a googol (10^{100}) universes as big as ours. That is a 1 with 100 zeros after it.[†]

If we could find a way to deal with the memory problem, we'd still have to check all the routes. If we had as many processors as particles in the universe, and if each processor could check a trillion routes per second, it would still take more than a googol years—far, far more than the age of the universe.

The Clay Mathematics Institute in Cambridge, Massachusetts, has even offered a one-million-dollar prize for the first person to find an algorithm to solve the Traveling Salesman Problem in a reasonable amount of time.

Many other important mathematical problems suffer from similar difficulties—we can't seem to solve them exactly because they are just way, way too big.

These sorts of problems show up in many aspects of our lives: curing diseases; preventing accidents; reducing pollution and traffic jams; and building smarter robots. They are also important for better understanding how the world works: modeling important biological and chemical processes; modeling populations of people, animals, and bacteria; understanding how galaxies form; and many other aspects of our world.

With all these problems, as long as we insist on getting a perfect answer—the one and only, very best route—we are utterly paralyzed by the size and complexity of the problem. You could say we are *paralyzed by perfection*.

But despite their complexity and size, we still need to solve these problems. So let me tell you how to become unparalyzed. And because this is a devotional talk, you know that I will also use this as a metaphor for something spiritual.

Step 1. Admit and Accept Imperfections.

The first step is to admit and accept imperfection.

For many of these hard problems, like the Traveling Salesman, if we really want a good answer in a reasonable amount of time, we must make a compromise; we must make do with an approximation and admit some chance of error. I am something of a perfectionist, so

[*] http://www.wired.com/business/ 2013/06/ups-astronomical-math

[†] Yes, I spelled it right—it is not the same as the search engine.

this is difficult for me.

But if I am willing to accept an answer that is only close to the perfect one—a good answer, but not the perfect answer—an answer with some error in it; as soon as I give up on perfection, something amazing happens. We can get a very good approximate solution to the Traveling Salesman Problem very quickly. In fact, not just very quickly, but blazingly, astoundingly fast.

Now, this solution is not a perfect solution. It will not win the Clay Math million-dollar prize because it is not exact. But it is a very good solution. And, if you need a better one, we can do that, too. Not perfect, but better.

Similarly, in our own lives, to avoid being paralyzed by perfection we must admit and accept imperfection. This requires honesty and humility. We can't try to cover up our ignorance or our mistakes. We must admit them and learn from them.

In fact, I know only a few things perfectly: among those, that the Father and the Son live and love me and you, that the *Book of Mormon* is what it claims to be, and that this church is where the Lord wants me to be.

I also know, with a perfect knowledge, that for now, on this earth, we are all imperfect, both in knowledge and in performance, but Christ's atonement can bring us to perfection, if we allow it to.

The first step to applying the atonement is to admit and accept our imperfection.

We are all imperfect, but it is not always easy to admit that. Being a mathematician often forces me to admit what I don't know. Julia Robinson, the first woman elected to the National Academy of Sciences, and one-time president of the American Mathematical Society was once required to submit a description of what she did each day to her university's personnel office. This is what she wrote:

Monday—tried to prove theorem.

Tuesday—tried to prove theorem.

Wednesday—tried to prove theorem.

Thursday—tried to prove theorem.

Friday—theorem false.[*]

Now, while a star like Julia Robinson may find her mistakes after only a week, people like me usually need a lot more time than that to figure out our mistakes, and even more time to get the courage to admit them.

And it is not only our knowledge that is imperfect. Just as the computer has limited ability to execute the programs given it, so we have limited ability to execute what we know we should. To survive and succeed in this life, we must admit and accept that imperfection, and be patient and understanding with imperfection in ourselves and

in others.

As Elder Holland told us at General Conference this April: *"Be kind regarding human frailty—your own as well as that of those who serve with you in a Church led by volunteer, mortal men and women. Except in the case of His only perfect Begotten Son, imperfect people are all God has ever had to work with. That must be terribly frustrating to Him, but He deals with it. So should we."*

And it is not only human weaknesses we must accept. Sometimes, perfection just isn't possible in our finite, imperfect world. When my wife was a missionary in Germany, she and her companion decided they were going to keep all of the mission rules—exactly. They got out their white handbooks and the additional list of rules for their own mission and sat down with their blue planners to schedule everything into the week. Wake up at 6:30. Spend ½ hour for personal scripture study, ½ hour for companion scripture study, ½ hour for exercise, and so on throughout the day. But somehow they couldn't make it all fit before their required bedtime of 10:30. They tried and tried, but just couldn't get it to work. They only figured out why it was so hard to schedule when they added up all the hours necessary to keep every rule each day—25.

The realities of living in our limited, imperfect world mean that we have no choice but to make do with an approximation—admit and accept imperfection.

Step 2. Work hard to get your best approximation

The second step is to work hard to get your best approximate solution to your problem.

As I mentioned before, accepting imperfection transforms many important mathematical and computational problems from being unsolvable in the lifetime of the universe to being solvable now, on current, actual computers; but the solutions still require deep thought and hard work.

In the same way, admitting and accepting imperfection allows us to find imperfect, but workable, solutions to our personal and spiritual problems; but these solutions also require deep thought and hard work.

As the Lord told Oliver Cowdery after he had tried, unsuccessfully, to translate the plates: *"...you took no thought save it was to ask me. ...you must study it out in your mind...."*[*]

And Brigham Young said: *"Whatever duty you are called to perform, take your minds with you, and apply them to what is to be done."*[†]

Not long ago, I had a student that told me he hated math and that he was no good at it. He was sure he would not understand the math

[*] D&C 9: 7–8

[†] Brigham Young, in *Journal of Discourses*, 8:137, July 29, 1860. Quoted in Jeffrey R. Holland, *A School in Zion* Annual University Conference August 22, 1988.http://president.byu.edu/documents/holland.htm

in my class, and he was a little angry because he needed my class for some requirement or other. But with a lot of encouragement he reluctantly promised me he would do something he had not done before. He would not only answer all the homework exercises—he would really make sure he understood all the steps in each problem, why that step was the right thing to do, and why it worked—he agreed to study it out in his mind.

At first, this was painful to him, because he had never done math this way before. He really had to fight his frustration and impatience. He wanted to say "Just tell me what to do and let me get this over with." But he kept his promise. He read and reread the explanations in the book. He came to my office hours and asked me lots of questions—questions about how and why things worked. He asked the TA many similar questions. And as he continued to work at it, he began to understand, for the first time, a little bit about how math worked and why it is the way it is. Partway through the semester he confessed to me that he actually liked the class. By the end of the semester, he not only earned a good grade in the class, he was really excited about what he had learned. He even wanted to take another math class. He was no longer "bad at math." His hard work and deep thought had transformed not only his attitude but his ability.

But this is not easy. My former neighbor, Elliot Butler, said it well: *"To learn is hard work. It requires discipline. And there is much drudgery. When I hear someone say that learning is fun, I wonder if that person has never learned or if he has just never had fun. There are moments of excitement in learning: these seem usually to come after long periods of hard work, but not after* all *long periods of hard work."*[*]

But, like it or not, it must be done. Hard work and deep thought are the only way. As The Lord said to Oliver, you *must* study it out.[†]

Step 3. Get up and act on your best approximation.

Now, it is not enough just to find our approximate answer to the problems. We must also act on that approximate, imperfect answer. This is hard, because we know our answer is not perfect. That might scare you. It often scares me. But we cannot let our fear of imperfection, our fear of making a mistake, prevent us from acting on our best approximation.

As Paul told Timothy, *"God hath not given us the spirit of fear; but of power, and of love, and of a sound mind."*[‡]

When I went to graduate school many years ago, I was lucky enough to be admitted to a school with some famous faculty members. I had done pretty well in my undergraduate classes, and I thought I was pretty smart, so when it came time to choose classes

[*] Elliot Butler, "Everybody is ignorant, only on different subjects." *BYU Studies* **17** no. 3 (1977) https://byustudies.byu.edu/showtitle.aspx?title=5289

[†] D&C 9: 8

[‡] 2 Tim.1:7

and teachers, I chose some of the most famous teachers I could.

One of them was especially impressive. He was a Fields medalist—the nearest thing in mathematics to a Nobel prize winner. Other students spoke of him with awe, both because of his brilliance and because of his reputation for criticizing students. When I heard how he had berated a student for being both lazy and stupid, I determined that I would never give him cause to criticize me like that. I decided never to ask him for advice or help until I had exhausted every other means for solving a problem. The result was that he never criticized me, but I also never learned much from him. I spent 3 years in his classes and only spoke with him for a total of about 45 minutes.

Another of his students had no fear at all—he would go to this professor almost every day to ask questions. And he was criticized regularly, but he never seemed to care. I thought he was completely crazy, but he went back almost every day, and got his questions answered, and learned a lot.

It took me several years after graduation to realize that I had wasted the opportunity of a lifetime—this other student wasn't so crazy after all. He got many hours of personal tutoring from one of the world's greatest mathematical minds, and I got... I got through graduate school safely—without being criticized.

Don't bury your talent

The Lord is pretty clear that he wants something more from us than this. He has given us many talents and opportunities. He wants us to face our fears and do something good with all he has given us.

Consider His parable about the rich nobleman who entrusted his wealth with his servants while he went traveling abroad.

You know the story, so I'll skip to the end.

"He which had received the one talent came and said, Lord,...I was afraid, and went and hid thy talent in the earth.... His lord answered and said unto him, Thou wicked and slothful servant.... Take therefore the talent from him, and give it unto him which hath ten talents. And cast ye the unprofitable servant into outer darkness."* [*] Matt 25:25–30

Now think a moment about that servant with one talent. This is a very severe punishment. After all, he took good care of that money. Not one cent was lost. Yet the master not only chastized him, and took his talent—he cast him into outer darkness.

The Lord doesn't care about *not messing up*—not losing what we have. It isn't enough to *preserve* what he has given us. He wants us to get up and do something with it.

Fear causes failure

Like the one-talent servant, when we are afraid of failure, we are more likely to fail.

When I was a teenager, I worked for a two summers as a lifeguard and a swim instructor. One of the things I learned in that job was that people's fear of water is usually their greatest obstacle to successful swimming.

A person learning to float on his back, for example, when he is afraid, will instinctively try to sit up, which causes him to sink. To float he must relax, put his head back and his legs down, and then he can float on his back with very little effort.

The real key is learning to trust that a little water splashing in your face does not mean you are drowning. It may not be what we imagine to be perfect floating, but it is good enough. Even going completely below the water is not failure—if you remain relaxed, a gentle hand motion quickly brings you back up to the top. But as soon as you become nervous, you try to sit up, and you sink.

Similarly, when my kids first started ice skating lessons, they were unable to stand on their skates without help and clung to the little walkers that were available at the arena for non-skaters. Even with the little walkers, they fell often. They were surprised when the first thing the instructor did was take away the walkers and teach them to fall. They practiced falling over and over. One of my daughters complained that falling was the one thing she could do without lessons or help.

But once they had finished their falling lesson, almost as if by magic, they could skate—and they didn't even fall much after that. By overcoming their fear of falling, by embracing the fall, they were able to learn to avoid it, and were able to try new things without fear.

The Plan of Salvation

The most important example of all is the Plan of Salvation. The entire plan depends upon our engaging in a very dangerous enterprise.

Recall that Satan's plan was to guarantee that bad things would not happen, that we would all be safe, that we would all return to our Father after our time on earth. This plan was rejected, not only because Satan wanted all the glory for himself, but more importantly, because **it would not work**. It just wouldn't work.

We cannot become like our Father in Heaven unless we learn for ourselves to refuse the evil and choose the good. We must act for ourselves, and choose for ourselves. But, as Lehi tells us, we cannot do this unless we are enticed by two opposites—unless we have the option to fail.

Not only must we have the option to fail, but we *will* fail. We *do* fail. Often.

The most miraculous proof of God's love for us is the atonement of Jesus Christ. The purpose of the atonement is precisely to allow us to recover from our many failures. He knows we will fail, despite our best efforts, and he has provided a way for us to be freed from our sins, to be healed, and to return to him.

We show our gratitude for the atonement when we use it to overcome our fear of failure, trust in Him, and act on our best approximation.

Aim high

Recently our academic vice president, Brent Webb, reminded us of something Elder Holland taught us, way back when he was president of BYU. He said that we hit what we aim at: *"So not failure, but low aim would be the most severe indictment of a Latter-day Saint fortunate enough to be at BYU."*[*]

[*] Jeffrey R. Holland, quoted in Brent W. Webb, "Where There Is No Vision, the People Perish." BYU Annual University Conference address, August 23, 2011. `http://speeches.byu.edu/?act=viewitem&id=1990`

I should have listened more carefully to President Holland before I went off to graduate school. I hit what I aimed at—I graduated, successfully, without criticism from my teachers. Technically I did not fail. But boy did I aim low.

Fear of embarrassment, fear of failure, fear of being considered dumb by someone I thought was smart—fear made me aim low. Don't make that mistake. Aim high.

Now, please don't misunderstand me. When I say *aim high,* I do not mean aim to be successful in your career. I do not mean aim to become rich, or famous, or powerful.

Those might be things that happen along the way, for a few of us. But if they are your target, you are aiming way too low. D&C 121 tells us that if we aim at these things, if our hearts are set upon the things of this world, and if we aspire to the honors of men, we may be called, but we will not be chosen.[†]

[†] D&C 121:34–35

No—when I say *aim high,* I mean we must aim to develop our talents and use our opportunities the best we can to build His kingdom, bless His children, spread His gospel, care for the needy, heal the sick, discover truth, teach that truth, and bring ourselves and our families back to live with Him.

We *will* make errors along the way. Aim high anyway. Not failure, but low aim, would be the most severe indictment.

Step 4: Do it again

Finally, an essential step after we try and fail is to repeat the cycle and improve on each attempt.

Some of the most powerful methods for solving hard mathematical problems are what we call *iterative methods*. You start with an approximate answer—sometimes just a random guess, but you use that guess to generate a new answer, a little better. Then you take that new answer and apply the method again, and again, until you get as close as you need to the correct answer. There certainly are situations where these iterative methods don't work, but in many settings they are both the fastest and most robust ways to solve problems.

Iteration is a powerful tool in our lives as well. We repeat the three steps over and over again.

Let me tell you about my son Spencer, who likes to run. His first official race, when he was 8 years old, was a 3k in Kiwanis park. He did not do nearly as well as he had hoped to do. He really had to push hard to stay with the leaders, and by the end, he just didn't have the strength to keep up. He was a little disappointed. The next two days he was really sore. He was forced to admit he wasn't as fit, or as good at running yet as he wanted to be. But during that week he pushed himself harder in our daily run than he had in the past—he worked hard to prepare for his next attempt.

At the next race, one week later, he was a little worried he wouldn't do well, but he got up and ran the race despite his fears. This time he still had to push hard to keep up, and he still didn't stay with the leaders for the whole race, but he was able to stay with them for longer, and his time improved, a lot. Some of that improvement was from working harder in our daily workout, and some of it was from really running hard in the previous race. He was still a little disappointed that he didn't do as well as he wanted to.

But he repeated the process. Again he was sore after the race. Admitting that he didn't know as much about how to prepare for a race as he wanted to, he asked his uncle, an experienced distance runner, for advice on how to train better. Again he worked hard all week. Again he felt nervous before his next race, but again he put his fear aside, ran hard, and did better than the week before.

All through that first season he repeated this process. He had a race almost every week, and each race he improved his time—a lot. Each race also motivated him to try harder in his daily runs and to learn more about running. Not only the preparation, but the races themselves helped make him stronger for his subsequent races. By the end of the season he had cut almost 3 minutes off his 3k time and had become one of the race leaders that others tried to keep up with.

Spencer was successful that running season because he followed the iterative method for pursuing perfection. Each week he admitted and accepted imperfection, he worked hard to improve, he braved his fears and made another attempt, and then he repeated the process, over and over again.

This same process, this iterative method, will bring each of us closer and closer to perfection. We will not actually reach that goal in this life, but we will be better than before. We will get better and better.

Conclusion

Let me conclude with the chorus of Leonard Cohen's song *Anthem*. Cohen may not have originally meant this verse exactly the way I interpret it; but, for me, it captures very well the idea I am trying to express today:

Ring the bells that still can ring
Forget your perfect offering
There is a crack in everything
That's how the light gets in.

Our bells are cracked. But let us ring those bells that still can ring. Stop worrying about your failure to achieve perfection—perfection is not possible in this life. Instead embrace the light and healing power of Christ that comes in through our cracks and imperfections.

Ring the bells that still can ring
Forget your perfect offering
There is a crack in everything
That's how the light gets in.