The Future of Mechanics

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Learn from yesterday, live for today, hope for tomorrow. The important thing is not to stop questioning.

Albert Einstein

As I mentioned in the preface to this book, I am a big fan of Carl Sagan. I am also a tremendous fan of Michio Kaku. Dr. Kaku has published a recent book entitled *Physics of the Future: How Science Will Shape Human Destiny and Our Daily Lives by the Year 2100* [129]. This is a fabulous book. I recommend it highly to anyone who finds my book interesting.

In his book, Dr. Kaku has laid out a carefully researched vision of the effects of science and technology on our future. Therefore, you may say that the final chapter in this book is either redundant or unnecessary. My response to that is this: Dr. Kaku has painted a grand vision of the world a century from now, whereas my ambition is much less lofty. I simply intend to describe developments in the field of mechanics that are either already underway, or are expected to be realized shortly.

Biomechanics

I am not a young man any more. When I go to see the doctor, I am usually informed of something called ‘risk factors’, such as, “You have a greater risk of developing heart disease because you have high blood pressure, and the statistics show that more people with high blood pressure die of heart attacks,” or, “You have a greater risk of dying of glaucoma because your parent had glaucoma.” Neither of these diagnoses is actually the case for me.

This sort of talk concerns me greatly. When I hear the term “risk factor” the first thing that I think of is statistics. In and of itself, statistics is a quite reputable field of mathematics. Unfortunately, the term “risk factor”, when it is used in the context of medicine, implies that no predictive methodology, ergo understanding of the underlying causes, has been employed with respect to the illness in question.

Here is more like what I would prefer to hear. “You have high blood pressure. Research has shown that high blood pressure causes cells to undergo chemical changes in the lining of the heart. A ten percent increase in blood pressure has been

D. H. Allen, *How Mechanics Shaped the Modern World*,
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shown to induce chemical changes in heart cells that causes them to die at the rate of etc., and we now have a model in place for both predicting the cause of this problem, as well as how to correct it". Now that's what I mean by employing mechanics in medicine to produce a predictive methodology.

Within the fields of science and engineering, predictive methodologies have been the focus of much endeavor since the time of Galileo. Indeed, it would not be presumptive to say that the entire world of science is predictive in nature, constantly seeking explanations for cause and effect, and testing those predictions with carefully controlled experiments.

But in the field of medicine, we are constantly bombarded with "risk factors", implying to me that there is no model yet available to explain the underlying causes of the illness in question. In fact, this sort of approach is entirely forensic in nature. Quite a lot of people have died on this planet (nearly as many as are alive today), and simply by keeping a record of the causes of their deaths, we can construct a forensically based methodology for defining the future. Unfortunately, this approach to predicting the future contains no scientific model for cause and effect. As I indicated in Chap. 10, this is tantamount to predicting where a hurricane will go based strictly on past hurricane tracks.

So what is going on here? Why has the medical profession not yet completely embraced the scientific method? The answer to this question is complicated. In fact, there is good news, but there is also bad news. Let's take the bad news first. The medical profession, like any other profession, is possessed of a certain amount of inertia. The learned doctors teach the newcomers, and this system encourages a certain amount of adherence to the old artistic ways. Artisty in medicine is in and of itself a good thing, but too much of it can be a bad thing. This then is the bad news.

But there is also good news. The medical profession is changing, albeit somewhat too slowly from my perspective. Here is a bit of reality. The human body is filled with all sorts of items that are essentially mechanical devices. Bones, muscles, tendons—all are designed to perform mechanical functions. And the failure of the aorta that killed Albert Einstein was essentially a mechanical failure, resulting from the fracture of the wall of the aorta. These kinds of illnesses that are driven by mechanics can be predicted using models already under development by the scientific and engineering communities, and in some cases this is already reaching medical practice.

The first case that I am aware of wherein a significant scientific discovery was made regarding the mechanics of the human body was by William Harvey in 1628. He discovered the nature of the blood circulatory system. After that, other major developments in medicine related to mechanics were few and far between.

In the 1960s a professor at Cal Tech named Yuan-Cheng "Bert" Fung (1919) began studying mice. He made mice do psychologically stressful things, and then he quickly cut them open and found that their veins doubled back over themselves when they were slit open. This did not occur when the mice were not psychologically stressed. This was the first scientific evidence (to my knowledge) that psychological stress results in physiological stress. In other words, mechanics is a big part of human health. If you stress yourself out a lot psychologically, you are literally killing yourself with mechanics. As a result of his groundbreaking research, Dr. Fung is today considered to be the father of modern biomechanics.

These days more and more medical problems are being addressed with the help of mechanics. This is a truly exciting area of research that promises to change the field of medicine from a forensically based profession to a predictively based profession. Imagine a world in which when you go to the doctor and there is a problem, he or she can tell you, “there is a predictive model for this illness, and using this model, there is every reason to expect that we will be able to not only prolong your life, but to also eradicate your illness using proven scientific methods”.

And now let me finally pay homage to the medical profession that I have just maligned. Of course, I was concealing the difficulty of the problems they face just to make a point. The reason that scientists and engineers have been able to develop numerous accurate predictive models outside the field of medicine is that in most cases they have been working with inanimate objects that undergo no (or in some cases rather limited and straightforward) chemical and/or biological change. When you take chemistry out of the problem, things are *vastly* simpler.

In the case of humans, when you take chemistry and biology out of the problem, the patient is already dead! The point of this is to say—there are almost no human illnesses that do not entail at least some chemistry and biology. Thus, while mechanics may be a significant part of the illness, it is rarely *all of the illness*. By itself, chemistry is well understood, as is mechanics, as we have seen herein. But when you mix chemistry and mechanics and add in biology you have what is to this eye the most complex scientific challenge on our planet, and that is exactly what we face with a living human.

So I was picking on the medical profession to make my point. I have nothing but the greatest respect for our medical specialists. But I do nevertheless have some advice for them: work with people outside your profession! By working together, we will move toward more and better scientifically based predictive models for illnesses, and some of these solutions will necessarily entail mechanics.

Unfortunately, despite the fact that mechanics plays an enormous role in the performance of the human body, professionals in the medical field are not usually trained in the science of mechanics. Alternatively, they receive substantial training in the fields of chemistry and biology. As an example, it has recently been suggested that aging is caused by the long-term statistical nature of chemical processes. The cells in all living beings are constantly being replenished, and as a result of the statistical nature of the chemical processes involved, a few of the chemical bonds are not formed correctly. It is hypothesized that the accumulation of these incorrect processes over time causes aging. Therefore, much medical research is currently focused on decreasing the probability of these incorrect recombinations and/or replacing them with correct ones. The leading supposition here is that if this can be accomplished, life can be made infinite.

Unfortunately, this is wishful thinking, because chemistry is not the only cause of aging. Aging is also caused by mechanics. This has never been more apparent than when astronauts began coming back to Earth after long stays in space. When they exit the reentry module, they are observed to have difficulty performing normal functions such as walking. This is due to the fact that they have been in a zero gravity environment for so long.

Because almost everyone who has ever lived on this planet has been subjected to Earth's gravitational field for their entire lives, it is difficult for us to conceive of what zero gravity would feel like. Albert Einstein is said to have once commented that humans cannot feel their own weight when experiencing freefall in an elevator. The next time you want to feel what zero gravity is like, try freefall in an elevator (or even better, on a roller coaster!). But don't do it for more than about a second, or you might be fatally injured when the elevator stops!

Another possible way to experience zero gravity (without going into space) is to fly on the so-called "Vomit Comet", NASA's aircraft that flies to a high altitude and then performs a slow arcing maneuver so that the force due to the Earth's gravitational field is balanced by the aircraft's rate of change of momentum (Fig. 14.1). This circumstance can be maintained for about a minute. That is actually the same physical means by which astronauts attain zero gravity in space, except that the rate of change of the momentum of the spacecraft in orbit has been purposefully designed to balance the Earth's gravitational force for much longer periods of time.

What all this is getting at is this—we Earthlings live in a gravitational field that exerts force on our bodies from the moment we are conceived right up to the instant we die (and even thereafter). This force invariably causes mechanical aging in all of us. All human tissue contains a significant amount of liquid within it, which causes the mechanical material behavior of our soft tissue to be what we call viscoelastic. All viscoelastic materials creep with time *under constant loading conditions.* What this means is that every bit of the soft tissue in your body is slowly deforming toward the center of the Earth throughout your lifetime. Other than standing on your head (which actually won't work anyway), the only way to reverse this process is to either replace the tissue, or tug it back the other way, typically using cosmetic surgery.

Fig. 14.1 Weightlessness in the "Vomit Comet"

Over the last 30 years, the field of medicine called biomechanics has developed. In this field of study, the mechanical material behavior of soft tissue is accounted for in the models used to predict failure of human organs. What we now know is that chemistry and mechanics are inately coupled within the human body. Mechanical stress causes some deteriorating chemical processes to speed up, and the resulting deterioration of the mechanical material properties further speeds up the associated chemical processes.

An example is the superficial muscular aponeurotic system (SMAS), the set of muscles within your face. Anyone knows what I am talking about when I mention aging of the face. Your facial tissue creeps with time, which is a fancy way of saying, your soft tissue is continuously sagging more and more toward the center of the Earth. The SMAS sags more rapidly in some people than it does in others, but no one is completely immune to this facial creep process over time.

Another example is glaucoma. Medical professionals have determined that there is a significant probability that people with high blood pressure will develop glaucoma, which is a progressive disease that can lead to blindness. Apparently many people with high blood pressure also exhibit high fluid pressure in the ocular cavity, called ocular hypertension. This high fluid pressure can cause deterioration of the optic nerve, which is chemical in nature. In other words, mechanical stress induces chemical change that leads to death of axons within the optic nerve, thereby eventually leading to partial or total blindness. Thus, we have another example of the coupling between mechanics and chemistry in the human body.

Still another example is the case of abdominal aortic aneurysms. Albert Einstein was told that he had an abdominal aortic aneurysm, and that, based on the available mortality statistics from previous patients suffering this sort of illness, he would die in a few years (he died seven years later). This is not good science. Good science would seek a cause of the aneurysm and attempt to intervene accordingly on the patient's behalf (Einstein did undergo repair surgery in 1948, but he chose to forego further surgery when his aorta ruptured in 1955) (Fig. 14.2).

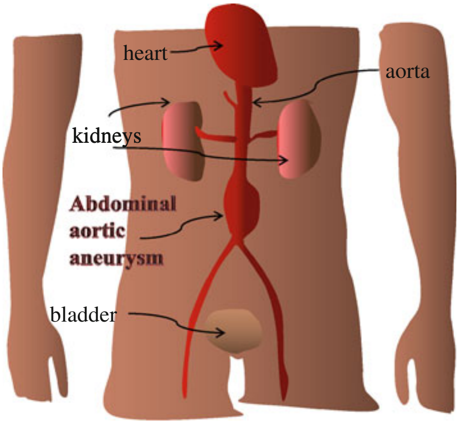


Fig. 14.2 A section of the aorta showing an abdominal aneurysm

A further example is the case of traumatic brain injury (TBI) induced by improvised explosive devices (IED's). This type of brain injury came to the forefront during the most recent war in Iraq. Insurgents made IED's that induced blast waves when detonated. In quite a few cases soldiers were impacted by these blast waves, subsequently exhibiting a variety of injuries and illnesses. The prevailing medical information suggests that the blast wave impacts the head of the soldier, thereby inducing a secondary mechanical wave to pass through the brain of the soldier, and this mechanical wave subsequently induces either mechanical damage to the brain such as the breaking down of cell walls, or mechanically induced chemical damage to the brain, such as cell death due to trauma. In some cases the effects of this damage are not observed until several months after the impact event. This type of mechanically induced brain damage is not yet well understood.

So what are the solutions to these multidisciplinary problems? The answers all point to multidisplinary research and development. The National Institute for Health is today funding more and more research that involves teams of doctors and other scientists and engineers who are not medical doctors. These highly accomplished scientific teams are working closely together to attack problems in a way that is revolutionary in nature.

As outlined by Dr. Kaku in his book mentioned above, we will see changes in the predictive nature of medicine that will dramatically alter the world in the next century, and many of them will involve mechanics. As an example, Dr. Kaku predicts that your toilet will perhaps become a device for diagnosing potential medical problems years in advance of the current diagnostic tools. This is a problem whose solution involves mechanics.

Another area of medicine wherein mechanics will play a significant role is in the insertion of devices inside the human body. We already have numerous procedures for inserting mechanically designed prosthetic devices inside the body, such as artificial hips, knee implants, heartbeat regulators, arterial stents, etc. In addition, quite a few surgical devices have been developed that either mitigate or completely do away with the necessity to make incisions in the patient.

In the future, many incisions will become unnecessary, and many others will be made by robotic devices that are inserted into natural orifices so that the patient is not subjected to life-threatening incisions. An example is the case of robotic devices injected down the esophogus of the patient and into the stomach. An incision is made in the lining of the stomach, where there are no nerve endings, and the robot crawls out onto the outer surface of the organs and performs laparoscopic surgery, such as the removal of the appendix. The patient then goes home without even having an incision on the extremity of his or her body. The technology already exists to perform these types of surgeries, which involves the use of mechanics (Fig. 14.3).

So long as there is the necessity to have a physical interface between the patient and the medical team, there will be applications involving mechanics. What we can say is that these devices will continue to grow both smaller and more intricate as the technology becomes available.

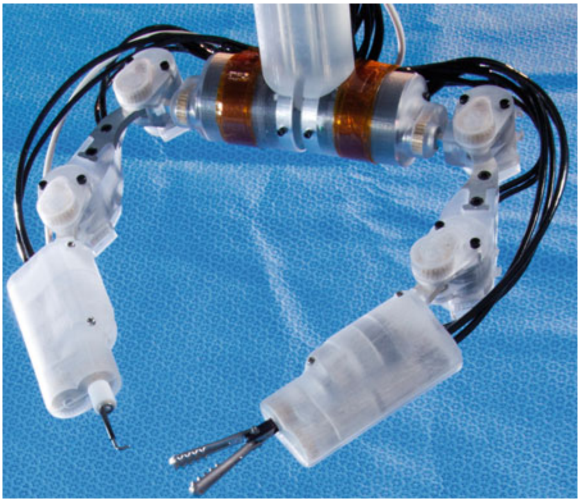


Fig. 14.3 Photograph of surgical robotic devices inserted through the stomach

The human body is perhaps the ultimate mechanical device ever devised on our planet. True, it has required millions of years of evolution for our species to reach our current state, but it is readily apparent to the average person that we are much more than the most intelligent species on our planet. In fact, anthropologists agree that a large part of the reason that our brains are so large compared to our total volume is that the superior mechanics of our bodies allowed for our brains to grow disproportionately to other species on Earth. An obvious example is our thumb, which can be utilized in a pincher movement to carry weapons to fend off the saber-toothed tiger.

I will not go into further detail on this subject, but suffice it to say this—as long as humans dominate this planet, mechanics will be a necessary part of our existence for the simple reason that our bodies deploy mechanics with each and every movement. And as long as humans exist, we will continue to find ways that employ the science of mechanics to improve human health.

Mechanics and Extraterrestrials

At some point, should our species survive long enough, we will surely encounter organisms from somewhere else in the universe. I am always a bit nonplussed by the shortsightedness displayed by Hollywood producers when I see another installment of their endless collection of movies that depict extraterrestrials arriving here on Earth. For some reason the hypothetical visitors in these movies always bear a distinct resemblance to us. For example, they almost invariably have two arms and two legs, and they have a head. They are normally no more than two feet taller than us, nor less than two feet shorter than us (ET excepted!).

I have the sneaky suspicion that most of this emanates from the unavoidable reality that if you want to allow a human to play the role of an extraterrestrial by suiting him or her up in a body suit, it will be unlikely that the body suit will be dramatically different in size from the range of available human talent.

However, there is hope! With the rise of electronically generated images in movies, we are beginning to see a few depictions of extraterrestrials that the science of mechanics suggests are more likely. Indeed, the mechanics of other planets may contribute to species that are *dramatically* different from us. After all, there are quite a few significantly different species from ours right here on Earth (take the giant squid, for instance).

So here are a few things for our Hollywood pundits to think about when planning future movies depicting extraterrestrials. First of all, there is no reason that life cannot be sustained and even flourish and evolve on planets (or moons!) of considerably different mass (and therefore gravity) from Earth. The planet that our visitors come from might be larger or smaller than Earth. If it is larger, then the larger gravitational field will most likely cause life from that planet to be much smaller than us. When I say much, I mean perhaps a whole lot! As we already know, there are some very small creatures on Earth. And there is no reason that they cannot have superior intelligence, because the molecular scale is considerably smaller even than the scale of single cells. For example, a single cell in the human body typically contains about 10^{16} atoms. Therefore we can conclude that the arriving extraterrestrials could be quite small without sacrificing superior intelligence.

Perhaps our visitors will not be tiny, but instead quite short and really wide! Perhaps they will be a thin film stretching over several acres, but only a few centimeters in thickness. That might not be unrealistic on the massive planet that they come from, where the force of gravity would kill you in the span of a few hours. And if they are shaped like that, I doubt that they will have two arms and two legs. They might have a head, but it will be rather compact vertically, and speaking of that, they will undoubtedly not be thin-skinned, as their enormous gravity will require them to have a very thick and durable skin in order to keep them from breaking apart.

By the way, when these short and wide extraterrestrials arrive on our planet, they will perform like super humans. They will quite likely win almost any sports event they enter on Earth because the gravity will be so slight to them that they will feel like they are floating in nothing. Think of Alan Shepard playing golf on the Moon during the Apollo 14 mission in 1971. This is of course where the idea for the comic book hero Superman came from, although for some reason he looked exactly like we Earthlings do.

Now let’s consider extraterrestrials that come from a planet with a significantly smaller gravity than on Earth. Consider for example a planet somewhat like the Moon in size, which has a gravitational constant about one-tenth of the Earth’s. These extraterrestrials will not be happy on Earth. They will likely be very slender and willowy. I seriously doubt that they will even be able to stand up on our planet. They will feel like humans would feel if we went to Jupiter—actually worse!

When you ride on a roller coaster, you feel like you are really heavy when you ride inside a loop due to the rate of change of momentum caused by the moving cars, and this is about how you would feel on Jupiter, because Jupiter's gravitational constant is about 2.65 times that of Earth's.

But that doesn't mean that there cannot be life on Jupiter. Jupiter's gravity is a mechanics issue, but that in and of itself does not preclude life. What precludes life is chemistry—a lack of the basic chemical elements for life, meaning carbon, oxygen, hydrogen, and nitrogen. If Jupiter had all of these (and perhaps a bit more sunlight), there is no reason that life could not flourish there. But those organisms would nevertheless most likely be short and wide due to the substantial gravitational field on their planet.

So we've discussed the effect of gravitational forces on the evolution of extraterrestrials, now let's talk about other effects caused by mechanics. On Earth all life is profoundly affected by several time constants that are specific to our planet. These include the time it takes the Earth to revolve on its own axis, the time it takes the Earth to revolve around the Sun, and the Earth's tilt with respect to the plane of the ecliptic (causing the seasons). Because of these, for example, we humans sleep once a day on average, and if we don't we eventually die. Many other species on Earth have similar sleep habits, although not necessarily identical to ours. Take bears for example. They sometimes sleep for months, called hibernation, but they are nevertheless constrained to their sleep patterns by our planet's mechanics of motion.

Now imagine that our visitors come from a galaxy where their home planet is the same size as ours, but it spins on its axis once every year (a day to them!), and it orbits their Sun once every 6 months (a year to them!), and somewhat bizarrely, their planet's axis of spin is oriented perpendicular to the plane of the ecliptic in their home solar system (implying that they would have no seasons). What I'm getting at is this—there is absolutely no reason to expect that they would be even close to what we humans are like despite the fact that their planet exerts the same gravitational force on them.

And here is an even more shocking revelation—because the natural time constants associated with their solar system will be radically different from ours, their sense of time will most likely be *totally* different from ours. They will not conceive of an hour, a day, a month, a year, or indeed anything at all that we use—with one possible exception. Perhaps they will use a second, the approximate duration of a human heartbeat. This span of time seems to be wholly dependent on Earth's gravitational constant, thus driving the volume of blood that can be pumped to the extremities of our bodies in Earth's gravitational field.

Therefore, if as I suggested their planet is the same size as ours, they might relate to our second, the approximate duration of a heartbeat. On the other hand, if their planet's mass is different from ours, even their conception of a second will most likely fail to coincide with ours, since their blood (if indeed they have blood at all!) will need to be pumped sufficiently to overcome their local gravitational field. Indeed, there may be no comparison at all between our two time scales. They might grow old in twenty seconds, or more ominous, they might not grow old in ten thousand years! In the latter case, let's hope that they move *very* slowly compared to us.

Okay, now let's take the other extreme. Let's suppose that our visitors come from a solar system that is *exactly* like ours, and that they live on the third planet from their Sun, and that it's mechanics of motion are *identical* to ours. This is highly unlikely (at least in a nearby galaxy), but nevertheless possible. What could we expect from these visitors? Even in this unlikely physically identical scenario it is extremely far-fetched to expect that they would be just like us. The reason for this is that the evolution of life is nonlinear and statistical in nature, and more importantly, it is chaotic (see Chap. 10). What that means is if you do the same experiment over and over again, very small perturbations in any of the conditions will lead to very large differences in the evolution of the species. Thus, I'm sorry to say that just due to the statistical nature of evolution, they will still most likely bear little resemblance to us. So the scene in the bar that we've all observed in *Star Wars*, despite the fact that we have all considered the beings in that scene to be amazingly different from us, depicts extraterrestrials most likely nowhere near as different from us as the actual beings will be when we finally meet them.

The most likely scenario for our visitors to be similar to us is the case whereby we evolved from the same biological ancestors. As we now know, the planets in our solar system have communicated with one another since the inception of the solar system via impacts from foreign objects that have knocked chunks of material into space and transported these chunks as meteors from one planet to another. This same physical phenomenon, caused by mechanics, could have transported biologic material from one solar system to another, or (more unlikely, but still statistically possible) even from one galaxy to another.

In this case the likelihood that we will be similar to our biologic cousins, though much higher than were we not biologically related, will nonetheless decrease with the time span since the material arrived on our two respective planets. Despite the possibility that the two pieces of arriving biologic materials may have been identical when they arrived on the two planets, differing physical conditions on the two planets, as well as the statistical nature of evolution, would invariably cause the two identical biologic entities to diverge with evolution, thus leading to significantly different cousins.

We of course know this to be the case because we have extant examples right here on Earth. For example, consider the fact that identical species on Earth diverged when Pangaea began to break up 200 million years ago. Thus, almost all of the marsupials on Earth today are in Australia, implying that they developed after Australia split off from Pangaea.

Now recall the fact that the Earth is 4.5 billion years old. And we just happen to have evolved into a superior species capable of manned space exploration in the past century. What if our visitors from an *identical* planet came from a solar system that was formed 10 billion years ago, or 5.5 billion years *before* ours was formed. What will they be like? There's no telling, but I can guarantee you this, if we humans are still around on this planet in another 5.5 billion years, at the point in time when our planet would be the same age as theirs is now, we will undoubtedly be quite different from what we are today, because 5.5 billion years represents about 280 million generations (and 7 billion gestation cycles) of our species, during which time we could well evolve from what we are today into a species that you could not even begin to imagine, all due to both mechanics and Darwin's law. If we are still around in 5.5 billion years, we might have wings, antlers, and legs like frogs. Hopefully, we will nonetheless still be attractive to the opposite sex. Otherwise, we will shortly thereafter become extinct.

So when we consider what our visitors from other planets will be like, we need to consider both length and time scales, as it is unlikely that they have evolved in any way similar to us. And need I say, virtually all of the possible differences I have mentioned above are due to nothing more than mechanics. Fortunately for our species, the distance between inhabitable planets in our universe over the span of time that we humans have become dominant is sufficiently large as to make the probability of actual direct interactions of intelligent beings from different planets to be unlikely.

The Mechanics of Our Destruction

Sooner or later our species will become extinct. This is due to the principle that if time is infinite, all events with finite probability will necessarily occur sooner or later. We have no way of knowing exactly how our extinction will occur, but we can be relatively certain that mechanics will be a factor, no matter what the cause will be. Here are a few of the most likely scenarios.

Destruction by the Sun

A solar flare event is likely to strike the Earth within the next few thousand years, and this would indeed cause widespread damage on Earth, including knocking out our power grid. However, scientists estimate that the loss of human life would be minimal, thus most likely obviating the possibility of extinction of our species from solar flares.

Scientists predict that our Sun will run out of fuel in about 5.5 billion years. However, before that the Sun will burn enough of its fuel that it will slowly expand, becoming a Red Giant. During this period, the Sun will expand to thirty times its current size and will glow so hot that it will burn away the outer crust of the Earth. If we humans are still around that far in the future, we will most certainly not survive this event. The Sun will eventually become a White Dwarf, but by then we will either all be dead, or we will have employed mechanical devices called spaceships to depart our dying planet for greener pastures.

Meteor Impact

As we all know, scientists theorize that the dinosaurs were wiped out by the meteor that struck the Earth at Chixculub 65 million years ago. That meteor was about 6 km in diameter. Around 35 million years ago a meteor 1 km in diameter struck the eastern coast of the U.S., creating Chesapeake Bay (Fig. 14.4). We know today that while this latter event caused an enormous conflagration, it did not rise to the level of species extinction that the Chixculub event caused. Thus, evidence suggests that it will take a meteor of the scale of several kilometers in size to destroy humankind.

There are two most likely sources for a meteor strike of this scale. We could be struck by either an asteroid or a comet. In either case, our best chance of survival is to prepare in advance and launch a vehicle into space with the intent to deflect the meteor away from our planet.

First, there is the possibility of an asteroid strike. Since there are many more large asteroids (that we are aware of) than comets, this scenario is the more likely of the two possibilities. That is the bad news. The good news is that because the

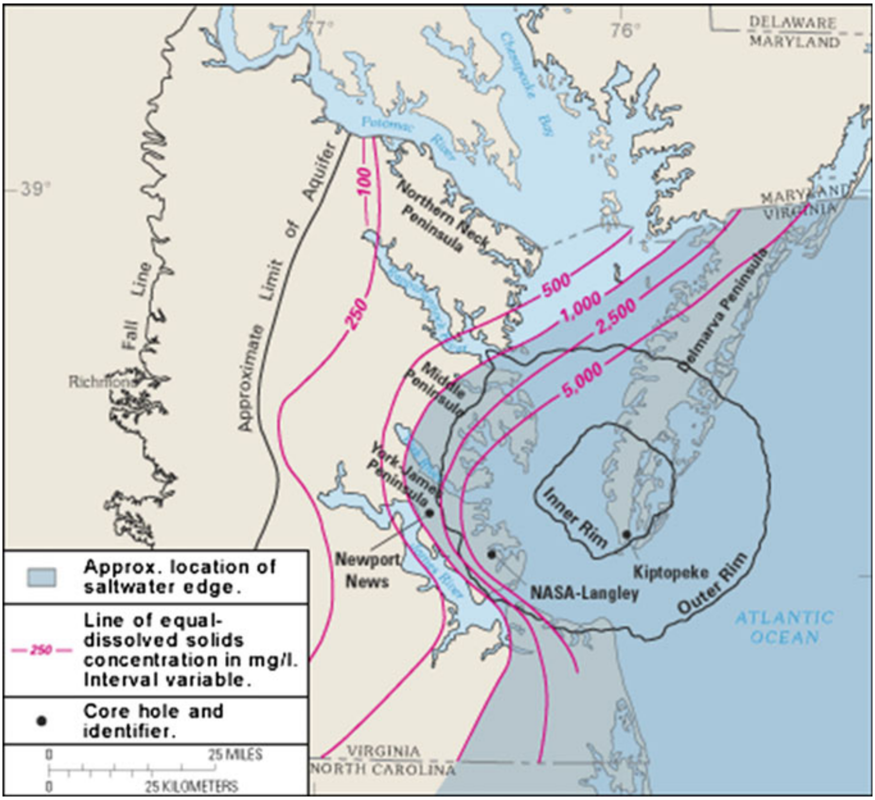


Fig. 14.4 Depiction of the Chesapeake Bay Meteor Crater

asteroid belt is fairly close to our planet we can (and actually do) track all of the kilometer sized asteroids, and we have the technology to predict several years in advance the probability that one will strike Earth. Thus, we will have plenty of time to send out a vehicle to divert this disaster.

And the earlier we do so, the smaller the force that will be necessary to divert the asteroid, a problem in rigid body dynamics. Scientists think that it will most likely not even be necessary to land on the asteroid. Simply flying a vehicle close by will cause sufficient gravitational interactions to divert the asteroid away from its destructive path toward Earth.

Second, there is the possibility of a comet strike. These come from deep space, and for this reason they are difficult to discover more than a few months in advance. Should a large comet come barreling down on Earth, we will only have a short period of time to attempt to deflect it from striking our planet. Thus, while this possibility is much more remote than the possibility of an asteroid strike, we will need to have our mechanics ducks in row, as it were, in order to avert the destruction of our species.

Scientists estimate the odds of a world devastating meteor strike occurring within the typical human lifetime is slightly greater than one in a million. And needless to say, this would be a mechanical event of global proportions.

Interstellar Radiation Event

There are stars blowing up in our universe all the time. Every so often one of them sends out a detectable amount of radiation via a supernova event or a gamma ray event. These types of events are unavoidable on Earth. Furthermore, there would be no forewarning of such an event because they travel at the speed of light. If sufficiently close to our planet, either one would wipe out all life on Earth. Scientists estimate the probability of one of these events destroying Earth at less than one in ten million. Although the rays emanating from these ill-fated stars are not mechanics per se, they both involve mechanics (explosions) and the results of their arrival on Earth will most certainly induce mechanics events on a global scale.

Pandemic

We now know that whole species can become extinct as a result of global scale disease. The transmission of disease is related to the mechanics of diffusion, fluid dynamics, flight (i.e. birds), wind and atmospheric phenomena, contamination of aquifers, typhoid, all directly related to mechanics.

Climate Change

Climate change is a hot topic these days (pun intended). There seems to be quite a lot of evidence that our climate is changing. However, it is difficult to determine the causes of this, as the process of climate change is extremely complex on our planet. Furthermore, it is presumptive to conclude that the current changes in our climate will be destructive to life, as the time scale of most observed climate changes in our planet's past have evolved over a scale of time that is much longer than the time span that we have been keeping scientific records. Thus, we continue to have major debates worldwide over climate change.

Another issue surrounding the subject of climate change is—if our climate is really changing, what if anything can we do about it? This is an interesting subject because it involves scientific challenges on a global scale. Just exactly what could we do to change our climate? Only a few attempts have been made in the past to control our climate (such as cloud seeding), and these have for the most part been unsuccessful.

Processes in our planet's atmosphere involve almost incomprehensible amounts of energy (see Chap. 10). Thus, in order to solve this problem, we will have to develop the ability to purposefully control enormous amounts of energy. I say purposefully because we seem to have already caused significant changes in the greenhouse effect on our planet via the burning of fossil fuels and emission of other gases that have depleted the ozone layer. Thus, some of our climate change could in fact be induced by our own ignorance and/or poor judgment. And where it is possible to affect our climate accidentally for the worse, the reverse should also be possible. This problem will necessarily involve mechanics, and it will most likely be addressed (and perhaps even solved) within the near future.

Human Initiated Extinction

Of all of the possibilities for destruction of our species, our own self-destruction is the most likely scenario. Among these are the following:

- Global nuclear warfare
- Human-induced climate change (mentioned above)
- Human-induced disease
- Economic collapse.

As unusual as some of the above possibilities may seem, it is nonetheless believed by many experts that human initiated extinction is by far the most likely scenario for the demise of humankind. I will cite just one example. In 1961, U.S. Air Force first Lt. Jack ReVelle received a midnight phone call from his commander. ReVelle remembers his commander saying, "Jack, I got a real one for you" [130].

Lt. ReVelle arrived at the site of the crash of a B-52 aircraft to find that two nuclear weapons had been onboard the aircraft when it went down. Fortunately for all of us, Lt. ReVelle and his team defused the bombs without incident. Had he not done so, we could have had a major nuclear disaster right here in the U.S., an event due in large measure to mechanics, in this case the failure of the aircraft, which broke up in flight. This type of human-induced event could quite possibly lead to extinction of our species.

Another possibility is that in our attempts to wipe out certain types of illness, we might actually insert chemicals into the environment that are capable of causing our own demise. An example that comes to mind is thalidomide, a drug that was introduced in the 1950s as a means of inducing sleep. It was subsequently found that when taken by pregnant women, the drug induced quite significant birth defects in their children.

We humans are not perfect, and where we have perfected weapons of mass destruction, we have created conduits for own destruction via our own imperfections. Scientists do not normally hazard a guess at the likelihood of our own self-destruction, but it would seem that of all the possibilities cited herein, this one is the most dangerous and likely, and in the most likely scenarios, mechanics plays a significant role.

Mechanics and Toilet Paper

We are finally coming to the end of our journey through the history of mechanics. Thus, now we can show the evolutionary family tree of mechanics (Fig. 14.5).

You may ask, where is this all leading to? I confess that I do not know. But as you now know from reading this book, it certainly will not stop me from hypothesizing. So here goes…to me, the future of mechanics is not unlike the future of toilet paper. Seriously!

It wasn't too long ago that toilet paper didn't even exist. Paper has been used for hygienic purposes as far back as the sixth century in China, and toilet paper is known to have been mass produced as far back as the fourteenth century. But the first rolled toilet paper was patented in 1883. Before toilet paper, people used all sorts of naturally available items such as leaves, grass, stones, and even sand (ugh!).

During the American Civil War, it is known that soldiers destroyed books wholesale by tearing out the pages in order to use them for purposes of personal hygiene. Think about living in a world where the only means of preserving personal hygiene is to destroy knowledge—not an easy choice by any means.

In the twentieth century, toilet paper seems to have reached the zenith of technological perfection. Two inventions substantially improved toilet paper, both of them rooted in mechanics. First, the softness of toilet paper was significantly improved by imbedding small amounts of nonevaporative liquids (typically non-toxic oils) in the paper. This made toilet paper much better at maintaining cleanliness without physically damaging the user (related to the mechanics of

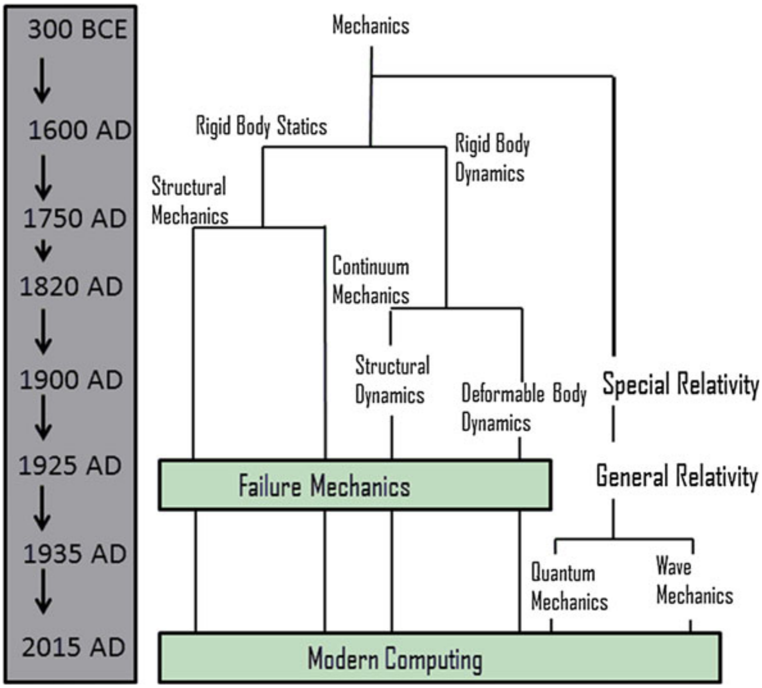


Fig. 14.5 The evolutionary family tree of mechanics

deformation of the user). Coincidentally, this also made it less likely that toilets would get stopped up, another problem in mechanics.

Second, toilet paper on rolls was perforated at spatial intervals in order to make it easier to tear from the roll (related to the mechanics of fracture of the paper). Both of these inventions seem to have been optimized within my own lifetime. And interestingly, they seem to have propagated across most of our planet, but at varying velocities.

This is an example of the interaction between mechanics and economics. You see, soft toilet paper that is easy to tear is not a necessity, it is a luxury! Soft and perforated toilet paper is also somewhat more expensive than rough and un-perforated toilet paper. For that reason, one tends to find more luxurious toilet paper in economically advanced countries (and luxurious hotels within those countries!), and less luxurious toilet paper in poor countries. Check it out the next time you visit another country.

Actually, you can test it out right here in the United States by visiting the bathrooms of various businesses and public facilities. If the quality of toilet paper therein is very low, you can bet that the company in question is in real trouble, because they can’t even afford toilet paper! Try this theory out at a public university. By examining the quality of toilet paper within the bathrooms in our public universities, you can get a good idea just how far our higher education complex has fallen from its lofty post-World War II pedestal. At my university, they are constantly changing toilet paper vendors in an attempt to save money.

How does this little discourse on toilet paper relate to mechanics? The answer is—not too much from the theoretical standpoint, because a single unit of toilet paper is so cheap that the product can be designed essentially experimentally, without recourse to much theory. On the other hand, it serves as a guide for those who are plotting out the rise and fall of a particular society or country. I submit to you that if you plot the quality of toilet paper versus time in the United States, you will observe a peak in the curve that coincides with the zenith of our country's *real* Gross Domestic Product (GDP), which appears to have occurred sometime shortly after the turn of the millennium.

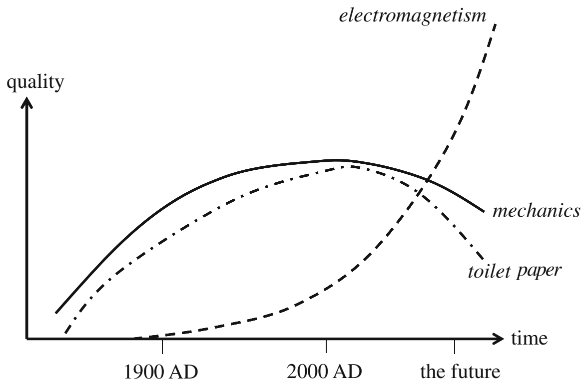
I am simply using toilet paper as a euphemism for the history of mechanics. Sadly, although there is not necessarily a connection between the two, the science and application of mechanics seems to have peaked around the same point in time that toilet paper reached its zenith.

Indeed, like the quality of toilet paper in the United States, mechanics appears to have reached its pinnacle. Unless and until there is a conflagration on this planet that somehow wipes out our ability to deploy the now superior field of electromagnetism, the wave that was mechanics has broken on the shore, and is destined to be a field of diminishing importance in the lives of humans (Fig. 14.6).

Where might this new-found scientific teenager called electromagnetism take us in the future? Perhaps we will no longer actually *go* on vacation. Perhaps we will simply *simulate* a vacation, thereby removing mechanics entirely from our pleasurable journey. You can already simulate a visit to Ancient Rome and walk through the Forum on Google Earth. Perhaps you will meet your next significant other while doing so. *Perhaps we humans will even evolve into less mechanical beings.*

After all, who needs to climb up the Eiffel Tower, or even the Leaning Tower for that matter, when we can *simulate it* electromagnetically for a lot less money! And forget golf, it will perish as well. It is simply too expensive! We will *simulate* a round of golf (this technology already exists), just as we will simulate most other

Fig. 14.6 The rise and fall of the quality of toilet paper



sporting activities (also already in existence). However, those who choose to *simulate* exercise will most likely shorten their lifespans.

Perhaps humans will not go to work in the future. We will *simulate* going to work electromagnetically. Gasoline (or any other source of energy) simply costs too much to drive anywhere. Not unlike the futuristic movie *Surrogates*, we will perhaps send a genetically perfect (and eternally youthful) image of ourselves to work on the wings of our electromagnetic devices.

Like many now extinct mechanical devices such as the astrolabe, the mechanical level, and the slide rule, the death of many additional mechanical devices is just around the corner. The mechanical wristwatch (see Chap. 12), the printed book, and the internal combustion engine (see Chap. 12) are all destined to become extinct before too long. Indeed, perhaps the entire mechanical world I was born into is rapidly approaching extinction.

I for one feel fortunate to have been alive during that brief period when mechanics was at the crest of the wave. I for one believe that the world of mechanics is the real world—a world wherein humankind has had the luxury to touch, to feel, and to experience the thrill of existence. And that, dear reader, for a mechanical species such as ours is simply as good as it gets!