RELAX!

The World Makes Sense!

SHASHIKANT MARUTI WAVHAL

Contents

|| Shri ||

Relax! The World Makes Sense!

Compilation of Thoughtful Snippets about

Where We Come From and Where We Are Going

By

SHASHIKANT MARUTI WAVHAL

This book has great merit not only in the contents of the text but also in the clarity and felicity of language. There is also an apt sense of humor making this a thought provoking and entertaining book.

- **Vicaji J. Taraporevala**
  Senior Advocate and Author of 'Tales from the Bench and the Bar'

Many of us have wondered about the nature of human behavior that governs our society, or have seen logic rendered limited in elucidating a sequence of events. 'Relax!' is an excellent attempt at unravelling the mysteries that govern human behavior. Using diverse illustrative examples from a wide array of subjects, a simple, free-flowing narrative and a concrete framework, it explains why we do what we do, and the consequences.
A must read for the curious and seekers amongst us!

- **Tirthankar Patnaik**
  Chief Strategist and Head of Research, Mizuho Bank India

Printed in India in 2016

Dedicated to GOD

Dedicated to my family and friends for their love and support

About the Author:

Shashikant Maruti Wavhal is a Chemical Engineer from UDCT (Mumbai), MBA from IIM (Lucknow) and also holds CFA Charter from the CFA Institute, USA. He has been working as an Analyst for almost twelve years covering various sectors of Equity markets in India. His passions are reading science fiction & action-thrillers, following geopolitical developments around the world, tracking technological advances in various fields & trying to make sense of Life.

Email: relax.twms@gmail.com

Website: http://world-makes-sense.com

Foreword

‘The only true wisdom is in knowing that you know nothing’

– Socrates

I am not an author. I am neither a scientist nor an economist. I am just a science & technology enthusiast who likes reading about new technology in various fields – right from a new cancer medicine to a new fighter jet. A few decades ago, the focus of technology development was mainly for commercial or military use. Today we come across a lot of new technology that is making the life of the common man easier. It is heartening to see the rich individuals and rich corporates thinking about the poor. In some cases there is some business angle involved but sometimes there is genuine altruism. Bill & Melinda Gates Foundation is giving millions of dollars for vaccination programs in poor countries. Google’s Project Loon and Facebook’s Aquila (both plan to provide free internet in remote areas) are great examples of how technology can be used for the benefit of millions of underprivileged people on earth. It also makes me think about the great divide between people – the ‘haves’ and ‘have nots’. Some people use their intelligence to develop technologies to enrich themselves even at the cost of others whereas some use their intelligence to help other people. Will our future be full of selfishness or altruism? If we want to make a guess about how our world will look like in the future, we will need to find the formula of what people are inventing and whether it will help themselves or the others. We will also need to figure out if the people of earth will really destroy each other over issues like food, water or religion within next few decades as some thinkers predict. The further you need to predict the future, the further you need to go back in the history first. What this means in our present case is that we need to go back into the human history and try to find answers to questions like what makes people selfish and what makes people altruist. Luckily, with increasing research across various fields and new thoughts and theories being debated it has now become possible to answer these questions in a fairly satisfying manner. From the various publications about science and technology I came across, from the collage of various thoughts, theories and scientific predictions, a bird’s eye view of this world took shape in my mind and it may provide answers to some of the queries mentioned above. In this

world, many times we come across things that don't make any sense. The bird's eye view showed me that in many such cases, there is some perfectly logical reason or idea that is working in the background. That is why I decided to name the book as "Relax! The world makes sense!" In this book, I try to piece together the answers to these 'whys' and make a coherent and useful collage for readers across the world who had the same questions as me. Further, it might be possible to use some of these concepts in areas that I have not covered in this book. Once you know how the world makes sense, it should drive away your agitation and make you relaxed, and hopefully, make you strive for a prosperous future for mankind.

The story in this book starts with how mankind has evolved the way it has evolved over last thousands of years and it proceeds to discuss how the future would look like if we cautiously extrapolate the trends keeping in mind the advances in technology and finance. I feel that the extrapolation of current trends give use some idea of how the world would look like in about 30 years from now. Beyond that, given the likelihood that the rate of change might be too fast, current trends might not be a good guide. Authors talking about the future generally exhibit either groundless optimism or exceptional despair. I confess that I tend to be on the optimistic side. But to remain grounded, I try to provide sufficient data and logic behind every thought.

The book is divided into three parts. To begin with, we will talk about the process of evolution over billions of years and how it has been driven by natural selection and gene maximization. Then we will piece together how these have affected human behavior from various angles and go on to analyze in detail the nature of human selfishness – right from the family level to the greatest of the wars in human history. After this analysis we move on to developments in science & technology like the breakthroughs being made in areas of solar energy, biotechnology & genetics, nanotechnology, artificial intelligence and robotics. We will look at how these developments will transform human life like never before. In the last part, we will discuss the trends in society and economy in conjunction with the technological advances mentioned in the second part and try to draw a picture of mankind a few decades from today. Post this, I have summarized some key takeaways from this analysis and what I feel as the key areas that the people at large and the people's representatives in the governments must focus on for achieving a

great future for mankind.

This treatise does not provide any precise theoretical or empirical solutions like we have in the field of physics or chemistry. This is a compilation of essays on different topics affecting our life and civilization and what can probably be the future status. Social sciences have always had to make their way through the jungle of the unknowns using nothing but meaningful, educated guesses and build theories that can be then subjected to empirical verification. Social scientific research is and will always be tentative and imperfect, as Thomas Piketty says in 'Capital in the Twenty First Century'. Anthropology and economics both fall under the same category and these two form a major part of this book. If a sector presents trends that counteract each other but both have equal merits, then I have favored discussing both trends, even at the risk of sounding uncertain, rather than firmly concluding in favor of one, without enough evidence. Human predictions about the future will always be imperfect and there remains a big difference between what should be and what will be.

One can separately analyze and discuss the different systems in our body (like digestive system, respiratory system, neural system, blood circulation, etc.) A good book on human anatomy not only discusses each of these systems in sufficient detail but also explains how they are all interlinked and how they work together coherently. Similarly, most of the global issues that we see around us today are interlinked and need to be painted in one single, coherent picture. That was the thought process behind the attempt to write this book. The myriad collection of ideas mentioned in the book has come from various different generic sources. Many are either logical thoughts or information that is freely available on the internet. There has been immense amount of research in the fields of human psychology, genetics, nanotechnology, artificial intelligence, finance and economics in last few decades. However the research hardly reaches the common man due to the vastness of these fields and the technical nature of the research. I assume Think Tanks working for the governments and corporates would have put together a coherent picture about mankind's present and future but those are not available to the masses. I have attempted to do that – write a coherent story about mankind's past, present and future without using much technical language. The objective of the book is to educate and motivate a wider

audience and not to sharpen the understanding of a few elite. With that in mind, I have not burdened this book with graphs, formulas, footnotes and references; readers interested in acquiring further and deeper knowledge in any of the areas mentioned in this book can easily find multiple useful websites as the themes mentioned here are quite generic in nature. I confess it is difficult to write about so many areas of research and still contain it within a few hundred pages. It is very much possible that I have left out some segments because I thought them to be less important for the overall plot but which a reader might think to be quite important. In such a case I humbly request any and every reader to email me their thoughts and I promise to consider them for the next editions.

Some of the conclusions about the future trends that I have mentioned here might be difficult to digest for the reader at the first go – they were so for me, too. However they are mostly just careful extrapolations of the present trends, talked about by many full-time experts. But we should also be aware of the pitfalls of making such long term predictions in relation to such complex systems. Chaos theory tells us that in complex systems, even a small change in input can cause an unimaginably large change in the output. They jokingly say that a butterfly flapping its wings in Mexico can cause a typhoon in China. The world that we live in today is an immensely complex system and hence the need to stay doubtful while making any predictions. Even with that doubt in mind, I think it is preferable to take some stand about how the future would look like based on current trends as against not taking a stand at all. If all the people on earth share a broadly similar vision of the future and agree on what potential impediments we need to take care of, then our coordinated efforts can be much more fruitful in speedily taking us closer to our shared vision of the future.

I am a regular reader of zerohedge.com and really appreciate the gamut of topics they cover. Their style of letting the cat out of the bag on behind-the-scenes maneuvering at the global, national or corporate levels deserves appreciation. At the same time, it can’t be denied that their stories typically have a bearish bend and a new reader is bound to end up with a feeling that the world is going to the dogs. But during the last decade when I have been tracking global financial markets and global geopolitical scenarios, I have observed one key trend. Conflicts do happen and they do escalate. But in

every conflict, world leaders (at the global, national or corporate levels) have risen up to the occasion, burned midnight oil and have come up with some solutions or some compromises. Even in the worst case scenarios, they have been able to at least kick the can down the road and save the day. In my opinion, this comes from two things – one is increasing maturity in our leaders (just mentally compare your President or Prime Minister with any King ruling 500 years ago) and the second is increasingly distributed nature of power and lesser of it in the hands of each individual leader. The first is quite likely to be the result of the second but both these trends have turned out to be really useful for the society that we live in. Human history is filled with dire circumstances where anyone would have lost hope but our world has pulled through such instances and moved on. Sometimes these circumstances have caused extensive damage but the fighting spirit and resilient nature of humans always come up with some kind of solution to save the day and put mankind back on the growth path. To be future-ready, this fighting spirit and resilient nature need to be supported through better focus on developing new technologies and innovations.

I expect the book to form an interesting and useful read for the part of the world population that is as curious as me but due to paucity of time, cannot fully indulge in the process of joining the dots in different fields and form a coherent picture of the life around us. Keeping in mind the same paucity of time on the readers' part, I have skipped the basics on fairly well known things like solar panels and have spent more time and space in elaborating the impacts of these things on human life.

This book would have served its purpose if it increases the level of altruism in the world and if it improves people's perception towards new technologies like solar energy, artificial intelligence, biotechnology and molecular manufacturing. I would feel I am successful in the endeavor of writing this book if the readers take away just one key theme from this book and it is this: the human civilization is on the right path of progress and prosperity but we all need to *walk the path together*.

Grateful to the Heroes: As I mentioned earlier, I have simply compiled some powerful ideas and trends floating around us and conjecture about where they would lead. Every idea discussed in this book is quite generic and discussed

extensively by various thought-leaders. There are a few geniuses whose work has been truly inspiring and I would specially recommend the readers to check out their work. Richard Dawkins (has extensively written about evolution and natural selection), Rey Kurzweil (the visionary who started talking about Singularity way back in 2005), Lawrence Summers and John Mauldin (two renowned economists) have been very though-provoking. Many innovators, researchers and scientists are credited at appropriate locations in the text of this book. I thank all of these for the great work they have done or are doing for the wellbeing of mankind. Another class I want to thank is the class of technology entrepreneurs. People like Elon Musk are investing their intelligence, time and energy into ventures that are likely to help mankind progress towards a great future. They deserve a big thanks, good wishes & support from every one of us.

I am extremely grateful to my friends who reviewed early drafts of this book and gave honest feedback that helped me evolve this book into what it is today. I am also grateful to my friends who helped me in technical matters related to this book.

Lastly, I urge the reader to NOT stop his/her quest for knowledge when the book ends. A large number of websites & publications are available on the internet should the reader want to pursue any of the topics mentioned in this book in further detail; just pick the terms and keywords that interest you and hit Google!

Shashikant Maruti Wavhal

February 2016

Part 1: Role played by Genetics and Resources in Shaping Behavior

'The further ahead in time we want to forecast, the further back in time we should search' – Brad Delong

The deeper we dig, the more remains we find and the better the picture we can form about the history of the place. If we plan to understand human behavior and try making predictions about human society a few decades from now, we need to first analyze the past and the present. We need to decode human behavior into its basic elements and figure out how each element came to be in the first place. Understanding the interaction of these elements with each other is also equally important. Luckily we can take help from scientists who have quite extensively studied the behavior of various animals and the impact of various factors on animal behavior. There have been zoologists who have lived in jungles for decades just to study animal behavior. The foremost guiding light in this field is Charles Darwin whose theory of evolution resolved unanswered questions lingering in the human minds for thousands of years. It would be perfect to start part one of this book with this theory of evolution and how natural selection ensures survival of the fittest. We will then discuss the concept of Gene Maximization (GeMax) and how it affects the behavior of animals under different situations. We will discuss the importance of various types of resources in the gene maximization process. The importance of resources flows into the processes of allocating and controlling resources which give birth to various concepts of social hierarchy. We will encounter the reasons behind human selfishness and how it changes with different levels of resources. We will also discuss the broad origins of nationalism, racism and religions. We will also analyze the key conflicts and wars in human history on the basis of resource theory. The world seems to be on the verge of running out of some key resources and its implications will be discussed in one of the chapters. Putting all these pieces together, by the end of part one we will have formed a coherent picture about human history based on the GeMax and resource theory.

Chapter 1.0: The Puzzle called Human Behavior

"Human behavior flows from three main sources: desire, emotion and knowledge" – Plato

Since childhood we start thinking about the world around us and try to fathom the unfathomable – human behavior. The inborn curiosity initially spawns simple doubts but very soon we end up with unsolvable ones. Sadly, these doubts and questions become larger with advancing age and there are no readymade answers. These doubts haunt you for years. But one fine day, different pieces of the puzzle click into place unexpectedly and you have the answer to a question that haunted you for years. I recently had such an epiphany and I feel very happy to be sharing my thoughts with you here.

Long back, questions started popping up into my mind when I started watching National Geographic and Discovery channel. These were about why different animals behaved in strange and inexplicable manners. Later on, the questions about animal behavior changed into questions about human behavior. Understanding and predicting human behavior is a nightmare. Humans are friendly. Humans are hostile. Humans are kind. Humans are cruel. Humans love. Humans hate. Humans are hardworking. Humans are lazy. Humans are generous. Humans are stingy. Humans say something and do the opposite. Why do humans behave like this? Especially the behavior towards other humans under different conditions can be very perplexing. A person X can be very helpful or very caring towards person Y but not at all so towards person Z. In fact it is quite possible that person X is neither helpful nor caring towards person Y at a different point in time. This question turns into an even bigger multidimensional question when we consider how groups of people behave with each other. The groups can be of any type, big or small, starting from a family to a county to a nation or a religion. An honest man can find himself in a maze of changing loyalties & priorities and would wonder why can't life's decisions be simple? What is & should be a person's real priority?

Chapter 1.1: Stories of Animals

Let’s start our journey in the African jungles filled with all kinds of dangerous creatures, right from ferocious lions to poisonous spiders.

For our first example, imagine a small lion pride which has one lion, a few lionesses and a few cubs. When a new lion defeats the incumbent pride-owner and takes over the pride the first task he undertakes is to kill all the cubs because they are fathered by the previous lion. Lionesses, on the other hand, try their best to hide their offspring from this attacker. After the infanticide is complete, a new cycle begins and the new lion and lionesses procreate and grow the pride.

Now we wonder why the new lion kills the cubs that posed no harm to him and who might have grown to enhance the herd’s hunting prowess. Would animals of the same species not care for each other? Is a group (like a herd) not the basis (the key unit) for survival and prosperity? This example leads us to believe that an individual animal (and not the group) may be the key unit for survival.

Now let’s look at another example. This one is about the mating of a male Black Widow spider and a female Black Widow spider. Post mating, the female spider eats up the male spider and, it seems he also doesn’t mind getting devoured. If, as mentioned in the earlier example, the individual is the key unit for survival then why doesn’t the male spider not try to defend that key unit, meaning himself? What would a male spider achieve by getting eaten when compared to some other male spider who is happy eating flies and never goes near a female spider? Given the fact that the female spider receives a boost of proteins by eating the male spider and then goes on to lay hundreds of eggs might give us some clue. The spider who got eaten will have hundreds of baby spiders down the line but the spider who kept eating flies and never went near the female spider will never have babies and would perish without a legacy.

A similar example is that of lizards. In some species of lizards, the male lizards are endowed with very bright colors which, as per scientists, help in signaling and attracting the females of their species. The downside is that these bright colors also increase their exposure to preying birds and other hunters. So the male lizard is also in the same evolutionary quandary – either

have dull colors and die childless or carry bright colors and be ready to be eaten by predators. Obviously it is not a conscious choice given to the lizards but a way in which natural selection works.

This ‘sacrifice’ does make some kind of sense. In human society also, we see many people doing everything in life for their kids. There are stories and legends about many fathers and many mothers who willingly sacrificed their lives for their kids. So this thought process leads us to believe that individual is not the key unit for survival but having babies is the key. Animals would typically do anything to ensure their babies’ survival, it seems. Probably the lion in our earlier example wanted to eliminate any potential competition for his own cubs and hence undertook a pre-emptive strike against the existing cubs. This might also explain the lionesses’ behavior who try hiding their cubs from the new lion. The mothers care for their own cubs and as our current thought process is telling us, the kids are more important than the individual.

Keeping that in mind, let’s talk about a story I had heard when I was in school. The story is of the great Moghul emperor Akbar and his friend and advisor Birbal who was famous for his wit and intelligence. It goes like this.

As some readers might be aware, Akbar frequently tried to pose tricky questions to the members of his court and every time Birbal came up with a surprising answer. Given this history Akbar was always looking for a way to outsmart Birbal. One day when they were taking an evening stroll through the royal gardens, they saw a bird feeding her babies. Akbar said to Birbal, “Motherly love is the greatest love on earth” thinking that this is a universally true statement and Birbal will have no other option but to agree with it. Birbal, however, said that there was another form of love higher than motherly love and he would prove it. The next day Birbal took Akbar to a few feet deep, square-shaped dugout built in the royal gardens. The accompanying soldiers put a monkey and her small baby in the dugout and then they started filling the dugout with water. As the water started rising the mother put her child on her shoulder to save it from drowning. Akbar looked at Birbal with a smile reminding him of his stance the previous day. Birbal said nothing and kept watching. As the water rose to shoulder level, the mother put her baby on her head. Birbal still did not meet Akbar’s gloating gaze. As the water kept rising and the mother could not keep out of it even

after standing on her toes, something unexpected happened. The mother took her baby and put it under her feet so as to keep her own nose out of the rising water and stay alive. Birbal immediately stopped the show and asked the soldiers to quickly rescue the mother and the baby. Then Birbal turned to Akbar and said, “Your Majesty, self-love is the greatest love on earth.”

From our own experiences we find that all the people at some times and some of the people at all times exhibit great self-love or, as we call it, selfishness. We ourselves would have achieved something in our life that came at the cost of somebody else. And it is not specific only to mankind, we do find some examples in the animal kingdom. When a lion is in pursuit of a deer in the grasslands of Savanna, there are some deer standing nearby, jumping up and down. Scientists have conjectured that the reason for doing this is to show the lion that “I am a strong and healthy deer and you won’t be able to catch me. Better focus on some other deer.”

But if self-love is the topmost priority of animals then why did the male spider in the earlier story sacrificed himself? We seem to be stuck in a circle and to solve the mystery we need to go further deep and understand how evolution works.

Chapter 1.2: Evolution and Mutation

Some tourists in the Chicago Museum of Natural History are marveling at the dinosaur bones. One of them asks the guard, "Can you tell me how old the dinosaur bones are?" The guard replies, "They are 73 million, four years, and six months old." "That's an awfully exact number," says the tourist. "How do you know their age so precisely?" The guard answers, "Well, the dinosaur bones were seventy three million years old when I started working here, and that was four and a half years ago."

The guard might not know much about natural history but I am sure you know a fair bit. Like, evolution is nothing but how organisms change over many generations. The flora and fauna present on earth millions of years ago was not the same as what we see today; they changed over generations. This change is called evolution and it is caused by various factors. Billions of years ago, the volcanoes, storms and the chemical soup existing in the oceans gave birth to some interesting organic compounds. If you believe in extraterrestrials, Earth was seeded with these compounds by some Superior Beings. Then, through some unknown mechanism, these compounds then formed even more complex compounds and a symbiotic cohabitation of such compounds gave rise to simple cells. Some of these simple cells cohabited to give rise to complex cells which could perform many more functions and had a better survival rate. Then collections, or colonies, of such complex cells grew and grew till they took the form of plants or animals, each of which would be having billions of cells cohabiting in the most suitable manner.

Various theories have been proposed over last two centuries for explaining the evolution mechanism but the one that is generally accepted today is the theory of evolution proposed by Charles Darwin in his book “On the origin of species” in 1859. This theory basically says that various traits are passed on from the parent to their offspring. Some of the traits give the offspring an added advantage for survival (very much required in this big bad world!). Some traits may be harmful and they would hamper the survival rates of the offspring vis-à-vis other members of the same species. Darwin goes on to say that the process of ‘Natural Selection’ would then favor the offspring with more useful traits and over time we will find the trait becoming more common in the species with each passing generation. That is the typical process of evolution as proposed by Darwin.

Why would some members of the species have traits that help in survival and some members be burdened with traits that impede survival? This, scientists have found out, is just a question of chance. The reproduction processes in living organisms have developed over millions and billions of years and have reached almost the perfect stage where the genes from the parents are quite faithfully expressed in their progeny. Genes are the codes that dictate the formation of various different proteins, chemicals and different physical traits.

Let me explain this mechanism with a very simple example – the color of our eyes. The color of our eyes depends on the Melanin content in our irises. This is the same pigment that gives color to our skin. The Melanin content is governed by a set of genes. During the reproduction process, father's and mother's genes mix to form a set of genes for the child. These genes, when expressed in the iris cells, dictate the cells as to how much of Melanin is to be produced. The result is observed as the color of the child's eyes. As mentioned above, this process has been perfected over millions of years and hence the chances of incorrect copying are less than one in a trillion. If both parents have black eyes then they will pass on the same set of genes to their child and so the child would typically have black eyes.

But there are times when the system doesn't perform as designed. In such rare cases, the copying of some parts of genes is not as required due to some indigenous or external factors. The new, 'different' gene is called a Mutated or Mutant gene and the process which led to a new gene is called Mutation.

To continue with our example of the eye color of the black eyed couple and their child, sometimes it can happen that the mutation process gives the child a different (modified) set of genes compared to its parents. In such a case the child can turn out to have light brown eyes if the modified genes dictate the iris cells to produce lower level of Melanin pigment. But as we know mutation happens rarely and hence it's not very often that parents have children that look vastly different from them.

Genes don't just govern the form factor (how the organism looks from outside) but also each and every process inside the body. Right from the enzymes required for digesting food to the white blood cells required for fighting viruses, everything is decided by the genes; they are like the production planning charts in a factory. The ongoing gene research has

helped us decode the impact of various individual gene sequences, meaning what each gene sequence governs inside our bodies.

Whenever there is a gene mutation, the offspring will have a new, different, changed level for the property (trait) governed by that gene. Just as you know, in life some changes are good, some are bad and some are just meaningless. Thus genetic mutation is what leads to the formation of new good or bad traits in organisms. An animal with the new, mutated quality will pass this new trait to its offspring, if it can survive till the reproduction age. If the new trait is useful for survival, the offspring will have a higher chance of surviving and passing on its genes to its offspring. In fact, if it survives longer than its peers, it will have a chance to father more number of babies which would carry the new gene. Pretty soon, meaning within a certain number of generations, the whole herd will be full of members carrying that new trait. That would now be an ‘evolved’ species, so to say.

Let us discuss a simple example that explains this phenomenon. Suppose we are looking at a herd of deer in the African jungles. For them, life is somewhat straightforward - run to be safe from lions and other predators, eat grass and produce babies. Assume that one fine day, a baby is born with a mutated feet. Suppose this mutation is 'good' as it will help that deer in running a bit faster than other deer. So, on day 1, we have just 1 mutated deer amongst a hypothetically large herd of, say, 100,000 deer. So the percentage of mutated deer amongst the overall population is 0.001%, an apparently insignificant and meaningless percentage.

We will make 4 simple assumptions (Please note that this is a very simplified set of assumptions just for illustration purpose; one can build a very rigorous model with real-life assumptions and obtain more accurate but broadly similar results):

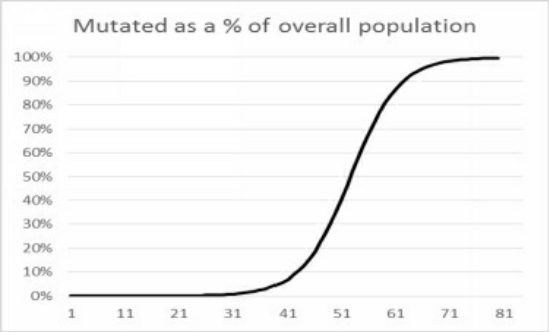
1. The reproduction age for the deer is 2 years

2. We assume that each male or female deer gives birth to four babies.

3. The mortality is assumed to be 50% - meaning 50% of the baby deer die before reaching 2 years of age. This is mainly due to hunting by lions, cheetahs, hyenas and other predators. Other factors like diseases, starvation, floods also contribute to mortality.

4. For the mutated deer (mutants), we assume the mortality at 40%, lower than normal deer. If a deer can run faster than others, it is quite natural that it will not fall behind and become food for the hunters and hence it will have higher chance of surviving. We are basically assuming that mutants are 20% better at running and surviving than the non-mutant deer.

Now using these assumptions, we calculate the number of mutated deer (mutants) in each subsequent generation and plot it in a chart, with number of generation on the X axis and the percentage of mutants in the population on the Y axis.



We get a chart that looks like an S and it is actually called ‘S-curve’. Because of faster speed leading to better survivability, mutated deer will have better chance of reaching reproduction age and giving birth to offspring. These offspring will also carry the mutated gene and will be counted amongst the mutated population. Offspring with mutated feet will, in turn, improve their ratio in the next generation and the cycle will continue.

In the S-curve we find that the mutated population is not meaningful even till the 30th or 40th generation. But after a certain threshold, the process of spread of mutation picks up speed. In our graph, the mutated population jumps from about 5% by 40th generation to about 95% by 65th generation. Thereafter the spread slows down and by 80th generation, the whole herd is made of deer with mutated feet.

As each generation is of 2 years, this whole process has taken just about 160 years. That is the beauty of processes like evolution which follow the S-curve. The start is so slow that it feels meaningless, but beyond the 'knee' phase the graph just takes off vertically and then stabilizes towards the end.

The time period of 160 years might look high in absolute terms but when put

into the context of Earth's age of 4.5 billion years, it's just miniscule. Organisms have been evolving on Earth for millions of years and this has proved to be an ample time for many trials and errors in the evolution process.

Mutation and evolution are completely random processes. Nobody can predict which gene would mutate and whether it will be for good or bad. If the mutation is bad (meaning it is hurting the animal's functioning), the mutant may not survive till the reproduction age and thus the mutation will not be passed on to its offspring and that will be the end of that mutation. Helpful mutations, on the other hand, spread throughout the population over generations. Here I urge you to notice a key concept i.e. *the unidirectional nature of progress – helpful gene mutations spread, unhelpful gene mutations perish*.

Evolution is not just about 'change' but about ‘survivability’. Evolution is famously defined as 'Survival of the Fittest'. This 'fit' is not in absolute terms but in the context of the animal's surroundings. If the surroundings change drastically, the animal, even if previously the fittest, may not survive. The best example of this is (obviously) dinosaurs. They had evolved to be the best and fittest on Earth but one asteroid strike changed the Earth's atmosphere and dinosaurs went extinct in no time. They couldn't 'survive' because they were no more the 'fittest'. Some small mammals living in that age turned out to be better suited to the environment. These then evolved to be today's mammals – right from humans to whales.

A very interesting example of evolution process is the use of sound waves by bats in navigation. Bats, as you know, hide from predators by hanging inside caves during the day and they set out to hunt at the nightfall. As the illumination level is very low at night, normal eyes are of no use for night hunters. If hunters are not good at hunting, they will soon go extinct. So they need to evolve. As evolution is random to begin with, a night hunter can either develop sharper night vision (what we see in case of lions) or sharpen some other senses. Bats have evolved into using reflection of ultrasound waves to accurately and instantaneously gauge the distances to any objects including obstacles and live animals; this process is called Echolocation. They emit an ultrasound wave from their mouths which strikes the object in front and bounces back (similar to a light beam bouncing back from a

mirror). The bat's ears catch and hear the reflected wave. The bat's brain calculates the time lapse between the emitted ultrasound wave and reflected ultrasound wave and calculates the distance to that object. In case of a moving target the bat's brain can calculate the relative positions quickly even when the bat is in motion and the target (say, a mouse) is also in motion. This superb computational ability of bat's brain is the result of thousands of years of evolution. The random mutations in body parts (throats, mouths, ears, brains) which helped bats become better at night hunting were accumulated during the process of evolution and population of these mutant bats overwhelmed the population of other bats which had no mutations or unhelpful mutations. Please keep in mind that the development of so many body parts would have happened over thousands of years; the probability of many useful mutations happening in one generation is abysmally low.

If evolution and mutations are random, one might logically expect bats evolving separately (living in different geographies) to have developed different echolocation techniques – and this is indeed true. Bats of different types are found to have different specifications for their echolocation systems. Those feeding mainly on scorpions have very low sound intensity than those feeding on moths and other fast moving prey. Bat species flying in mainly open spaces use longer pulses in their echolocation system than the bat species which mainly fly in cluttered spaces. Evolution process weeds out inferior organisms (remember Darwin's 'Survival of The Fittest') and leads to the best possible option for any given system. The process of evolution weeds out even the inferior body parts and an interesting example of this is the Ganges river dolphins. The river water is so muddy that visibility is near zero and the Gangetic dolphins have to rely solely on echolocation technique for hunting and navigation. Eyes have no use for these dolphins and hence during the process of evolution they have lost these unused, unhelpful body parts. Gangetic dolphins are born blind.

This discussion about evolution tells us that evolution process is random and it is filled with jerks and shocks. It also tells us about the importance of mutations and genes that lead to different traits in organisms.

Chapter 1.3: Gene Maximization (GeMax)

In last chapter we saw that genes are the key building blocks characterizing any animal and superiority of genes in a given atmosphere will decide if the animal will flourish or go extinct.

Given the fact that animals do nothing but eat, sleep, run (or hunt) and procreate, we can decipher that a key objective of animal's life is to give birth to babies and in that process, pass on their own genes to them.

To figure out the ultimate objective of life, let's juxtapose this with the observations we got from our earlier stories. Animal behavior sometimes seems to be guided by love (or care) for its group or babies or self and sometimes it doesn't. I am sure you have picked up on a commonality between these three – they all have some common genes.

In very small organisms like bacteria, asexual reproduction is quite prevalent. The mother cell just grows and splits into two identical cells which carry the same genes. In case of higher organisms like mammals, sexual reproduction is the norm. Under a process known as Meiosis, Mother's egg and father's sperm (called female gamete and male gamete respectively) pool in their genetic material to form the baby embryo (the first cell that later on grows into a full baby). In a process called Genetic Recombination, the two set of genes mix and match to form a new set of genes for the baby with some coming from mother and rest coming from father.

We humans carry 46 chromosomes in the form of 23 pairs in all our cells. Each chromosome is made up of genes and genes in turn are made up of DNA sequences. In the meiosis process, reproductive cells like the female’s egg and the male’s sperm carry 23 chromosomes each, fusing together and resulting into 46 chromosomes for the baby, just like its parents. The baby will resemble its mother in some features and some features will be similar to its father because various genes control various internal and external features and a baby randomly receives some genes from its mother and some from its father. Just to take a simple example, a baby might have nose and jaws like its father and eyes and ears like its mother. Even height, body type and other physical features of the baby depends on the genes it receives randomly from its parents.

Now comes a very interesting idea. The reproduction process which randomly propagates parental genes into the next generation also tells us that genes are shared amongst the family members and relatives. You have received some genes from your father and your siblings did, too. Ditto for some of your mother's genes. So you share some genes with your siblings and your dad shares some genes with his siblings, who, in turn have passed on their genes to their kids, meaning your cousins. So you share some genes with your cousins. And taking the logic further, you share genes with your distant cousins, people of your community and people of your village, town and nation (who are your distant blood relatives from past generations). Obviously, more genes will be shared in closer relations – the similarity between you and your siblings is stronger than the similarity between you and your cousins, which in turn, is stronger than the similarity between you and your distant cousins. It is easy to see how the impact fades with passing generations. The son of Mr. John Smith will receive approximately 50% of his genes from his father and rest from his mother. The grandson of Mr. John Smith is likely to share half of that, meaning approximately 25% of his genes with Mr. John Smith. Another way of putting it will be that the grandson has genes coming in from four grandparents so about 25% from each grandparent. We go down a few more generations and pretty soon, we find that the descendants carry very few genes of Mr. John Smith. If Mr. Smith had a prominent nose, many of his kids might have a similar one but down the generations, the prominent nose will be seen in a very few cases.

Let's juxtapose the shared genes concept with how much people typically care for other people and see if there is any relation. Typically, any person loves himself or herself the most and what is the commonality of genes with oneself? 100%! Moving on, a person typically cares for his parents and siblings more than people outside the family. The commonality of genes between a person and his/her parents/siblings is approximately 50%. With cousins, the commonality of genes falls to about 25% and it falls further by 50% with each step away from the person. Based on this, there seems to be some relationship between the percentage of genes we share with a person and the love and care we have for him/her. We can make a broad behavioral statement that a person will tend to favor a person with whom he/she shares more genes. What if there are more than one person to be compared and prioritized based on gene sharing? Then the decision criterion will be the sum of genes on each sides. Actually genes are not like apples or oranges whom

we can easily add or subtract but still, if we need to compare two groups of people, we can generally do the math at the subconscious level and come up with an answer. If you need to compare between a group consisting of three cousins and a group consisting of ten strangers, you will not need a calculator to figure out that the first group carries more of your genes.

Let us take this example of comparison to an extreme level. Assume a man travelling through a jungle with his three kids meets an armed robber who intends to kill them all. Now assume that the man cannot run away with all the kids but he can run away alone and save his life. The other option he has is to fight with the robber but this action carries the risk of losing his own life. It is possible that the man may run away alone but it is more probable that he may try to fight with the robber and save his kids even at the cost of his own life. What goes on in his subconscious mind that leads to that decision? Let's look at it from the gene angle. The man carries 100% of his own genes. Each of the kids carry about 50% of his genes. By running away, the man can save himself, meaning 100% of his genes. By giving away his life but saving the kids he leaves behind more than 100% of his genes (remember it may not be a straight addition of 50+50+50=150 but it is certainly more than 100%, meaning his own gene pool). His kids, in turn, will grow and have kids, thereby passing the father's genes into next generation. So from this example we can tentatively hypothesize a person is likely to take a decision that chooses a course of action that maximizes the chance of survival for his/her genes.

The famous evolutionary biologist Richard Dawkins has reached the same conclusion (via a different line of thinking) in his book 'The Selfish Gene', first published in 1976. He proposes that *'genes' make organisms behave in a way that maximizes the chances of survival of those genes*. That is the reason he calls them 'selfish genes' – *they ensure their own survival*, sometimes even at the cost of (i.e. demise of) their owner/carrier. This is a very potent concept and I urge my readers to peruse this original work whenever possible.

Over the course of this book, I endeavor to apply this theory of gene maximization to explain hitherto inexplicable behavior patterns of different animals including humans. For the sake of brevity, let me call this gene maximizing behavior as GeMax (pronounced as Gee-Max). As discussed

earlier, GeMax is a subconscious decision making process, exhibited by various animals. Let me start the explanations with the examples of animals mentioned in the first chapter of this book.

The lion which killed its predecessor's cubs and the lionesses which tried to hide them did exhibit GeMax. The lion shared hardly any genes with the cubs he killed and thus, by killing these cubs he can make the lionesses ready for his own cubs which will share his genes and thus maximize the survival of his own gene pool. The lionesses already share their genes with the existing cubs and they will share their genes with the new batch of cubs equally. So, for them both batches are of equal importance. In fact, the first (existing) batch of cubs is somewhat better from the survival angle because they are already in this world and have gone through the initial phases of life whereas the new batch of cubs may have problems at birthing, feeding, etc. So it makes immense sense for the lionesses to try to save their existing batch of cubs by hiding them from the new lion. This is nothing but GeMax behaviors exhibited by the lion and lionesses both, leading to different (actually, opposite) courses of action but which are both justifiable using the simple straightforward logic of GeMax.

The male 'Black Widow' spider we discussed earlier has two options in life. One is not mating with the female ever (because she eats him after mating) and just live a happy life. With this option, the spider gets survival of 100% of his genes for a finite period. The second option is to sacrifice 100% of his genes by mating with the female spider but have his genes delivered to hundreds of baby spiders. At least a few tens of them will ultimately grow to be future spider moms and dads, spreading the male spider's genes further. The male spider clearly picks the option which leads not to his own survival but which maximizes the survival of his genes, a classic case of GeMax.

Similar logic can be applied to the brightly colored male lizards we discussed earlier. Lizards can either be (a) dull-colored, safe from the predators and die without offspring or (b) they can take a chance, be brightly colored and have higher chance of mating with females and passing their genes into the next generation; but risk getting spotted by hunters, too. From the number of brightly colored lizards today, we can figure out the preferred option.

Please keep in mind that the spiders or lizards are not making conscious choices – they are just part of the evolution game that goes on over thousands

of years and as a result, the behavioral choices are ingrained in their subconscious. The animals making inferior choices (from GeMax point of view) will die without babies and will be eliminated from the gene pool. After many generations, the animals in the gene pool will be those who happened to have taken the right decision (meaning whose traits and behavior happened to be fit for surviving in the given conditions) and by now the decision, the choice, the action comes as a second nature to these animals. The male 'Black Widow' spider does not consciously sit and think about approaching the female spider, it has become his nature, his trait after generations of his ancestors doing the same. Those who hesitated were swiftly eliminated by the evolution process. Today, if there were to be a male spider with a mutation that makes him worry about getting eaten by the female, the spider will die childless and that particular mutation will end without affecting anyone else from the species. *The force of evolution process is such that anything supporting GeMax is accepted and spread throughout the species (like the feet mutation helping the deer run faster) and whatever is not supporting GeMax is discarded* (like the spider mutation we just discussed).

Now let's discuss the behavior of Birbal's monkey. As you know, when they were being gradually drowned, the mother monkey first tried to save her baby but afterwards tried to use the baby to save herself. Initially when the water was at lower levels, she may have subconsciously thought that both of them can get out of this risky situation so she helped her baby by holding it over her head. As the water level increased and she herself started drowning, what were her choices? Either keep holding the baby up till she drowns or try to stand over the baby to save herself. In the first option, she is surely scarifying her own genes and taking a bet on her genes carried by her baby. But is there any hope for the baby after the mother is dead? It would be a miniscule hope, indeed. On the other hand, if the mother can somehow save herself by standing on the baby and keeping her head out of the water, she is taking a bet on herself. If she survives, she can give birth to more offspring and ensure survival of her genes. So this episode also seems like a good example of GeMax.

Subconscious behavior means something that comes naturally, it doesn't have to be taught. A newborn fish knows how to swim, it doesn't need to learn the physics and chemistry of water. Similarly, GeMax based actions are

exhibited by even newborn baby animals. It is found that many a times the firstborn amongst a batch of baby birds uses his size advantage to push one or two smaller babies out of the nest. If there is food scarcity, the firstborn is ensuring that now more food goes to itself, thereby ensuring survival of its genes. Other babies are not innocent, either. Typically, at the time of feeding, the babies make a noise which lets the parent birds know who is hungrier and accordingly feed it more. This noise can also increase the risk of a predator finding out the location of the nest. For both these reasons, parent birds quickly try to satisfy the baby making maximum noise and make it go quiet. In a world where the risk of predators and competition with its siblings affect the chances of survival, even a baby bird subconsciously decides (or learns) to pretend to be much hungrier than actual and make noises louder than its siblings.

Another interesting example is that of a sand tiger shark. Large sand tiger sharks don't hesitate to eat the smaller ones in the group and such an event nullifies all the time and energy the mother shark put into making babies. In this case, evolution has led to an amusing result. Female sand tiger sharks keep the eggs inside and directly give birth to babies when they are old enough to face their uncles. Inside the womb of the mother, the first baby shark born uses its first mover advantage to start devouring the unborn eggs around him (which are actually his siblings) so as to get more nutrients for himself, achieve faster physical growth and minimize competition inside and (in future) outside the womb. So here, we find that GeMax is working at two levels – mothers birthing babies instead of eggs and newborn babies eating their sibling eggs.

GeMax seems to work when we want to explain behavior of humans and animals but what might be the reason for 'genes' being the key unit of survival? Research is still on for this query but a possible reason can be that genes are the smallest units carrying particular traits inside the living organisms. As we go to a scale lower than genes we meet the DNA, whose job is to decide what proteins and chemicals will be synthesized in the cells in the body. DNA is more about the production of basic building materials whereas genes are the building blocks for distinct traits.

In plants, the survival and evolution is dependent mainly on the external factors. For example, the plants that make tasty fruits will find their seeds

being spread by the birds to faraway lands and hence greater survival. Plants with bitter fruits will not find many takers and will be left with just a few descendants growing out of some fruits falling nearby and taking roots. There are examples of some plant seeds having evolved to be able to fly in the wind and travel modest distances but even these are no match for the evolution in animals.

In animals, the evolution process is faster because any mutation will get a faster positive or negative response from its surroundings. Additionally, animals have the ability to make decisions and act on decisions. As a simple example, an elephant in a jungle may have the option of going to the river or to the lake to quench his thirst and he may choose any option based on his mood and his perceptions of risk and reward involved. So this ability to 'act' combined with the GeMax behavior driven by selfish genes present inside lead to many exciting results.

First of all, evolution process changes from purely passive to slightly active. A simple example will be a dolphin looking for food. Dolphins communicate using sounds – whistles, chirps, screams and clicks. So when it finds a nice bunch of fish it would call its group members by sounds. The group is made up of family members and relatives which share genes with the first dolphin. The larger the inviting sound made by the dolphin, the more group members it can call in for lunch. After all, more food for all group members will mean higher chance of survival for the genes of the first dolphin. What if the sound can also attract predators like sharks or whales? In such a scenario, a louder lunch announcement can actually result into a predator attack and a resultant drop in the number of group members and obviously, a lower chance of gene survival. A dolphin would instinctively / subconsciously decide the optimum loudness level of communication sounds they should use. The dolphins with wrong instincts have gone extinct during the evolution process over thousands of years.

On a lighter note, we humans also take great efforts while deciding about sharing food amongst family members and distant relatives; especially if it is an occasion like a marriage in the family where scores of hours are spent in deciding who should be invited and who should not.

Chapter 1.4: Resources are the Key for GeMax

In the last chapter we saw how GeMax based decision making explains the behavior of animals in various different conditions. In some conditions, they end up favoring themselves; in some conditions, they end up favoring their babies and in some conditions they end up favoring the whole herd. Apart from the subconscious math of ‘who is sharing how many of my genes’, there is another very important dimension in this decision making and that is availability of ‘resources’. At a very broad level, *Resources can be defined as each and every thing that supports GeMax or is required for GeMax.* As GeMax is the central process governing life of every organism on earth, resource availability is extremely critical. Study of resources leads us to the answers of many of our doubts about life.

What are the methods for GeMax, for maximizing your genes? You yourself carry 100% of your genes so in order to maximize the survival rate of your genes, you need to first survive as long as possible and as healthily as possible. In fact, that is why ‘suicide’ is such an abhorred thing in the human thought process and unheard of in animal kingdom (mass suicides of lemmings is a myth). What more will you need to maximize your genes? You need to have as many children as possible and also ensure their survival. You can also try for a good number of grandchildren who will also carry some of your genes. The same logic can be extended for future generations, but keeping in mind that with each generation, the percentage of genes carried ahead keep on falling. So finally your genes, your children’s and grandchildren’s and great-grandchildren’s genes put together is the GeMax objective you have achieved. Rather, this is how the selfish genes inside us make us subconsciously think and make us crave for resources that support this goal.

Chapter 1.4.1: Food as a Key Resource

'Worthless people live only to eat and drink; people of worth eat and drink only to live' – Socrates

So what resources will you need to carry out this plan? The very basic and most crucial resource is food – you cannot survive without food; you cannot procreate if you are not well fed or at least, fed to a certain level. Your children will need food for survival and growth. Within food, various different nutrients are needed for various different functions within our body and these are acquired from different sources. An interesting example of this is when cattle or deer visit salt-lands and lick salt-rocks so as to acquire mineral nutrients which they might not be otherwise getting from their normal food sources like grass and leaves. Food is special for humans, too. Why Master Chef is one of the top rated program in almost every nation is not a surprise. Which are the foods that we humans crave the most? Typically it is the (a) crispy fried food like chips and French fries, (b) food loaded with sugar and fats like cakes and ice-cream and (c) food high in carbohydrates like breads. A research team at University of Michigan recently conducted a study on the most addictive foods and the top 5 most addictive foods were found to be Chocolate, Ice-cream, French fries, Pizza and Cookies. The reason for such preference is easy to explain. The constituents of these are mainly fats and carbohydrates (including sugar) and these are the easiest sources of calories for the human body. Thousands of years ago, during the process of human evolution it was necessary to spend many hours hunting animals for lunch or looking for some edible fruits and roots for dinner. Such a situation not only increased the risk to life (from predators in the jungle and hunting accidents) but also left less time and energy for procreation. Hence any food which is easy to digest and can provide higher number of calories quickly will be preferred by the body – it is just another subconscious learning our genes have acquired during the course of evolution. Foods like raw vegetables or half-boiled vegetables are difficult to digest and have more fiber content which remains undigested and is thrown out of the body. That further reduces the usability (digested to ingested ratio) of the food and makes it less preferable to the body (the subconscious mind). That is the reason why human body inherently prefers junk food and dislikes vegetables. The past history of erratic food availability also led to animals' tendency to eat voraciously when food is available and go hungry for long periods when

it is not. Humans typically need about 2000 calories per day but can easily consume two times that in a day. Grazers like cattle developed multiple stomachs just to store more food quickly before the hunters came attacking. Their digestion system evolved into two separate parts – collecting food on the go and chewing/ digesting later at a safer location. Snakes evolved loose jawbones so as to swallow larger prey. The best example would be a python being able to kill and swallow a whole deer and then go for months without food. Evolution has taught this great lesson to all – accumulate when available, consume when required.

On a side note, even though this thought process explains why humans crave feasting on junk food, recent medical research has shown that it should be avoided completely because it causes multiple ailments such as diabetes, hypertension, heart attacks, strokes and various types of cancers. The craving for fatty and sugary food was acquired by human body thousands of years ago when any and every type of food was very scarce. At that time the common people could enjoy calorie-rich food just a few times in a year, during some special occasions. With innovation in agriculture and food processing, junk food is now easily available and affordable. People can now easily consume thousands of calories but if they don’t do physical work or exercise regularly to get rid of the accumulated calories, the health problems will be just round the corner.

Chapter 1.4.2: Money / Wealth / Assets as a Key Resource

'When I was young I thought that money was the most important thing in life; now that I am old, I know that it is'.
– Oscar Wilde

Moving on from food, what is the next key resource? We need money to buy food and everything else so money is an important resource. As such, money has multiple forms and multiple functions. The first is that money is a unit of accounting. We all express our wealth, assets and liabilities in dollars or some other currencies but never in terms of millions of pumpkins or thousands of pillows. That will be too cumbersome. Money also functions as a medium of exchange. If you are a wheat farmer you will sell your wheat for some money and then buy other things like shoes or a car with that money. A few centuries ago, when money system was in its infancy, barter system was prevalent where a wheat farmer would go to a cobbler and exchange wheat for shoes. Even then, it would have been too cumbersome to remember exchange rates like one bushel of wheat is equal to a pair of shoes is equal to twenty mugs of beer is equal to one and half sheep and so on. Use of money has streamlined trade very nicely. To make this discussion on money more fun, here is a brilliant joke on money:

A teenager once lost a contact lens while playing basketball in his driveway. After a brief, fruitless search, he gave up. His mother took up the cause and within minutes, found the lens. "How did you do that?" he asked. "We weren't looking for the same thing," she explained. "You were looking for a small piece of plastic and I was looking for $150."

The joke indirectly points out the third use of money – it is a store of value. In fact, anything that can store a perceived value can act as money in this sense. Can an apple act as a store of value? No; because it doesn't last beyond a few days. Stones last for centuries; can they act as money? Yes, they can and they did in some cases. About a thousand years ago, people on the Yap Island in the Pacific Ocean used giant circular disks made from limestone as their currency. It was called Rai. As you can imagine, it is literally impossible to carry large stone disks with you every time you go for shopping. So the Yapese people found a simple solution. The Rai stones were

kept wherever they were but the ownership was publicly transferred during each transaction and the records of all transactions were stored in the public memory. Announcements like “the Rai lying near the river bend, belonging to John is henceforth owned by Peter in exchange for twenty cows” would have been quite common amongst the Yapese. We can call this the earliest ancestors of today’s dematerialized assets (like shares and bonds in their non-physical, electronic form). As you can imagine, it becomes unwieldy to maintain records of stone ownership when the society becomes large and number of transaction grows exponentially and then the society has to shift to an easier form of currency. There are many other interesting examples of money in world history. These include wages to Roman soldiers in the form of salt (hence the word salary), cheese, cocoa beans, squirrel pelts, potato mashers, knives and metal snakes. In normal conditions, money can be easily converted into any type of assets or resources. Properties like houses, farms, land, etc. cannot be used for day-to-day transactions but they are stores of value (because you can sell a property even after a hundred years to get cash) and hence similar to money from that angle. In recent times, other assets like stocks, bonds, precious metals and alternate assets (like art, wine, vintage cars, etc.) have become alternate ‘stores of value’.

Starting with the tenets that human behavior is a continuous stream of GeMax decisions and money/assets are one of the key resources for fulfilling GeMax, we can explain much of the human behavior towards money and its various forms. Just like our genes (i.e. our subconscious nature) ideally prefers maximum amount of quick and easy calories human nature tends to prefer maximum amount of money and assets with minimum inputs of time, energy and costs. Let us start with some contrasting examples. Imagine a person of medium age having a few kids and steady source of income and/or sufficient accumulated assets which provide him/her reasonable assurance for own survival and the survival of children/grandchildren then the GeMax decision process is likely to make the person more conservative and not take much risk with the income or assets. On the other hand think of a young person who doesn’t have enough assets and no steady means of income to help him achieve the subconscious objective of GeMax i.e. marriage, kids, grandkids, well-funded retirement, etc. Such a person is very much likely to become a risk taker because under the current set of rules, he has nothing to lose; with the current path he is likely to leave the world without passing on his genes. On the other hand, if he can pull off a risky venture, the resultant

resources (money, assets and others) can help him meet his GeMax objective. This is the subconscious thought process at work and hence sometimes uncontrollable by the conscious mind (what we call as impulse). Crimes committed to seize other person's assets come under the category of such risky ventures. Youth is more headstrong and acts on the impulses whereas a middle aged person might have some worldly experience and maturity which will control the impulses. Unemployment (or unsteady employment), lack of education, utter poverty are factors that typically affect a person's ability to generate a steady income. With this logic, we should see a higher percentage of criminals coming from categories like youngsters, unemployed, less educated and utterly poor (and combinations of these). This theory is actually corroborated by data in the real world. Various government data and many research papers prove that there is a direct relationship between these categories and crime. Various other factors like race, work issues, family issues, psychological and other health issues certainly affect a person's propensity to commit crime but a simple GeMax metric (combination of age, status and income potential) does explain a lot of crimes. GeMax is also the reason behind the bitter feuds we sometimes see amongst blood relatives over ancestral properties.

Starting level of assets also shape the lives of people as it typically sets the risk appetite level of an individual. A person with almost zero assets and a person with abundant assets are both ideally placed from a risk appetite perspective to become an entrepreneur and jump into a new start-up venture. The uneven payoff potential of a start-up venture means that if it fails (like most start-ups do), what the entrepreneur loses is just his time, efforts and the equity he put in. If he succeeds in his venture he can generate substantial wealth. Christopher Columbus who discovered the Americas in 1492 AD was son of a wool weaver in Genoa, Italy. Francisco Pizarro, who conquered the rich and powerful Inca Empire (largest Empire in pre-Columbian America, located in present day Peru) in 1532AD, was an illiterate, illegitimate son of an infantry colonel in Trujillo, Spain. These explorers fit the first type of adventurers who had nothing to lose but much to gain from taking risks (of exploring unknown geographies and wars in this case). On the opposite end of the spectrum was Vasco da Gama, a Portuguese explorer who discovered the sea route to India in 1498AD and ended Portugal's dependence on the old route passing through unfriendly territories of Middle East and Mediterranean Sea. His father was a civil governor and tax collector in Sines, Portugal.

Starting with a strong base in life, Vasco da Gama set out to explore a hitherto unknown sea route to India and add to family riches. He succeeded beyond expectation and became the Admiral of the seas of Arabia, Persia, India and all the Orient and Viceroy of India; after all, his discovery had helped Portugal get a monopoly in the spice trade for almost a hundred years.

A person starting with medium level of assets, on the other hand, will find it very hard to jump into an adventure. Fear trumps greed and the fear of losing what you have typically outweighs the potential joy of extra assets. The subconscious thought process inside our brains, formed during millennia of evolution, shaped by the selfish genes inside us generally gravitate to the most optimum solution. The thought process would go like this – a decent level of assets typically ensures marriage and kids and thus, propagation of your genes into the next generation. It is certainly much better than dying childless and not leaving behind your genes (not counting those of your cousins and other relatives). For such a person, if a risky venture goes off well and adds to his wealth, he can ensure a better life for himself and his kids and leave behind more wealth so that his kids don't have to work and can focus on continuing the bloodline. There is no denying that it is incrementally beneficial but it is not a huge addition to what he already had. That explains why, in our society, most of the people just take the beaten path and not venture out into the unexplored which can bring in untold riches.

Amount of assets is crucial but the type of assets/properties is also a big factor shaping the behavior of people. There is a very interesting case of farmers vs. herders. A few hundred years ago, when there were no factories and no computers, agriculture and animal husbandry were the key professions all over the world. Farmers had farms and crops as their assets and as farms were typically in one place, farmers' locations were fixed. Herders, on the other hand, were nomadic and needed to move with their herds of cattle, goats or sheep to newer pastures. Enemies or diseases could destroy a few crops but it was almost impossible to take the land away from a farmer. That gave a certain stability and support to the lives of farmers. Neighboring farmers were typically seen to be collaborating with each other, sharing ideas on which crops make more money, what new breeds can be planted, etc. In case of herders, the wealth was their animals which an enemy could take away by force leaving the owner with nothing. It sometimes took just a single bout of some disease to wipe out the whole herd, again leaving the owner

with nothing. Neighboring herders typically competed for moving to better pastures in the common areas and hence were generally not on friendly terms. All these factors made the herders very jittery compared to their farming counterparts. It helped if the herders had a fierce reputation. If somebody was caught stealing a few cattle, the herd-owner had to make an unforgettable example of that thief so that any competing herders would think twice before attempting it. Wars were quite common amongst the herders all over the world, especially amongst the very poor herders. Wars, in this case, had a very sound implicit logic – if you pre-emptively attack others and win, you will get more resources. If you lose but survive with just a small loss, you will still earn a reputation of fighters and it would help from a political angle later on. If you lose completely, you anyway had very little to begin with, that's why you started the war. The best examples of such herders were the Mongols living about a thousand years ago in the area that's presently northern China, Mongolia and Siberia. Genghis Khan gathered together various factions of utterly poor Mongol herders. These nomadic people had many traits that proved useful in war: they were good at riding and hunting; they were able to live on little food at times; they followed their leaders (a trait generally found in war-prone areas) and they had no mercy for their enemies. After winning over various Mongol, Tartar and other factions, Genghis Khan set his sights on the world. One logical reason for continuing wars was that warriors cannot live peacefully together in a world with low resources; they start fights to grab resources and they already know how to fight. Within twenty-five years of setting outside Mongol country, Genghis Khan had captured the greatest land mass any emperor has ever captured in world history. His kingdom was spread from Korean peninsula on the eastern side to present-day Germany on the western side. There are many similar cases of herders' empires. Huns, who formed an empire in the Europe under Attila the Hun in the 5th century AD were also nomadic people to begin with who migrated with their herds of cattle, horses, goat and sheep. Other tribes like Visigoths, Ostrogoth and Lombard which founded various European kingdoms during the 3rd to 6th century AD were also migratory tribes. Yuezhi tribes living in the arid grasslands of eastern Central Asia went on to found the great Kushan Empire during 1st to 3rd century AD which spanned from eastern part of present Europe to northern part of present India. The invaders like Mahmud of Ghazni, Muhammad of Ghor and Babur, who invaded Indian subcontinent between 11th to 16th century AD originated in present day

Afghanistan, a land unfit for farming but satisfactory for herders. Areas with lack of faming resources have, time and again, produced invading armies in the world history whereas agricultural societies (India, China, Egypt, etc.) tended to be peaceful, prosperous societies and the targets of invading armies.

This is not to say that nomads are always belligerent aggressors. There are examples where the nomads have tried using their brains and hard work rather than brawn for improving their financial conditions. Such people have faced great many hardships to achieve a respectable social status and it would be interesting to look into their story. The best examples of this are the Jews and the Marwaris (a clan in India). The hardships of Jews over thousands of years has been quite meticulously documented in many books. Today we will try to explain reasons of their hardships from the resources angle. Jews originated in the area around today's Jerusalem. The Negev desert of southern Israel and lands eastward weren't too benign for farming and hence many of them spread out into the western world (Egypt, Rome, etc.) for earning bread. They toiled under the pharaohs of Egypt till Moses led the Exodus to settle back in Israel around 1300BC. When Julius Severus ravaged Israel in 136AD and exiled the Jewish population, many of them moved to Europe. They were not allowed to own lands but they came to prominence in the social structure through success of their moneylending business supported by their hard work, talent at finance and favorable factors like the Church not allowing Christians to lend. Jews happened to be involved in crucifying Jesus and they have been doubly persecuted since the time Christianity gained prominence in Europe. There are examples of Jews being made scapegoats with downright foolish accusations. When the plague was spreading in Europe in mid-14th century AD, killing almost half the population, accusations were made that Jews caused the disease by poisoning wells. Jewish massacres became common, with the largest one in Strasbourg on the St. Valentine's Day in 1349 when 900 Jews were burnt alive. The story of persecution and massacre of Jews went on till the 20th century when it climaxed with the genocides by Hitler and Stalin. Throughout this period of persecution, they stuck with their key businesses of trading and finance. Throughout the history we find that Jews were moneylenders to the classes and the masses both, leading to literary references like Shylock in Shakespeare's 'Merchant of Venice'. The Rothschild family has been the

most famous Jew family in history. They were financiers to Kings across Europe and the family said to have possessed the largest private fortune in the world during the 19th century AD. Jews have continued expanding their financial prowess and currently own almost half the Wall Street firms and substantial portion of the corporate world (companies in technology, food & retail, entertainment and other sectors).

The story of Marwaris is shorter and not so gory but equally interesting. This clan originated in a place called Marwar in Rajasthan, India a few centuries ago. This place is akin to a desert and prone to famines. The infertile nature of land and harsh weather conditions discouraged farming and made herding unappealing. This made the community disperse to wherever business opportunity was available. It is said that Marwaris are already present on all continents except Antarctica and even that would be corrected as soon as some business opportunity emerges there. Just like the Jews, Marwaris have been present across the lending business spectrum, right from a pawnbroker to being Kings' financiers. Their business sense is revered in this quote: 'Marwaris can buy from a Jew and sell to a Scot and still make a profit'. They are also reviled for their penny-pinching behavior. Some old Indian movies showed a Marwari moneylender driving peasants to bankruptcy with his mountainous compounding interest leading to confiscation of collaterals like the peasant's farm. Marwari professionals have a good head for numbers and excel at accounting and finance, just like the Jews. Many amongst the Chartered Accountants and finance professionals in India are Marwaris. The world's largest steel company Arcelor-Mittal is headed by a Marwari Mr. Lakshmi Mittal, who was amongst the world's topmost billionaires. Within India, Marwari-owned companies claim significant market shares in many businesses.

How can GeMax and resource theory explain the meteoric rise of these communities and the hardships they had to suffer at the hands of others? We need to look at the origin first – the lack of farming and herding resources of their homeland made them move to other countries and other cities. Being landless, they had to start at the bottom of the pyramid in any business they joined. Such people who started with zero and who were conditioned by their surroundings to take maximum possible risk for a great payout generally shunned the employment route (as it gives just a stable, finite income) and jumped into businesses. What businesses were possible for the landless, poor

people? They could not put up factories which require lot of upfront capital but they could start businesses like trading and moneylending which can be started with a small capital. How could they succeed at these businesses beating the local competition? Typically, because Jews and Marwaris moved into relatively prosperous lands seeking opportunities, the local population was more prosperous than the Jews and Marwaris. Prosperity generally leads to complacency and the outsiders could beat the relatively complacent local competitors by putting more time and energy in the business, as the growth and profitability of these businesses depends on the efforts put in (collecting more information about the commodities traded, making more efforts to collect the loans given, etc.) They also embarked on a miserly lifestyle, saving money wherever possible so that the saving can be channelized into the business as additional capital, thus growing it faster. Harsh conditions make people ruthless and in case of Jews and Marwaris this ruthlessness was exhibited, not in the form of violence but in the form of ruthless conditions applicable to their customers. They did not hesitate in charging the highest possible rates on the loans given and the highest possible margin on the goods sold. They developed another system to their advantage. In the foreign lands, there were few people of their own ethnicity so they stuck together closely and helped out each other whenever possible. This is another corollary of the GeMax logic. When you have lots of cousins and relatives lying around, you don't need to think about helping them so as to preserve/propagate their genes which are indirectly (to some extent) your genes. When there are only a few people of one ethnic group in a foreign land, these subconscious connections become stronger and the close cooperation and co-dependency arising out of this mindset helped these people grow their businesses quickly and profitably. In fact, that's why even in today's times of professional management structure, we frequently see a 'family business' structure in Jew and Marwari businesses where key positions in the management are with close or extended family members. Their expertise in the area of financial mathematics, which arose out of their business needs, was another very important factor contributing to their success. The families accumulated all these traits through their growth and development phase and passed them down the generations. Even today, we typically find qualities such as friendly, workaholic, good-at-math, good business sense and frugality amongst the Jews and Marwaris.

Throughout history, we find that the local populations, mostly the local

farmers, had changing attitudes towards these trading/moneylending classes depending on the availability of resources. First of all, the local people typically happen to be distant relatives or relative of relatives and hence there is a chance that they share some genes. But with outsiders, there is zero chance of sharing genes and hence zero concern for outsiders at the subconscious level from the GeMax angle. Secondly, there was a natural grudge amongst the locals against the outsiders for starting with almost nothing but still getting ahead of them in life on back of sheer hard work and frugality. Thirdly, the wealth of the Jews/Marwaris was typically not in the form of farms, land and buildings like the local people but in the form of money/cash and loans outstanding. A farm or building cannot be stolen but money can be seized and loans can be defaulted upon. This nature of their wealth made them (the outsiders) more vulnerable to asset seizures and loan defaults. It also made them vulnerable to being made easy scapegoats. The subconscious human mind, having gone through millennia of evolution, has become an expert at sensing vulnerabilities in opponents and exploiting them when an opportunity presents itself. When the going was good, the farmers took loans from the Jews but in bad times, when they could not repay it, they tried to renege on it siting the excessively high interest rates charged. Kings were a few steps ahead in this as they enjoyed legal power over Jews. King Edward I and his Noblemen had taken so much loans from Jew moneylenders that by 1289AD it was impossible for them to pay those back. Being a King, he simply issued an edict (1290AD) expelling all Jews from England and thus abolishing his outstanding debts. In 1306AD, after the Flemish war, King Philip of France was in large debts and resorted to expelling Jews from France and taking over their wealth, thereby saving himself from bankruptcy. All this discussion is not to take a particular side in these age-old conflicts but just to explain how the changing human behavior under different circumstances can be explained with simple principles like GeMax and resource availability.

Chapter 1.4.3: Other Key Resources: Power, Fame & Energy

'The measure of a man is what he does with power' – Socrates

The interesting thing about resources is that, just like different forms of energy, they are generally interchangeable. If you have money, you can buy food. If you have extra food, you can sell it to get money. If you have power, you can get more money. If you have money, you have power. Of course, the ability to interchange resources is found only in animals whose brains are developed enough to understand value of resources and are able to plan for a future benefit while foregoing an immediate one. Vampire bats regularly regurgitate blood and donate it to other members of their group who have failed to feed that night, ensuring they do not starve. The arrangement is reciprocal in nature so over a long period (like a year), every bat is likely to have been a giver on some days and a taker on some days. With increasing brain size and complexity, we start seeing more complex social behavior, more interactions and more planning & coordinated execution by the group. Coordinated hunting by wolves or lions needs no introduction. Humans evolved at faster rates when they started forming larger groups. These large groups helped their survival rates as living together made them more secure from predator attacks. Hunting and gathering became more productive because they could plan better together and trade new ideas on improving efficiency (like making better tools and weapons). As the groups become larger and interactions become complex a need for hierarchy arises. That is why we see hierarchical structures amongst developed animals like large mammals but not amongst mice or cockroaches. Amongst humans, as the groups became even larger, the initial simple hierarchical structures (like a bunch of elderly people advising the villagers using their experience), developed into an elaborate system of command and control hierarchy with Kings, Ministers, Generals, Tax Collectors, etc. For the smooth functioning of the group, work was divided between different people of the group and for executing the allotted work, each of these was required to be given a certain amount of discretion and authority to direct the people assigned to them (like a General would have control over soldiers and the Minister for taxation will control all the Tax Collectors). This discretion and authority is the origin of 'power' in human society.

Power is another great resource that can (and does) help in achieving GeMax objectives. Power can be of different types. The first is obviously political power. A person can be the head of a small tribe or the Emperor of an empire or the President of a modern nation, extra power always leads to better availability of required resources and ultimately GeMax goal. First of all, being in a position of power improves a person's ability to get more number of mating partners of a good quality. In old times, a King could have any woman in his kingdom. Such power is important because, as we will see in the next chapter, availability of mating partners is a very crucial resource from the viewpoint of GeMax. Power also gives you followers, willing or sometimes unwilling, who would toil for you and gather or develop resources for you. These followers would also secure you and your kin from any potential attackers and invaders, thus contributing to maximizing your genes. Power need not be just political power, it can be spiritual (motivational) power, financial (rewarding) power, military power or intellectual (knowledge) power. In each of these cases, we typically find that power can and is used to increase number of followers (which adds to the power), improve the survival chances of the leader and the group and gather various types of resources for the group or sometimes, for the sole benefit of the wielder of the power. In ancient times, when resources were scarce, the situation was almost binary. If you had power, you had access to resources and the ability to propagate your genes. If you didn't have power, you were likely to fail at the objective of gene propagation. Aurangzeb, son of Shah Jahan (the Mughal emperor ruling Indian subcontinent during the 17th century) murdered his three brothers and imprisoned his father to grab the throne. Many such examples are available in human history which will surprise a person and shake its gentle core until the episode is viewed and analyzed from the viewpoint of availability of the resource called power – either you had power or you were powerless. In recent times, as resources have become relatively more available and affordable to common people, the sharp polarization of old times has abated. Power is more distributed at various strata of the society. In a later chapter we will discuss in detail how that has reshaped the human society.

Fame is another type of power, another type of resource that is sought by almost every person on earth. In 2007, Pew Research Center surveyed 18 to 25 year olds for their most important or second-most-important life goal.

81% respondents mentioned ‘getting rich’ and 51% mentioned ‘getting famous’ as either topmost or second topmost life goals. Everybody wants to be famous, wants to be on TV or in the newspaper and wants to be talked about amongst acquaintances and also amongst strangers. Why is there a subconscious craving for fame? For a moment, keep aside the fact that today we have thousands of TV channels and millions of websites. Historically, people had to work hard for a living and did not have too many hours left for gossiping. Media like newspapers were quite few and could carry only so many news. In such a scenario, only the very successful and the extraordinary people could find entry into the ‘famous’ club. Conversely, the famous people were those who had achieved success and greatness in life. As you know, success begets success. The fame and mention in prominent places got more business deals to the already successful people and added to their success. The critical step is to get an entry into this virtuous cycle either through hard work or through sheer luck, as is the case sometimes. Success, in turn, acts as the ticket to amassing resources like money, wealth, power and mates, which as you know, are ultimately for GeMax and hence the subconscious human brain craves ‘fame’ as a type of power or useful resource.

In last few centuries, Energy is another form of resource that has gained prominence. Energy, by definition, means the ability to do work. When the hunter-gatherer ancestors of ours started settling down and domesticated bulls and horses to plough farms, the competition for energy resources slowly came into existence. The industrial revolution was underpinned by the steam engine which was the most revolutionary invention at that time. If a person has better energy resources, he can get more work done with minimum dent in his own physical energy and time. This will help him in focusing on GeMax and in focusing on gathering other resources required for GeMax. The competition for inventing and owning new energy resources has led mankind to various energy sources viz. coal and petroleum in the last century and wind, solar, geothermal and ocean waves in more recent years. As resources are fungible, rising demand for energy sources made the people owning these resources very powerful and rich. You would have read stories about how people in some nations went from driving camels to driving Mercedes cars almost overnight after oil was discovered there. With advent of various different kinds of machines, no work is impossible to accomplish if you have an energy source to back it up. You can demolish a whole

mountain and make a nice Formula One racing circuit out of it if you have the fuel to run the demolition and construction machines (and the money to get the machines and their operators). Here we have discussed the importance of energy as a resource; in a later chapter we will revisit the issue of energy sources and how it will transform our world.

Chapter 1.4.4: Mating Partners as a Key Resource

'If women didn't exist, all the money in the world would have no meaning' – Aristotle

'By all means, marry. If you get a good wife, you will become happy. If you get a bad one, you will become a philosopher.'

– *Socrates*

During the preceding chapters discussing various key resources, we frequently came across remarks such as '… this resource would help a person in getting a better mating partner…' Why is it important from a genetic and biological perspective to get a good mating partner? How is it a very important, rather the most crucial, resource for GeMax? How does the need for mating shape the behavior of animals? Since last two centuries, many evolutionary biologists (like Charles Darwin, August Weismann, Bill Hamilton, George Williams, John Maynard Smith, Graham Bell and Richard Dawkins) have proposed numerous theories that throw some light on this issue. As our focus is on theories relevant to human behavior, we will be discussing only certain aspects from this body of research. For the readers interested in deeper analysis, I strongly recommend a leisurely and thorough perusal of works of these brilliant scientists.

Except for a few primitive organisms, most animals on earth procreate through the sexual reproduction process. Let us start from here – why is there a need for sexual reproduction? Why is sexual reproduction better than asexual reproduction in various organisms like bacteria, where the parent cell just splits into two copies (clones) of itself and the work is over? What are the extra advantages brought in by the sexual reproduction that compensate for the investment of time and energy required? Also, if genes are selfish and want to ensure their continued existence, why would they allow establishing a system in which only half of each parent's genes are passed onto the child; as against asexual reproduction in which all genes are copied into the next generation?

The answers and conjectures in response to these queries are quite interesting. The first and foremost insight is that genes are selfish not as a group but as individuals and hence, through the process of natural selection, each gene would seek to partner with fitter genes that would help in

improving its own survival rate. Thus, genes fit for the given environment will tend to come together through natural selection. For example, the genes providing camouflage and speed are both very useful to a Cheetah. The survival rate of the gene providing camouflage trait is improved because the gene providing speed improves the survival rate of the animal and all the genes it carries. In the same way, the camouflage gene improves the survival rate of the speed gene and so on.

Put in a different way, what this means is that sexual reproduction has the ability to combine different mutations coming from the parents in different combinations so that nature can select the best, the fittest combination. As Charles Darwin said “The offspring of two individuals, especially if their progenitors have been subjected to very different conditions, have a great advantage in height, weight, constitutional vigor and fertility over the self-fertilized offspring from either one of the same parents”. In asexual reproduction (think bacteria), when a cell just splits into two copies (clones), any mutation is just carried into the next generation and subsequent mutations are just added to the gene pool. If a mutation is harmful, the whole organism can go extinct. In sexual reproduction, the harmful mutations are removed and useful mutations are encouraged by the process of mixing parent genes and putting it to nature’s test. One interesting example combining asexual and sexual reproductions is Cadocera, also known as Water Fleas. When the living conditions are favorable, this small animal reproduces by asexual route, where the females of the species clone themselves to give birth to next generation of daughters. When the living conditions deteriorate, males are produced and sexual reproduction route leads to long lasting dormant eggs which can flow in the wind like pollens. When they reach favorable conditions, they can hatch and continue their life cycle. Certain lizards are also found to be reproducing sexually during periods of environmental uncertainty and reproducing asexually when conditions are more favorable. This shows that there is a selective advantage and natural robustness in sexual reproduction.

One key benefit of sexual reproduction and genetic variation occurring thereby is the increased resistance to parasites. We know that all animals carry numerous bacteria and other parasites outside and inside their bodies. The ability to withstand these parasites is crucial because the parasites evolve with every generation and are better able to grab more nutrients from the host

body. In asexual reproduction, the offspring will have resistance to new breed of parasites only if a mutation occurs. In sexual reproduction, the offspring will have different combinations of parasite resistance genes. This hypothesis is called the Red Queen's Hypothesis because, like Lewis Carroll's Red Queen, sexual hosts need to continually adapt so as to stay ahead of their parasites. In 2011, biologist Levi Morran and team conducted experiments on a host-parasite system involving roundworm C. elegans as host and bacteria S. marcescens as the parasite. The roundworm C. elegans can reproduce asexually (self-replication) as well as sexually and hence a comparative study of efficacy of both modes against parasites can be conducted. The researchers found that that the self-fertilizing populations of C. elegans were rapidly driven extinct by the coevolving parasites while sexual reproduction allowed populations to evolve with their parasites, a result consistent with the Red Queen Hypothesis.

For sexual reproduction there is requirement of a male gamete and a female gamete bringing in genes from the father and mother respectively. Fossil records show that sexual reproduction first appeared on earth about 1.2 billion years ago. So the process of organisms evolving from being hermaphrodite (sexless or containing both sexes in one) to being separate males and females would have begun much before that. The key difference between males and females, apart from their genitalia, is the differently sized gametes. The female gametes are called eggs. These are large and number just a few hundred over the lifetime. The male gametes are called sperms. In size, these are about 20-40 times smaller than the eggs and over the lifetime of a male, he produces billions of sperms. What can explain this stark difference?

Billions of years ago, there could have been a state of isogamy meaning there wouldn't be much difference between the male and female sexes yet and the male and female gametes would have been sized similarly (for example, primitive organisms like fungi cannot be differentiated as male or female as they have similarly sized gametes). However, there would be some larger eggs and some smaller eggs due to the sheer random and inexact nature of the process. Now the larger eggs would be favored during the natural selection process because they would bring in more nutrients, more food for the resultant embryo and improve the chances of its survival. Over many generations, the eggs became large and nutrient-rich but less numerous. We

can call this the honest strategy or the high-investment strategy. Typically the females exhibit this strategy and are more involved in the process of birthing and nurturing the child. The smaller sized gametes, on the other hand, would have had advantage of being quicker than other gametes and hence they had higher chances of locating a large, nutrient-rich gamete. Such strategy was also successful during the natural selection process and this led to the male strategy of having very small, mobile gametes in a large quantity. This can be called as the exploitative strategy where being quick in exploiting others' resources is the key to survival. The gametes ranging in-between in terms of size had neither the advantage of food nor the advantage of speed (i.e. locating food); these were eliminated during the evolution process and as a result, distinct male and female gamete forms came into existence. We have seen that once a useful pathway has been discovered, evolution keeps progressing unceasingly in that direction. In developed organisms we find that females expanded the high-investment strategy even further by starting to carry the egg inside their bodies for extended period and feed nutrients to the embryo during that early development phase. Even after birth, female bodies developed mechanisms to feed nutrients to their newborn. The pinnacle of this strategy is found in mammals where the name 'mammal' itself is derived from Latin 'mamma' meaning breast. Such extended feeding greatly improves the survivability of the offspring and thus its chances of growing to a mature state. This thought process explains a mother's attachment to its baby and at the same time, explains the GeMax strategy at work from the mothers' perspective, because a healthy and mature progeny would be key in propagating the mothers' genes further. The fact that females prioritize having a few but healthy babies affects the process of how they would choose mating partners, as we will discuss later.

Males started with the exploitative strategy as it was suitable for their numerous, small sized sperms. Males have to invest less in each sperm and they can produce millions of sperms in a day. Over millions of generations, the sperms have also evolved to be perfect at what they are supposed to do – find the female egg before other sperms do. Recently researchers from Zurich and Stockholm conducted a study to find out the relationship between the size of 100 different animals species and the sizes and lengths of their sperms. What they found was fascinating but also in tune with the evolution theory. The key finding was 'the larger the animal, the more important the number of sperms is relative to the sperm length'. Considering that producing

sperm requires an investment of resources, the animal has to optimize the quantity and quality angles. Sperms can either be small in size but large in number or they can be less numerous but have long tails to move faster. That is why elephants have smaller sperms than mice, as per the researchers. What seems to matter more for the large animals is number of sperms per ejaculate. In large animals, the female reproductive track is voluminous and hence many sperms would get lost; the sperm length or speed become important only when some sperms come near the egg. Thus quantity of sperms becomes the key parameter amongst large animals. In small animals like mice, the distance for sperms to cover is shorter and the risk of loss much smaller, allowing the advantage of longer sperm to demonstrate itself. The culmination of this phenomenon is seen in case of fruit flies. These flies exhibit longest sperms ever known (coiled sperms that reach 2.3 inches on unwinding); and not Whales, whose sperms are a thousand times shorter than those of the flies (just 0.1 millimeter).

In order to achieve GeMax under the condition of numerous sperms, the purely logical action for a male would be to mate with many different females so that a large number of children can be produced. Where conditions are ideal for the male, we actually find this happening. In some developing countries, where social customs don’t pose a barrier, many wealthy men marry with multiple women and produce dozens of children. The obvious corollary of this situation is that the males (fathers) cannot properly nurture and care for their children; the subconscious GeMax logic dictates that time and energy is better spent in creating more children than in caring for one child. However crass this sounds, this is a very selfish but logical outcome of the billion year old exploitative strategy of the small male gametes – mate with maximum number of females, use the millions of sperms to create as many children as possible and not care for any of them. This is not to say that any one sex is better than the other; the number of males and females of any species is always broadly in balance because if there were to be any accidental discrepancy, nature will tend to correct it. Both partners within the reproduction process are made equally selfish by the evolution process and they both want to achieve GeMax with the least possible inputs from their side. On land, the gamete evolution process has led to a situation where the father would tend to desert the children and the mother has to look after the children (it is typically difficult for a mother to leave a small child as it is a large genetic investment on her part). But the

tables are turned in water, where this system does not work. Male fish have to be more cautious with their sperms as the small particulates can get carried away quite easily in the water. In certain species of fish (Jawfish, Sea Catfish, Cardinalfish and Arowana) we find that the female fish just leaves after releasing her eggs in the water (land animals cannot use this idea because the egg is likely to die outside the female body). The male partner (fish), who fertilizes the eggs with his sperms, has to look after the fertilized eggs till they hatch. He does this by holding the eggs in his mouth and has to go hungry till they hatch. Female fish of these species do not waste time in childcare at all. In some fish species we find the mother taking care of the fertilized eggs and in some fish species, we find the mother and father jointly looking after the eggs. In water, the rule is that the partner that provides gametes last is likely to be stuck with the unborn embryos. So basically, selfishness is not exclusive to one gender.

Coming back to land animals, what strategies would the female develop given the fact that males are likely to desert at the first opportunity? Evolution has provided two different strategies – one helps the female in reducing the chances of the male desertion and the other reduces the impact of male desertion. The first strategy is called Domestic Bliss strategy. In this strategy, the female refuses to mate with the male until the male has invested sufficient resources of his own into the partnership. This can be in the form of making him build a nest or bringing food for her. The courtship period also gives the female a chance to observe if the male is a philanderer or not. By making him invest his time and resources, the female is creating an exit barrier. If the male wants to leave the female after childbirth, he is likely to think of the time and resources he will need to invest in the second female and may end up living with the original mate, preferring to have more offspring with her, thus the name Domestic Bliss strategy.

The second strategy a female can adopt is called the He-man strategy. In this strategy the female would delay mating till she has found a male with the best possible genes. The ‘best’ genes will be defined by the female in the context of her surroundings. Depending on the circumstances, the He-man male can be a horse with the most muscular legs, a bird with strongest wings or the most famous Rock star. The subconscious thought process here will be that the child of such a male will be expected to have an inherently better survivability due to the ‘best’ genes and hence having such a child can

propagate mothers' genes even without receiving care and nurturing from the father. In addition to better survivability, the mother's subconscious thought process expects the child to have traits that are favored by the female population (meaning they will find him attractive). That would ensure multiple mates for the child when he grows up and hence better gene propagation. In case it is a female child, it will have genes for selecting a He-Man and assuming it is a good strategy, the gene propagation continues.

Male attractiveness is a heavily researched and debated topic amongst biologists. It is easy to understand females' preference for straightforward characteristics like muscles, legs, jaws and paws as the case may be for different animals. The key resource for survival in the animal kingdom is sheer physical strength and these are different forms of it. The preference can be easily explained saying that these traits help in hunting the prey or running away from the hunters and thus add to survivability. In case of some herding animals like deer or lions or elephants, the case is quite straightforward, the male claiming to be the strongest clashes with the leader of the herd and if successful, becomes the owner of the herd and has access to all the females in it. In these cases, physical strength is the first and last determinant.

But when it comes to explaining females' preference for male characteristics like extra-long tails and vivid colors, the real fun begins. What would happen if all the male birds in a group are the same in terms of survival characteristics like muscle strength, wing span, length of beak, etc. How would a female choose between the males and how would a male beat other males in attracting females? It comes down to signaling – the male has to signal to the females that he has an extra something compared to other males. This 'extra' can be useless or sometimes even harmful. In case of peacocks, the beautiful, long tails have no use for the male peacock; in fact, when a predator chases a male peacock, the tail is a hindrance in running away and hiding. Some scientists conjecture that such handicaps are exactly what make the males attractive for females. There is some logic to it – assume two men running a race and finishing in equal time. That data is not sufficient to decide which man is fitter. If we are told that one of those men was running with a large weight tied to his back, then clearly, that man must have been stronger of the two. Female birds may possibly be thinking the same when it comes to long tails and female lizards may possibly be thinking the same when it comes to bright colors. This is called 'signaling' where the males

signal the females about their fitness through an outwardly visible trait. We have an example to show, as to what extent the ‘signaling’ can spiral during the evolution process.

Assume that in a bird population females have normal tails but they develop a preference for longer tails in males assuming it is a signal for better fitness. In initial generation, the offspring of a female bird preferring and mating with a male bird with a long tail is likely to have a bias – if it is a male offspring, it may have a long tail and if it is female offspring, it may have genes for preferring a long-tailed male. As the females in next generation also start preferring the long tailed males, the males with shorter tails will not find mates and will not be able to push their genes to the next generations and they will slowly go extinct. Any residual female with genes for preferring male with shorter tail will give birth to offspring with a short tail, who in turn will not find mates and will go extinct. Just like we saw in the example of the deer with mutated feet, once an evolutionary trend starts, it moves along a steep S-curve and leads to spectacular changes. In the bird example, if this logic is really correct, we should see examples of birds where male tails have reached a surprising proportion. There is actually such an example; ‘Birds of Paradise’ is a species of birds renowned for their long tails. One subtype of these birds is called Black Sicklebill and it is found in New Guinea. The male Black Sicklebill has typical body length up to about 110cm out of which almost three-fourth is just his tail. Female Black Sicklebill length is about 48cm including her tail. Such a long tail on the male does not help in any real work like finding food but can only be justified through GeMax, signaling and natural selection logic.

There are two opposing forces at play here – males with attractive traits will be eliminated by the hunters (because they become easy to spot or catch) but the males with non-attractive traits will be eliminated through non-mating (because females don’t prefer them). However, as one male can have multiple offspring even in a short lifespan (example: the male Black Widow spider), the lineage of males with attractive traits continues whereas the lineage of males without such traits terminates along the way.

In many animals it is found that males have evolved to be quite flashy whereas the females are quite drab. The simple reason can be that females prove their worth by bringing in the larger gamete and looking after the

offspring. It is the males who need to attract the females by developing noticeable outwardly traits. Scientists have been puzzled by the fact that the same theory does not seem to apply to humans where females use make-up which works as signaling but males have not developed any noticeable outwardly features, like an extra-long tail. One explanation can be about the societal structure. In animals like birds, where the societal structure is almost non-existent, all males are on the same level and they need to compete for the females. As we discussed in the chapter on Power, human society has developed in such a way that males occupy different positions of power depending on their abilities and availability of power (to a large extent) decides their ability to support the family. Females understand this dynamics and try to partner with the males with the highest power. A female mating with a King will obviously be more successful at GeMax than a female mating with a foot soldier. In such a polarized world, the King will have to choose just a few from hundreds or thousands of potential mates. Females, in such a situation, will need to use signaling techniques (like make-up, etc.) to become part of the chosen few. It is simple evolutionary tactics at work. Those females who are not selected by the King will find it logical to try their luck with the Ministers or Generals and so on. That is the reason why we typically see men with money and power having beautiful wives whereas poor men have to be content with plain wives.

There is another possible reason for signaling by females. From historical perspective, it is possible that many a times males were involved in wars with other clans (humans do seem more quarrelsome than other animals) and due to the war-toll, availability of young and healthy males fell short of the females. A good example is that of Russia in the Second World War. Out of the population of about 200 million, 25 million died due to war related causes and most of these casualties were young male soldiers. This sudden shock dramatically altered the male-female ratio by the time peace returned. In the post war period, females had to fight for being selected by males. Beauty and physical build are some of the key criteria of selection in such a scenario and those lacking on these counts perished, without a chance to propagate their genes. As it was mainly the beautiful women who got to procreate, the resultant population was obviously more tilted towards beautiful women. This is possibly the reason why we find that today an average Russian female is more beautiful than an average female of any other ethnicity.

Beauty is an interesting concept. What exactly is beauty? Why do we inherently desire a beautiful partner? Can evolution explain this remarkable human behavior? Many scientists have tried to fathom what constitutes beauty by showing thousands of photos to volunteers and then by matching the statistical data of facial features with the beautiful/ugly ranking provided by the volunteers. What has emerged is that beauty is more about the facial dimensions than anything else (not getting into the skin color as of now). Scientists have found that we typically prefer or like faces which have average values of all the key distances like the distance between two eyes, distance between eyes and jaw line, length of nose, etc. Any major variation in any of these dimension makes us like that face less. For example, if a person has very large ears or has a very small nose or has eyes far away or too close to each other or has a very long chin, our mind subconsciously calculates that these are major deviations from the ‘average’ values and hence deems those as less likeable faces. Why would our subconscious mind reject these deviations? As we know, the outwardly physical traits are due to the genes inside us. If a person has disproportionate facial features, it indicates a mutation. Now, mutations can sometimes be helpful, like the feet of mutant deer in our earlier example. But for a system like our face, which is already honed to apparent perfection by millions of years of evolution, a mutation in gene is more likely to be harmful and hence warning bells go off in our subconscious mind. Mutations happen due to any reasons including exposure to certain chemicals or radiation. There is a saying that if you see a single cockroach, rest assured there are more. Assuming the mutation is due to exposure, there are good chances of multiple mutated genes being present inside the person, many of them not outwardly visible. If you are evaluating a potential mating partner, such subconscious thinking would make you feel that the person is not good-looking (even without you consciously noticing the mismatch in facial dimensions) and this evolutionary intuition would dissuade you from mating with a person which might have harmful mutated genes and combining your genes with such potentially faulty genes may not be a good idea from the GeMax perspective. There is another angle to facial dimensions. Assume that you are from a clan which, due to some reason, has always featured a very long nose. During your childhood, you would see long-nosed people everywhere around you and that would subconsciously make you believe that a long nose is a normal nose when it comes to facial dimensions. If you come across a person with a very short nose the

evolutionary instinct inside you would start thinking that this person is not from your clan so it's possible that he is from a rival clan, approaching you to grab your resources. Moreover, a person from a different clan is unlikely to share any of your genes and hence will deserve zero consideration in your GeMax induced priority matrix. Indeed, we don't require such caveman instincts anymore but these instincts are honed over millions of years and will not go away within a few decades of experiencing prosperity. Coming back to noses, basically this instinct makes us skeptical of people with uncommon facial features. Even the preference for skin colors can, to some extent, be explained by this caveman logic. The key skin colors (white, black, yellow and brown) are particular to different continents due to the factors like sunlight intensity and skin pigmentation. A person with skin color different from you can be a rival or at least a person sharing zero genes with you and hence deserving zero consideration, if we use the caveman logic mentioned earlier. In some cases, the subconscious preferences get modified if the underlying GeMax conditions change. If a royal family of a certain color is ruling over citizens of a different color for a long time, then the people will see connection to the royal color as an instrument of advancing themselves in life and thus the royal color will not just be accepted, it will be sought after (through marital connections with the royal family). Thus, it is quite true that beauty lies in the eyes of beholder; and equally true is that behind the eyes lies the evolutionary instinct.

Another preference is shaped by simple GeMax logic – the preference for physical features of the potential mate. Since many decades, scientists have tried solving the puzzle as to why men prefer women of certain build and physical features. Recent research findings at the University of Aberdeen throw some light on this. The researchers found that men find thinner women more attractive and the reason is that they equate such body type with health, youth and fertility. From the evolutionary perspective, we have seen that 'fit' is nothing but 'able to reproduce' with the inherent condition of 'able to survive' first. Similarly, it stands to reason that a fit partner would be someone with the ability to survive and reproduce and all three attributes mentioned above (health, youth and fertility) are related to either survival or reproduction. The male or female brain would subconsciously reject extremely thin or extremely obese people and people with genetic deformities as potential mates thinking them to have faulty genes; normal genes typically result into average, medium, healthy body shape and outwardly features. One

interesting fact is that the perception of ‘average’ has changed with time. In older times, when availability of food was uncertain, people with better food availability could be distinguished from the fat accumulated around the belly and other body parts. A male in such times would subconsciously prefer a female with higher fat content because the fat content would help her survive during periods of famine and would provide her energy to look after the kids. Larger muscles on the female, like hips, provided indications of her better physical strength. Larger breasts provided indications about her ability to feed the newborns. Hence in those times, these female features were genuinely required for survival and reproduction. Hence these features were sought by the male brains subconsciously and over many generation, they became part of the male psyche. In recent period, at least in the western world, famines have become a thing of the past and harmful effects of higher body fat have become widely known. Hence the male preference has shifted to thinner female body types, sometimes going to the extremes portrayed by zero sized fashion models. In places like some African countries, where famines are still common, the male preference is towards females with higher body fat content, as is justified using the logic mentioned above. In fact, a few weeks before the marriage, the bride starts gorging on carbohydrates and fatty foods so as to gain weight and ‘look her best’ at the time of the wedding.

If we are discussing human behavior, it would not be wrong to make a comment about the evolution of the marital system here. In older times love, marriage, copulation and child-bearing were closely intertwined. Here we are not talking about cases like Helen, Queen and wife of Menelaus, eloping with Paris, the Prince of Troy; these stories did give us nice stories but were not the norm in the society during human history. As we saw earlier, mating partners are also a kind of resources for GeMax, just like food, money, power, etc. From a historical perspective, in order to avoid a potential theft, the ownership of any resource had to be communicated clearly and authoritatively by the owner to the whole clan or whoever could be the potential thieves. Depending on the type of asset, this communication of ownership of assets took the form of fencing the farm or branding the cattle or carrying/wearing the badge of authority (portraying power). In case of mating partner, this communication took the form of marriage where the clan proclaimed the concerned female to belong hitherto to a certain male and this ownership to be respected by all clan members. Please notice the clear

dominance of male in this marriage system. In human history, we find that male polygamy, meaning one man marrying many females, had been quite common and that also shows us the dominance of males in the marriage system. The reason for this also emanates from the evolution process we had discussed earlier. As females focused on the strategy of nurturing the children, males were left with the responsibility of bringing food for the family. During the hunter-gatherer phase and the farming phase of the human evolution, males had to perform very hard physical labor outside the house. This situation, coupled with the process of natural selection led to emergence of males with higher physical strength and better cognitive skills, at least in terms of coordination and spatial geometry as compared to females. In times when food was the key resource, the food-earner had the highest power in the family. These factors led to a system of male dominance in the human society. As we saw earlier, the logic of GeMax explains accumulation of higher resources and the same logic led to male polygamy in human history, especially in cases where males with power and money were able to feed many wives. Even from the biological perspective of gamete evolution we discussed earlier, it was seen that males would prefer to use their numerous gametes on multiple partners to achieve GeMax. In case of males without resources, monogamy was the only option left. In their case, the internal biologically promiscuous orientation was not supported by external level of resource ownership.

Marriages, till about two hundred year ago, were typically arranged so as to forge new connections with other wealthy or powerful families and thus benefit own family. In such arranged marriages, love between the married couple developed post-marriage. Love marriages, meaning marriages arising out of love, came into fashion in recent history. Many forests have been sacrificed for the books written on Love till date but the concept still eludes understanding. Poets, philosophers and scientists from all over the world have failed to discover the formula governing this extraordinary aspect of human behavior. It reminds me of the joke about a person who went to a library and saw a thick book named “Everything We Know about Love”. With a burst of happiness, he opened the book, only to find it empty from cover to cover!

Love and concern for blood relatives can be explained using the concept of shared genes and our tendency of maximizing genes. How can we explain

love for mating partners? Let us try building a logical sequence here. For GeMax a person needs to procreate. For procreation, the person needs to find a mating partner; an ideal partner would be physically fit and good looking. Human brain has reasonable ability to figure out good potential mates, based on external physical features, leading people often to ‘Love at First Sight’. I don’t intend to debase the beautiful concept of love but the love for a potential mate is quite possibly akin to attachment to any valuable resource. Let’s take the example of a big box of treasure. The owner of this box will constantly think about the treasure, will check frequently if it is safe or not and will boast about it to his friends but will also be worried if someone might steal it from him. Just juxtapose this behavior with the behavior of a man with a girlfriend and you will agree that there are many similarities. Moving on, GeMax does not stop at just birthing children but also to nurture them till the age of their own procreation, and if possible, even after that. This is especially important amongst humans who have less offspring than other animals but focus more on each of them. The process of nurturing children is so tedious and consumes so much resources that it is a job one person can hardly accomplish (hats off to all the single parents out there!) This condition makes it a team game, the team being the two parents. In a game, potentially spread over decades, where you have only one partner to depend upon, you are bound to figure out early on if this will work or not. In fact, that’s why many marriages disintegrate within the first few months or 1-2 years. In case the partners accept each other in the game of child rearing, they need to develop the ability to understand each other, compromise when needed and support each other as the condition warrants in order to win the game. This process creates a team spirit, a camaraderie, a mutual respect between the two which we name as love during the child rearing phase. To understand the co-dependency and team spirit at a subconscious level, let’s take an example. If a person traveling with his wife and kids through a jungle where they meet a robber, the person might risk his life so as to let his wife and kids escape. This makes sense from a GeMax perspective; rather than getting everyone killed, the person might sacrifice himself knowing that his wife will surely look after the kids as they carry her genes and in the process, the husband’s genes residing inside the children also get to survive and flourish.

What happens when the kids are old enough to venture out on their own and the parents team is left with hardly any objective to achieve? The love had

arisen out of a need for co-dependency required for achieving the GeMax objective; it should logically wither out once the objective is (sufficiently) met. That is what we observe in the real world – amongst couples whose kids have grown up and left home and there is no physical or financial dependence on the partner, the divorce rates are substantial. Sadly, it seems that love for mating partner is nothing but a temporary arrangement for compromise and cooperation between two people for GeMax.

There is another interesting aspect of human behaviour when it comes to mating partners. As we discussed earlier, the quartet of love, marriage, copulation and child-bearing was a single package throughout most of human history. From an evolutionary perspective, we can conjecture that the selfish genes inside us aim for GeMax and obviously, mating with a suitable partner being the key to procreation, the human brain evolved into preferring suitable partners amongst all the potential partners and also evolved into liking the process of mating itself. This is like the human body's tendency of liking sugar because it is one of the best source of calories and leads to better survival so the human body evolved into liking sugar. Similarly, because the process of mating leads to GeMax, the human body evolved into liking the process itself. In recent times, scientific and social changes have separated the quartet of love, marriage, copulation and child-bearing into four distinct, independent elements of life that can be separately pursued. Global spread of antibiotic usage about 50 years ago reduced the fear of diseases arising out of sexual contact. Use of prophylactics over last few decades has separated the processes of copulation and child-bearing, thereby increasing immoral behavior on one side but also reducing the worrisome social burden of unwanted pregnancies (which also helps towards reducing the level of crime in the society, as you might have read in the groundbreaking book Freakonomics). With inventions like those of test-tube babies and surrogate pregnancy (womb-on-hire) the act of child-bearing is further removed from the act of marriage. South Korea just recently legalized adultery, thereby officially separating love and copulation from marriage. In countries like Japan, young people are foregoing marriages because it adds to financial burden. It is amusing that even with rising prosperity and life spans, the tendency to procreate has reduced. Humans have mostly shifted from the 'have many kids and let them be' idea to the more evolved idea of 'have one or two kids but make them great'. Due to such trends, the reason for most of the mating today is not child-bearing but mainly companionship. However,

the attributes expected in the potential mating partner are still shaped by evolution; any person would still aim for a partner with the most beautiful/handsome face and the ideal body structure, though these factors have almost no relationship left with mating and raising children. It is this nonlinear and sometimes conflicting nature of the different phases of relationship, the different expectations of the two partners and also the centrality of a mating relationship in human life that has led to all those forests being sacrificed for publishing books about love and marriages. In fact, if you have noticed, even the number of jokes about love and marriage surpasses the number of jokes in all other categories. Let’s end this rather long chapter with this funny quote on marriage:

Marriage is when a man and woman become one;
The trouble starts when they try to decide which one!

Chapter 1.5: Resource Allocation Process and Birth of Social Hierarchy

'Man is, by nature, a political animal' – Aristotle

In the previous few chapters we discussed different types of resources and how they affect human behavior. In this chapter we will try to work out how GeMax and resource availability have shaped our present world.

We have seen that a person will always make decisions that would maximize the chances of survival of his genes. We have seen that gene survival is hugely dependent on availability of resources. That's why the ability to grab resources is inborn in all animals (try taking a toy away from a 2 year old baby and it would cream "It's mine! Give it back, now!") With these two guiding principles as our starting points, we can work out the behavior of a person with others under the scenario of limited resource availability.

Assume a person has two children and the resource availability is such that only one child can be fed and raised and hence the person has to necessarily abandon one of the children. What would the person do? How would he decide which one to abandon? Given the fact that both are his/her children, the genes shared by each with the person are about 50% each. So the GeMax calculation going on inside the brain will think about the future potential of each child in terms of growing up to be a person capable of surviving, gathering resources, procreating and also helping the parent live longer. Amongst the two children, if one is quite grown up and capable of surviving on its own, the parent is likely to abandon that grown-up child and focus on the younger one. If both the children are young but one is extremely young, then the parent is likely to abandon the younger one because it will need much more efforts & resources to be put in and the risk is higher due to very young age (lesser immunity, etc.) It makes more sense for the parent in such situation to focus on the elder child. What if one of the children is mentally or physically handicapped? It may sound crass but from a GeMax perspective, the parent is likely to sacrifice such a child in favor of the healthy one. What if both the children are almost similar in all respects but one is a male child and the other is a female child? We have seen earlier that due to an unfortunate quirkiness of the evolutionary process human society has evolved to be mostly patriarchal in nature and it is the males and not the females who

go on to control power, money and other resources. The males also typically look after the parents in their old age. Hence for a parent who has to choose between a male child and a female child is quite likely to choose the male child and abandon the female child. In recent history, we have seen cases of female infanticide in India arising out of the parents' poverty (not having enough money to marry their daughters off into prosperous families). Cases of female infanticide have been reported in China where the one child policy strictly implemented by the government forced the parents to desire the single child to be a male child who would grow up and look after the parents in the old age. This unhappy situation has recently started turning around thanks to falling poverty levels in India and relaxation of one child policy in China.

What if a severe resource crunch makes the person choose between his/her two children and his/her old parents? Remember that each of the children share about 50% genes with the person and each of the old parents also share about 50% genes with that person. Obviously the GeMax system residing in the subconscious brain thinks about the potential of the two options – the children can go on to produce more offspring and will (hopefully) look after the person in his/her old age. The old parents of the person can offer none of these options and hence will quite likely be abandoned. This is not just a theoretical discussion, the world history has many examples where old people were left to die or sometimes murdered for the simple reason of resource crunch.

The practice of killing old people (senicide) during difficult times can be seen in the history of ancient Greek and Roman cultures. The Greek residents on the island of Sardinia (presently in Italy) are believed to have made sacrifices of old males to the titan Cronus. Another example is of the people on the island of Keos who, during a war with the Athenians, voted for all people above sixty years to commit suicide by drinking the poison called Hemlock. The key reason for this was to preserve food supply on the island under the siege.

Japan, one of the most developed nations on the earth today, had a past filled with draughts and famines. Such natural disasters caused so much food scarcity that people could not feed their families. Many people resorted to carrying their old parents in the mountains or other desolate places and

leaving them there to die of starvation. This depressing practice was called Ubasate and its literal Japanese meaning is ‘abandoning a parent’. There is a heart-rending poem in Japanese folklore about Ubasate, it goes like this:

In the depths of the mountains

Who was it for the aged mother snapped

One twig after another?

Heedless of herself

She did so for the sake of her son

The poem talks about a mother being carried to Ubasate Mountain by her son. The mother snaps the twigs on the road that might poke and hurt her son while returning alone. The old mother is on the verge of dying by starvation but her heart filled with motherly love is still caring for her son. Surely, is there anything on this earth that can match motherly love?

As we look outside the immediate family, the behavioral patterns start changing but the principle holds. Have you ever noticed the difference between how your spouse treats your extended family (say, your nieces and nephews) as against his/her own nieces and nephews? By now, you can figure out the genetic reason behind it. The GeMax logic inside your spouse’s brain would think in the following manner. Your niece or nephew share about 25% of their genes with you whereas he/she shares zero genes with your spouse. In fact, the spouse subconsciously perceives a potential risk that you may divert your resources towards them or other such family members on your side and that may hurt the prospects of your own children (with whom your spouse shares 50% genes). That is why the subconscious mind of your spouse is likely to have a neutral to negative attitude for your nephews, nieces and other relatives.

Let’s move from the family to friends. Friendship, if we were to define it, is where friends care for each other and look after each other’s well-being. Long time ago, friendships would have been predominantly inside the clan, amongst blood relatives like cousins. First contact with non-blood relatives would have been when different clans started interacting through trade or wars. First friendships would have occurred when trading became frequent

and the people trading with each other felt that by not cheating each other, they can build a relationship that will give them continued profits for a long period vis-à-vis earlier practice of sporadic trading which might have involved cheating. In fact, if you have come across the famous ‘Prisoners’ Dilemma’ in the Game Theory, you know what the Game Theory says: if you are not likely to interact with a person again, cheat; if you need to interact with a person frequently, cooperate. When early humans had to work or trade together frequently, they had to develop cooperation. Cooperation involves letting go of a short term benefit so as to benefit in the long term. If the buyer doesn’t have money for the time being then the seller can either scrap the deal or give a credit period to the buyer and maintain the relationship. The seller is cooperating with the buyer by deferring his payment and sacrificing the time value of the payment. But once he achieves the buyer’s goodwill, he will benefit in the future from the continued demand for his goods and additional references. Such cooperation and willingness to sacrifice short term profits leads to trust amongst people and such trust is the foundation of friendship. Try to remember the beginning of your friendship with your best friends. The foundation must have been some trustworthy behavior exhibited by them which gave you the confidence that you can depend on them. Just going to movies or bars together doesn’t create real friendship. Real friendship is formed in bad times when a person has to sacrifice some valuable resource for his friend. But if the human behavior is driven by GeMax and resource availability as our earlier discussion suggests, then how can we explain such resource sacrifice for a friend? I think that some real friendships do exist where friends will sacrifice anything for their friends without expecting anything in return but most of the friendships the world are typically arrangements for convenience and for deriving benefits in future at the cost of some short term sacrifice, just like the example of trading partners we saw earlier. The school friend who saved you from bullies expected you to do the same when he needed it. The office friend who looks after your work when you go on a vacation expects you to do the same when he would go on a vacation. The friend who lends you money in bad times expects you to pay back and lend him money if bad times happen to visit him. The ultimate sacrifice a person can offer is the sacrifice of genes, of blood, of life. In human history, there are some inspirational examples of people sacrificing their lives for their friends but they pale in comparison to far more numerous examples of people sacrificing their lives for blood relatives like their

children or siblings. In fact, that is how the adage came into being: blood is always thicker than water.

Seeing that the cooperation between two people leads to mutual benefit, human societies evolved into cooperative structures so as to benefit all members. We briefly touched upon this topic in the chapter on ‘Power as a key resource’ where we discussed how a unified command and control structure developed various different roles for people in the society. As the groups became larger, increasing conflicts of interests and altercations between people with diverse objectives would have become more frequent. To control this, there would have been a need for convincing people by means different from the heavy handed decrees of Kings. There would have been a need for methods that touched people’s heart and have a long lasting impact on their behavior. Birth of religions exactly filled this gap. If you analyze what most of the religions preach, you will find that many of them teach the same things to followers: be nice to your neighbors, elderly people and other society members, don’t steal other people’s property or women, don’t speak and act dishonestly and don’t have violent fights amongst yourselves. All these were very relevant teachings for the society at that time. These teachings were meant to maintain solidarity amongst the followers and work as one unit. Working as one unit was especially important – fights with other groups over resources almost always saw the most coherently working group coming out as the winner. But just preaching behavioral norms was not sufficient to influence people into changing their behavior, especially when selfishness and resource grabbing are so much ingrained into the human mindset through the evolutionary process. Religions had to sugarcoat the bitter medicine to make it more palatable and the sugarcoating they used were the concepts of God and Acts of God. People, by nature, had always been curious about their surroundings and unexplained phenomena such as eclipses, storms, lightening, etc. They also wondered how they came into being and how the flora and fauna came into being. The early religious preachers had to develop a position of credibility amongst the followers by being seen as omniscient. This they did by narrating mythological stories about the creation of the world, creation of animals and humans. This is how various early religions took shape. Even a brief analysis of key religions would indicate that religions have had two important aspects – the first was to gain credibility and mindshare amongst the followers’ hearts by offering explanations about the origin of beings which typically involved miraculous

Acts of God. The second and more important aspect was to introduce social behavioral norms for the smooth functioning of the society.

The concepts of racism, nationalism, regionalism, etc. have sprung up from the basic human tendency to collaborate with blood relatives to fight external enemies in order to protect or grab resources. Over the centuries, as contact between diverse human groups increased through trade, the size of resources to be grabbed and size of enemy groups to be fought, increased proportionately. For such large ventures, larger groups or societies of people needed to collaborate and form a coherent facade. Humans like us evolved around 100,000BC in Africa and spread across Europe and Asia later on. In initial times, the wars would have involved a few tens of warriors from the fighting clans. By 1200BC when the Trojan War was fought between Achaeans (Greeks) and the Trojans, more than 100,000 soldiers were involved. Within just three thousand years, when World War 2 was fought, the number of soldiers involved across both sides was about 70 million. Managing increasingly large societies or coordinating increasingly large number of troops requires a banner, a cause for which people would leave their selfishness behind and contribute towards the common goal (merely having a common leader rarely galvanizes people into contributing). One of the best causes for such purposes, as seen throughout history, is a perceived threat to the common bloodline. People of a family share genes, people of a race share genes and people of a nation also have shared genes, though the proportion decreases as we move outwards (from family to nation). As we saw discussed earlier, GeMax mentality makes a person fight for his genes and even if he sacrifices himself for saving others (who share his genes), it is preferable from the GeMax perspective. Depending on the threat level, people of a family or a race or a nation can easily come together under one banner, under one cause to collectively face the enemy. Even in today's times, when lower resource availability leads to conflicts among different human groups, racism, nationalism or regionalism comes to the fore as the rallying point. UK citizens protesting against Polish immigrants just because they take away many of the lower end jobs like gardeners and plumbers is an example of just this type of conflict and such conflicts would remain as long as resource availability remains constrained.

Origin of various –isms is also linked to constrained resource availability and methods of distributing resources. In old times, the clan leader or the King of

the kingdom used to be the sole authority on distributing resources amongst all people. Some of them, being true to the basic human nature, tried keeping it all for themselves and had to face a sharpened blade sent by other family members or a guillotine put up by the commoners. Then it dawned on the rulers that they need to make some efforts towards distributing resources throughout the society. In last 100 years the world has experienced four key -isms viz. Fascism, Socialism, Communism and Capitalism. These are actually nothing but ways of dividing resources amongst the people.

Fascism involved a government where a dictator held absolute power, suppressing opposition and pursuing aggressive nationalist and sometimes racist policies. The government, however did not own the property or factories and neither did it force industrialists to produce specific goods. Fascist government also did not pursue the goal of economic (wealth) equality amongst citizens. Fascism is rarely seen in today's world, except for some small countries ruled by dictators.

Communism is the absolute opposite of Fascism, with the government being the owner of all property and means of production. The stated goal of Communism is social equality via economic equality. The state takes the onus of planning production and distributing profits to the citizens. After the fall of USSR in 1991, very few communist states are left on earth today and China is the most prominent amongst these.

Socialism is less harsh than Communism in terms of economic policies. A Socialist state owns some common property and some industrial units. Much of the industrial and economic activity is in the private hands. Economic equality is not a stated goal but efforts are made to redistribute wealth from the rich to the poor in a benevolent manner. Many European countries follow socialist policies.

Capitalism is a system where all economic activity is in private hands and there are no government constraints on levels or flow of wealth or other resources; everything is decided by the private citizens purely based on profit maximization motives. US and UK are the key nations on earth with capitalist governments (though these are not purely capitalist because the government still owns some social infrastructure like schools, roads, etc.)

Social market economy is a hybrid system practiced in northern Europe and

it’s a socio-economic system that combines free market capitalism (that encourages private enterprises) with social policies (that encourage fair market competition & a social welfare state).

With little differences here and there, almost all nations in the world today have adopted a system which is a mix of capitalism and socialism and I think that is quite fine. However, it is generally observed that each person prefers a different –ism from the basket depending on the overall availability of resources and current distribution of resources amongst the people around him. It’s typically observed that the young college kids are pro-socialism or pro-communism as they typically earn zilch but desire the wealth of the rich amongst their society and hence demand government policies to redistribute wealth from the rich to poor. After a period of 10/20/30 years, many these same college kids would have a prospering business or employment somewhere and have a family to care for. In such a situation, their bias then typically shifts towards capitalism, demanding no constraints whatsoever on amassing and enjoying wealth.

As a side note, based on our discussion so far on human behavior, the factors affecting human behavior and the emergence of social hierarchy, one can work out the hierarchy of needs applicable to humans – needs they must fulfill, needs they strive to fulfill and needs that may or may not get fulfilled. American psychologist Abraham Maslow proposed a theory called Hierarchy of Needs in 1943 based on his analysis on human behavior and their motivations. He classified five types of human needs viz. physiological needs, safety needs, love/belonging needs, esteem needs and self-actualization needs. He proposed that humans generally try to satisfy needs in that order, starting from physiological needs. These five needs are typically shown as five layers in a pyramid called the Need Hierarchy pyramid. Even though the impact of genes on behavior was not known at that time, the theory very nicely captures some of the corollaries from our GeMax hypothesis. Here are the needs in detail with their connections to GeMax.

The most basic needs are Physiological needs like food, air, water, shelter, sleep and sex. From the GeMax perspective we know that the first objective of the subconscious brain of any animal or person is procreation and survival. Food, air, water, shelter and sleep are all quite crucial for survival.

The second stage needs are Safety needs like security (freedom from fear),

order, law, stability (in the form of stable employment and stable family), resources, property, etc. In earlier chapters, we have discussed how GeMax leads to accumulation of resources and cooperation amongst people to form a coherent, stable, law-abiding society.

The third stage needs are Love and belongingness needs which include friendship, intimacy, affection and love from family, friends, work group and romantic relationships. From the GeMax perspective, closer friendships and family ties would lead to more (soft) power, meaning more people being available to help you when you need them. Higher power, safety and stability, in turn, support better GeMax outcomes and hence such relationships are naturally desired by humans.

The fourth stage needs are called Esteem needs and these include self-respect, respect from others in the society, achievement, confidence, status, dominance and prestige. These desires are akin to amassing more power. As we know, higher the level of ‘Power’ resource, higher is the ability to gather more resources like assets, food and mating partners and hence more power is incessantly sought by the subconscious mind.

The fifth and topmost type of needs is called Self-Actualization needs and these needs include realizing personal potential, creativity and self-fulfillment.

The first four types of needs are known as Deficit needs. This is because if a person has not fulfilled one or more of these needs, it would make him feel deficient and make him strive for it. But when these needs are fulfilled, then he would feel content. These needs are basic needs and not motivational needs that propel a person to real greatness and superior contentedness.

The needs that would take a person to greatness are the Self-Actualization needs and this is where the advanced human brain leaves behind the animal mind and moves to another level. Many animals today have sufficiently evolved brains to subconsciously strive for procreation, safety, cooperation and power within the group. But the self-actualization needs arise out of conscious brain, after the basic needs are fulfilled. If a person is well-fed, has a decent family and kids, has a steady income to feed his family and has a decent friend circle to discuss his ideas then it is quite possible that he has scaled the first four layers of the Need Hierarchy pyramid and would move

on to realizing his true potential – it can be painting or singing or solving unsolvable problems in mathematics.

According to Maslow, self-actualizing people tend to have some wonderful qualities like honesty, uprightness, benevolence, aliveness, simplicity, wholeness, perfection, structure, order, synergy, acceptance, resolution, spontaneity, self-regulation, idiosyncrasy, individuality, novelty, suitability, justice, fulfillment, fairness, lawfulness, simplicity, abstract, bluntness, intricacy, totality, playfulness and independence. This list is quite long and few of these are somewhat contradictory if seen at a superficial level. However the important thing is that these are exactly the qualities that each and every human would consciously want to develop and achieve in his life. This conscious desire is what sets the human brain apart from animal brains. Achieving these qualities is what makes a person truly happy. However it is also very important to remember that to reach the pinnacle of the pyramid, we need to first scale the bottom four layers viz. the deficit needs. This point is of great relevance in later chapters where we will discuss the future of mankind.

Chapter 1.6: Running Out of Resources

I was always fascinated by the great civilizations of old times and used to wonder how great civilizations like the Indus Valley civilization and the Roman civilization could go extinct. The reasons for decline or disappearance of various civilizations were different but there is a common denominator – they all went downhill when they ran out of resources to sustain growth. The Indus Valley civilization is said have gone extinct when the river Saraswati dried up after an earthquake (about 1900BC) and the people had to abandon cities in search of water. The great Roman Empire lost its shine around 5th Century AD and various reasons are offered by historians to explain the downfall. One reason put forth is that the empire had grown so large that there were no new lands to conquer and bring in more wealth to sustain the ongoing levels of consumption. Another interesting theory suggests that the rich class at that time had piped water supply systems, with pipes made from lead. Even the utensils used in rich households were made of lead as it was more precious than the copper available to the commoners. Given the fact that lead consumption severely affects key organs like heart, kidneys and brain, the rich Romans which consumed food and water contaminated with lead on a daily basis started perishing rapidly. The whole top layer of the civilization was thus struck down by lead poisoning over a relatively short timeframe and the civilization became a rudderless ship as very few who could lead the society with their wisdom were left alive. Be it water, be it wealth, be it wisdom, it is the resources which make or break a civilization.

Lawrence Keeley, a professor at the University of Illinois has said that approximately 90-95% of known societies throughout history engaged in at least occasional warfare. Why do societies engage in warfare? The culprit behind wars is the same as the culprit behind declines of civilizations – constrained resource availability. If you look at the great wars in history, you would find different versions of same theme: ‘resource shortfall leads to wars’. World War Two which led to about 70 million deaths was started by Germany because it had fallen behind Britain and France in the race to acquire colonies which would supply raw materials required for industrial growth. World War One, which saw about 20 million deaths during 1914-1918, was started by Germany and Austria-Hungary for exactly the same reason (grabbing colonies). Mongol invasions from China to Europe during

the 13th Century AD led to about 60 million deaths; the invasions were a result of poor Mongolian herders taking up arms to grab the riches from the wealthy kingdoms. Similarly the wars waged by Huns and Kushans about two thousand years ago were for seizing more land for their growing population. The famous thirty year war between Athens and Sparta, known as Peloponnesian war, was caused by rise of Athens as a great power that threatened the Spartan alliance.

Which wars or conflicts do we see around us today? One can immediately think of the civil war in Iraq and Syria where the local ethnic groups are fighting to grab power and resources in economies devastated by war. The civil war in Afghanistan is again the result of a weak economy (that can barely produce anything) being ravaged by different militia groups. Wars in various locations in Africa also fit this pattern of resource deficient economies torn apart by fighting factions.

Developed economies are not waging outright wars but are still fiercely competing with others for some key resources – the major ones in this list are crude oil, water, space technology, capability of exploring oceans, ownership or control over strategically important places like Antarctica, Arctic Sea, etc.

Crude oil has been the key contributor to the industrial and overall economic development in the last century. Products obtained from crude oil were used for various applications, right from running vehicles to making plastics, paints and textiles. In the last decade, the demand for crude oil had suddenly surged due to rising consumption of developing countries like China and India. On the supply side, however, major constraints emerged in the form of large suppliers like Iraq and Iran almost going offline and new oil discoveries turning out to be very costly to extract. The world saw the prices skyrocketing from about US$30 per barrel to about US$150 per barrel within a decade. Such great supply constraint is what made many countries develop alternate energy resources and some of these countries decided to take further long term measures – explore oceans and even continents like Antarctica for the yet untapped sources of crude oil. Fortunately, recent breakthroughs in the technology of extracting shale oil (meaning the oil trapped in the shale rock formations underground) has come as a Godsend because the great shale oil reserves in many continents can now be tapped to balance the falling supply of traditional crude oil. Another benefit from the price spike in crude

oil was renewed efforts in developing alternate energy sources such as wind energy and solar energy. Years of technological developments have now made these energy sources easily and cheaply available to the common man in almost every country. We will discuss the implications of this in the later chapters.

One underappreciated resource needs a special mention here and that is water. For those who have water available on tap (pun intended), it is not even registered by the conscious brain. But there are people, especially in the remote places in Asia and Africa, who have to walk many miles daily just to get two buckets of water for a whole family. It is estimated that more than 1.2 billion people lack access to clean drinking water. Water is available in the form of oceans and icecaps at the poles but humans cannot consume these. As per the United Nation's estimate, out of 1.4 billion cubic kilometers of water on earth, only 0.2 million cubic kilometers is freshwater, that can be readily consumed by humans. Conflicts over water are likely to become very common in coming years, if humans don't develop the technology to improve water availability. Luckily there have been a few breakthroughs that we will discuss in a later chapter.

The message from this discussion is simple: if the future of mankind is to be different from that of the Indus Valley civilization, the Roman Empire and countless other tragedies, we need a keen focus on resource availability.

Chapter 1.7: Is our Past our Future?

The essence of our discussion till now, would be:

Human selfishness arises out of GeMax and limited resource availability. Generosity arises out of resource abundance.

We discussed how each of the element in this principle has evolved over time and how this pithy formula can explain most of the human behavior we have seen. It can explain why a starving, destitute person might devour his own pet dog but given enough wealth, why the same person would offer lavish dinners to his whole village.

It is ancient knowledge that human selfishness and the desires thereof cause huge suffering in the world. A King may attack neighboring nations for their resources but the war would end up killing thousands of innocent souls. Thieves, cheats, spies and quacks are a few more examples where selfishness leads to suffering of a great number of people.

According to the Buddhist tradition, the Buddha first taught the four noble truths in the very first teaching he gave after he attained enlightenment. Within this discourse, he said:

Now this, Bhikkhus, is the noble truth of suffering: birth is suffering, aging is suffering, illness is suffering, death is suffering; union with what is displeasing is suffering; not to get what one wants is suffering; in brief, the five aggregates subject to clinging are suffering.

Now this, Bhikkhus, is the noble truth of the origin of suffering: it is this craving which leads to re-becoming, accompanied by delight and lust, seeking delight here and there, that is, craving for sensual pleasures, craving for becoming, craving for dis-becoming.

Now this, Bhikkhus, is the noble truth of the cessation of suffering: it is the remainderless fading away and cessation of that same craving, the giving up and relinquishing of it, freedom from it, non-reliance on it.

Now this, Bhikkhus, is the noble truth of the way leading to the cessation of suffering: it is this noble eightfold path; that is, right view, right intention, right speech, right action, right livelihood, right effort, right mindfulness, right concentration.

In short, Buddha said, life is full of suffering, desire is the cause of suffering and only by giving up desire altogether and following the righteous path can a person get rid of suffering.

Our earlier discussions brought out that humans have evolved to desire resources for propagating their genes and these desires drive his life. Even though the concept of genes was unknown at that time, Buddha recognized the central role of desires in human lives and their role in causing suffering. Using the Need Hierarchy theory we discussed earlier, it becomes clear that Buddha was asking his followers to give up the pursuit of the four deficit needs and move onto the self-actualization stage. This would have been a very sound advice at that time.

Is the same applicable today? Is this what our future should be? We need to consider a key difference between the past and the future. Resource availability, especially for the poor people, at the time of Buddha would have been severely limited. So it would be logical to conclude that desiring larger fruits would have surely ended in suffering in those time. But just like the mutation in genes, where only those gene mutations fit for survival accumulate in the body, *beneficial technological advancements accumulate and grow*. Better technology made resources more easily available to people and helped them live a better life. As and when resources have made life easier, human selfishness has given way to altruism. In ancient times, about 45,000 years ago, the human life span was about 18 years. With the advancement of technology, work like farming became less taxing and work like hunting became less dangerous. This resulted in expanding human life span. It gradually grew from 18 to about 37 around 2 centuries ago. So during the last 5000 years the average human lifespan was about 26 years. The age of reproduction was about 13 years. As people became old, meaning about 25-26 years of age, they were not physically capable of reproducing. The males are less likely to have survived to very old age because typically older males had higher risk of getting injured during hunting. However, old females would have continued to live on in the households, with their key contribution to the group shifting from producing offspring to looking after their grandkids and directing young women in the clan. This was a revolutionary step in the evolution of mankind; other animals hardly exhibit such grandmother-grandchildren relationships. During the same period, languages were being invented and honed (thanks to the larger human brain

size and complexity not seen in other animals). This allowed the grandmothers to talk to the grandkids and pass on the knowledge of earlier generations to them. *Knowledge is cumulative in nature, it builds on itself.* It obviated the need for each new generation to reinvent technology from scratch; it could invent something new using the earlier technology. Grandmothers also taught the grandkids about their 'culture' which, at its core, is 'behavioral norms for group members'; norms that help a group perform effectively and succeed as one unit. As we saw earlier, the parents would have been required to spend most of their time in hunting and gathering respectively in this phase and hence could spend less time with their kids. Having grandmothers around overcame this problem and formed a bridge for transfer of ideas on technology and culture. Today scientists call this phenomenon as Grandma Hypothesis. This phenomenon might have helped human evolution greatly.

This could also have been the beginning of Altruism. Altruism is when a person A does something that benefits person B, but costs something to person A. depending on the nature of the cost incurred, we can make two classes of altruism – one is Mild Altruism where the cost incurred today is expected to be recovered later in some form and the second is Strong Altruism where the cost incurred is substantial and is not expected to be recovered. If you agree to look after your neighbor's dog when he goes abroad for vacation because you expect him to do the same for you next month, you are indulging in the mild form of altruism. You are helping out your neighbor and you agree to spend time and energy for his dog because you expect to recover this cost later in the form of free time when it is your turn to go on vacation. Such acts greatly benefit society as they facilitate cooperation amongst the society members and increase the productivity of the society. Evolution would favor such behavior through natural selection and hence we should see such behavior as inherent across most of the people on earth, which we do. Another form of the mild altruism is when you ask a stranger for directions to locate an address and he guides you. It is obviously quite unlikely for him to come to your locality so that you can return the favor, then why is he helping you? By helping you, he and you are building a culture where any person would feel free to ask for directions to any stranger and the stranger would reply, knowing that if he were in a similar position, somebody else would respond. Sending donations and consumables to flood-hit people is also a form of such apparently one-way altruism but it builds a

more altruistic society and hence such actions form an important social pillar.

What can be an example of the strong form of altruism where the cost incurred towards helping others is not expected to be recovered? A unit made of a few soldiers was under heavy enemy fire. There was no way they could win and there was very little chance of escaping. George, the most fearless warrior in the group offered to keep the enemy down with his heavy covering fire and asked the remaining group members to escape. Having no other option, the group accepted with a heavy heart and just about made it to a safe zone to be evacuated. Brave George laid down his life during the battle but was given a posthumous Military Cross and was fondly remembered as a hero thereafter. This seems like an example of the strong form of altruism where poor George has given his life for his comrades but did not get anything in return. You might recollect the examples of GeMax induced sacrifices we encountered earlier. Even in case of George, his subconscious brain might have decided to pick the option of saving at least some gene-sharers (his team members) as against the option of all of them perishing in the battle. This is the option of last resort, but still a fair option, for the subconscious brain running GeMax program.

The strong form of altruism can be found just occasionally in our society but the mild form is quite prevalent. It is interesting to note that even the mild form comes after some basic requirements are fulfilled. First of all the person helping out should be having the ability or the required resources for helping out the other person. If you don’t have enough free time, you can’t volunteer to look after your neighbor’s dog. If you don’t have money, you can’t help your friend in need, however strong and noble your intentions might be. Other important criteria is the time-frame over which the favor is expected to be recovered. If you don’t plan on getting a dog anytime soon, you are not likely to volunteer for looking after your neighbor’s dog when he goes on vacation (the neighbor I mean, not the dog!) Higher the time gap between the initial help and returned favor, lesser is the value of the returned favor. Just like they say ‘justice delayed is justice denied’, indefinite delay in returning a favor is as good as not returning it. The time factor has a human mortality angle to it as well. Because humans have a finite lifespan there is a chance that either the person returning the favor or the person taking it back may conk off before the favor is returned and this uncertainty sometimes weighs on the mild form of altruism. Over last few thousands of years, increasing

awareness about the benefits of cooperation has helped in spread of altruism but, in my opinion, the simultaneous expansion in human life span, from about 20 years to about 75 years now, has also contributed a lot. Higher life span allows a person to take a longer term view while undertaking any altruistic action.

Now we are coming to the conclusion of the first part, the part about what shapes human behavior. We have discussed two key aspects – we saw that the GeMax mentality is inborn in humans and it dictates almost every action that we do. We also saw that constrained availability of resources affects our behavior. The lesser the resources, the more selfish we behave and there is more suffering in the world; the more the resources, the more benign and altruistic we are. This is the key to use while revisiting Buddha's teachings today – improving resource availability may help mankind conquer desire rather than shunning it as was more suited in the past.

The question to ponder about is what would happen if human lifespan continues to expand rapidly and if mankind gets access to almost infinite resources?

In such a case, how vastly different will our future be?

Part 2: Technological Breakthroughs and their Expected Impact on Mankind

'Any sufficiently advanced technology is indistinguishable from magic'. – Arthur C. Clarke

When I tell people that in a few decades' time, we will have the option of living forever, the typical reaction is, "Impossible! Not only is it impossible, it is also against the laws of nature!"

When I tell people that in a few decades' time, problems like global warming, pollution, water scarcity, deforestation, AIDS and Ebola, conflicts and wars, poverty and hunger will have been solved, the typical reaction is, "Impossible! Simply because these problems have now grown so large and unwieldy and all attempts hitherto have proved to be woefully inadequate".

In this part we will discuss how these missions could become possible through research and development efforts of many scientists and technologists and how nature is not a hindrance but a facilitator of mankind's growth. This part is not continuation of Part One of this book but is worth reading because it forms the base to what we will discuss in Part Three – the future of mankind.

I recollect a very apt quote on technology by Roy Charles Amara, a researcher, scientist and past president of the 'Institute for the Future'. He said, "We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run". In the upcoming chapters, we will look at how new technologies would change mankind in the long run. We will first discuss current technological research in multiple fields and how it is helping in making human lives better and extending human life span. We will also discuss how we will have the option of shedding key organs and possibly the whole body!

Every technology, every development and every production process needs some kind of energy source and we will discuss the best energy source that mankind has begun to harness viz. Solar energy. We will peep into what have been the technological advances in the area of harnessing solar energy and how the costs have been plummeting. We will then see how an inexpensive and abundant energy source is almost equivalent to multiplying all other

available resources many fold and how it would be possible to use these resources for solving all global issues.

Towards the end we will encounter Singularity, a concept where the machine intelligence rises to unprecedented levels, leading to unimaginable outcomes and altering human life forever. We will try to tackle the persistent fear people have – that one fine day, robots fitted with Artificial Intelligence will take over the world and the Judgment Day will be upon us.

Chapter 2.0: Recent trends in Society

In earlier chapters we found that conflicts are a result of constrained resource availability. As the population increases worldwide, the resource bases are further strained. Farms are stretched to produce sufficient food for more people. The key reason for deforestation today is for increasing farm area for food production. Cattle and farm animals cannot produce sufficient dairy and meat for ever increasing population. Cities have become overcrowded, roads are choked with cars and trucks; trains are overflowing with office-goers. These scenes are not restricted to just a few developed or a few developing countries; it is universal today. Governments are trying their best to cope up with solutions for these issues by promoting creation of more resource capacity or using alternate resources. You may already know about better yielding hybrid crops and hybrid cows which give more milk. Governments are trying to promote more social commuting by running more buses, trams and underground metros and simultaneously making individual car ownership more difficult through higher VAT, congestion charges, etc. However, all these efforts keep falling short due to the rapidly growing human population everywhere on earth.

About 10,000 years ago, the human population was about 5-10 million. About thousand years ago, human population was roughly 500 million, meaning an addition of almost 490 million over 9000 years and roughly 1000 years were needed to double the population. But in the last millennium the speed of growth has reached a humongous proportion. Earth's population has almost doubled within the last 50 years to about 7 billion today. One key reason for population growth is the falling infant mortality. About 200 years ago, one out of five newborn babies used to perish before their first birthdays; this ratio has now fallen to just one out of a hundred. Availability of better birthing methods, vital nutrients, medicines and cleanliness have aided in reducing infant mortality. Another reason for population growth is rapidly increasing life expectancy. The life expectancy at birth for the Cro-Magnon man (around 45,000 years ago) was about 18 years which increased to about 25 years during the Ancient Egypt civilization. With passing time, the life expectancy improved faster; the life expectancy in 1400AD Europe was at 30 years which went to about 37 years for 1800AD Europe/US and to about 48 years for 1900AD Europe/US. Today, barely 100 years later, the life expectancy in many nations is about 78 years. Higher life expectancy is the

result of two key factors at work – better nutrition on one side and better health & hygiene on the other side. Great killers of the past viz. plague, cholera, smallpox, polio which claimed millions in casualties are no more. Today's key killers are cancer, heart disease, diabetes, AIDS, etc. and our scientists and biologists seem to be on a slow but steady path to victory. The higher life expectancy arising out the factors mentioned above adds a phenomenal number of elderly people to the society. In some countries like Japan the condition is quite extreme, with almost a third of the population being old.

But there is hope. Recent data shows that reproductive rates are coming down in many countries. An average women needs to have about 2.1 children in her lifetime if the world population needs to remain in balance. This number is already falling to about 1.7-1.9 in many countries today. Given the falling reproductive rates in various nations and the increasing lifespans, it is quite possible that the Earth's human population growth may cool down. We may reach a total population of about 9-10 billion in a few decades time and then just stabilize there. If a stable level of population is reached, there is a chance that Earth and the various resources on Earth might be sufficient for the 9-10 billion people to live peacefully. Some currently uninhabitable areas like desserts or tundra can surely become habitable as problems of transportation, in-house climate control and food production are already being solved. In addition to these, innovations inside and outside the human body would make humans feel very comfortable in such climates. In fact, as the resource requirement for 9-10 billion humans will not be too large, I feel that mankind may not even need to explore living inside oceanic domes and in space pods. Of course, those research areas would still flourish in my opinion, but it would be more from an academic point of view.

The main contributors to my positive outlook for the future are the visionaries (entrepreneurs and scientists both) amongst us who dream of the unthinkable and realize the dream through unceasing efforts. Today's technology is changing much more rapidly thanks to so many Henry Fords and Akio Moritas working across thousands of start-ups and laboratories today; some of these we will meet in later chapters. One estimate says that globally, about 500 million entrepreneurs annually try launching about 300 million businesses but ultimately about 100 million ventures are launched. The nature of start-ups is just like Darwin's natural selection thesis, leading

to evolution. The unfit ventures close down over a few months or years, the total number being close to 100 million per year worldwide, keeping the numbers in balance. Number of scientists working across the world over the years is hundreds of thousands, with about 30,000 PhDs added by US and a similar number added by other countries combined to the pool of scientists annually. Government funding is falling short, but fortunately the private sector has stepped up to support research in many areas, right from drinking water to biotechnology to quantum computing.

The pace of research has increased so much in recent years that commercialization and consumer adaptation is falling behind in many cases. The new laptop model launched just yesterday is already a generation old compared to what is being developed in the labs today. The new fighter planes being tested in the skies today are already a generation older than what's being designed today. In the upcoming chapters, I plan to talk about some cutting edge research being done in many industries that would greatly benefit mankind by improving the availability of and accessibility to various resources.

Chapter 2.1: New methods of food production

Two friends are sitting in a restaurant. One complains, "You know, the food here is just terrible". The other solemnly adds, "And the portions are so small!"

Food is the key resource for humans as we saw in one of the chapters. A growing population demands higher food and higher food requirement results into more agricultural land, leading to massive deforestation. Within last 400 years, human habitation requirements in US have caused complete destruction of 90% of indigenous forests in that country. On the global scale, it is estimated that about 18 million acres of forests (the size of Panama) are lost every year. If this pace continues, we will see the rainforests going extinct in just 100 years. Environmental impacts of deforestation, such as soil erosion, loss of species and climate change, are well known by now.

Animal husbandry is another leading cause of deforestation. Globally, as populations of various nations are becoming more prosperous through economic growth, they are shifting from vegetable sources of proteins to animal sources of proteins (meaning meat). Meat, typically being costlier to produce and having lesser availability, is a prestige food for the economically backward classes in many countries and hence as soon as income permits, meat consumption shoots up. In recent decades this phenomenon has been observed in large countries like China and India. Cattle and sheep need mainly grass and hence grasslands and ranches are needed more than forests to support animal husbandry. Animal agriculture is also a big drain on water consumption and leads to massive pollution. Cars belching out smoke are generally the easiest culprits when it comes to pointing out sources of greenhouse gases. What is less commonly known is that animals raised for meat release a lot of methane (natural gas) in the atmosphere and these animals are responsible for about 18% of greenhouse gas emissions, more than the cars, planes and all other forms of transportation put together. Another problem with meat is that it requires a disproportionately large amount of water and nutrients. Cattle typically consume 16 times more food than they give out as meat. Water consumption required for growing various vegetables and fruits ranges from about 25 to 40 gallons per pound of product but in case of chicken, pork and beef, the water consumption jumps to about 800, 1600 and 5200 gallons per pound of product. The wastage doesn't stop

with just nutrients and water; proportionately higher land, manpower and energy is also required to process such meat.

There is an elegant solution for this problem of meat production and that is ‘in-vitro meat’. In-vitro meat is also called as test-tube meat or lab-grown meat. It is a meat that was never inside any animal. The idea is to start with a few muscle cells and add nutrients and proteins to aid growth of these muscles inside a production facility. Once the conditions are right, the muscle cells can continue to grow indefinitely without the need of a body. It is claimed that in ideal conditions, in-vitro meat production technique can give us 50,000 tons of meat in two months, starting with just 10 animal cells. The first burger made from in-vitro beef was eaten for a demonstration by the Dutch inventor team in 2013. The total development cost for the beef-burger was about US$300,000, which is certainly high for a burger but very low for a groundbreaking technology. The same team has recently proclaimed that lab-grown meat is on its way to hit shelves in about five years. That means issues like cost, taste and shelf life are being worked out. Just like any other commodity, large scale of operation will bring down the costs of production drastically. As and when this actually happens, it might mean an end to growing millions of cattle, goats, pigs and other farm animals. This will also mean less cruelty to animals, saving precious resources spent on meat, fall in deforestation and lower emissions of greenhouse gas.

Hybrid crops have found acceptance across the world in the last five decades; though the spread in developed countries started much earlier with the first hybrid maize launched in US in the 1920s. Crop yields achievable using hybrid varieties are significantly higher than the traditional ones. Hybrid crops are also capable of growing in harsh conditions, using less water. With hybrid seeds, the seed wastage is minimum, vigor and vitality is higher, stem structure is more uniform, leading to easier processing and the root structure is extensive, leading to draught resistance. The next logical step in increasing food production is Genetically Modified (GM) foods. In this segment, genetic engineering is used to remove unwanted genes from the plants and useful genes are inserted. Various different types of genes, like genes for pest resistance, draught resistance or any other property can be inserted in the seeds. Such seeds can not only provide better yields, thereby lessening burden on the arable land, they would also provide nutrient rich foods to the world population. A good example of this is GM Golden Rice. This rice

variety developed by International Rice Research Institute carries greater amounts of vitamin A and use of such varieties can provide vitamin A enriched rice to those in need at low costs, like the millions of African people who suffer due to vitamin A deficiency. A type of GM soybean can produce oil that is healthier for human consumption as it has a better composition of useful fatty acids. Use of GM crops is thus on its way to solve world's nutrition problems. There are some downsides to GM crops, like the uncertainty over how these can impact humans over the long term and the patented ownership of these varieties is a prickly issue. I hope scientific and economic breakthroughs over these issues would soon pave the way for the acceptance of GM crops.

Innovation in food technology is not just happening in the large research divisions of multinational companies; solitary innovators working on shoe-string budgets have also made some wonderful breakthroughs. One such innovator is Jared Wolfe; he has designed a crowd-funded internet connected Biopod. This Biopod is a habitat that's automatically controlled – humidity, light, temperature, rain, etc. are controlled through a mobile application and this Biopod can be used to nurture almost any kinds of flora and fauna. Large vertical farms may be the ultimate evolved form of such biopods to take care of the food requirement of entire cities. These vertical farms will have robots and sensors, finely tuned lighting for the plants, water at perfect pH and nutrients at perfect levels which will give superfast growth and maximum yields. Such habitats are a great leap over the greenhouses and when available at economically feasible price points, these can address food production issues even in hostile environments such as deserts & snow-clad lands.

Chapter 2.2: Healthcare Innovation

The Japanese eat very little fat and suffer fewer heart attacks than the British or Americans. On the other hand, the French eat a lot of fat and also suffer fewer heart attacks than the British or Americans. The Japanese drink very little red wine and suffer fewer heart attacks than the British or Americans. The Italians drink excessive amounts of red wine and also suffer fewer heart attacks than the British or Americans. Conclusion: Eat and drink what you like; it is speaking English that kills you.

Keeping aside the funny part, it is a disturbing statistics that today heart failure has become one of the top three causes of mortality in many nations. On one hand, scientists need to be applauded for eliminating the key killer diseases of the past century like polio and smallpox. Scientists and innovators should also be applauded for the vast improvement in the amount and quality of food being made available to the common man today. However, these developments have created new demons to be fought – heart attacks, cancers and organ failures caused by high blood sugar are just a few of those. New breed of scientists ably supported by latest developments in computing technology are working on almost each and every human malady and early results are promising. Thanks to technology, heart transplant has become a simple procedure and worldwide, more than 5000 heart transplants are done every year. Stents in arteries and artificial heart valves have become quite common around the world and the innovators are working on various different prototypes of completely artificial hearts.

Another disease that has gained prominence in the last 50-60 years is Cancer. Various forms of the disease put together claim more than half a million patients in US alone and more than 8 million worldwide. Due to better diagnosis, the patient population is increasing every year; WHO expects the number of new cases to grow by 70% over the next two decades. In last twenty years, scientists have developed a plethora of new molecules to fight cancer viz. monoclonal antibodies (mabs) which specifically attack cancer cells. In addition to developing new types of mabs, other approaches, such as developing vaccines and viruses, are also close to bearing fruit. Just recently, US Food and Drug Administration (USFDA) approved the first cancer killing virus for human use. It is named Imlygic and it is developed by Amgen. In patients with inoperable skin cancers, this virus can directly attack cancer

cells and also help the body's immune system identify and kill the cancer cells. This is a great breakthrough in cancer treatment and with such multi-pronged approach, we can feel hopeful about a complete victory over cancer within a decade or two.

Technological advances are helping medicine in many other ways, too. The latest talk of town are the 3D printers which can print any shape including shapes that were too complex for the traditional manufacturing processes to achieve. Traditional manufacturing follows the method of starting with a large piece of material and removing unwanted portions from it. 3D printing works in the exact opposite manner, by adding a layer of material, solidifying it and then adding the next layer. Depending on the type of printer and the product required, various materials, right from plastics to metals to paper can be used for 3D printing. Today 3D printers can print anything from jet engine parts to even buildings made of concrete. How is 3D printing useful for healthcare applications? Patients who have lost ears or teeth in accidents can now get identical parts made quickly using 3D printers, helping them back to normalcy. Doctors in Spain have recently fitted 3D printed ribs made from Titanium metal into the body of a cancer patient who had lost his sternum and pieces of four ribs when the doctors removed a lung cancer. Personalized joints and bones can be developed with 3D printing. In 2014, it is claimed that 3D printed body parts worth more than US$50million were ordered worldwide. USFDA recently approved a 3D printed drug named Spritam, developed by Aprecia Pharmaceuticals. This epilepsy drug tablet is made by 3D printing layers of the powdered drug and the product's resultant ability to dissolve faster than the average pill makes it an easy-to-consume product for sufferers of seizure attacks. In future, we are bound to see more 3D printed drugs.

Prosthetics is another key area of the healthcare innovation happening around us. Prosthetics is an artificial device that replaces a missing body part. It typically means a bionic arm or a leg. Advancement in technology and development of new lighter-but-stronger materials like special plastics and carbon fibers have greatly enhanced the quality and usability of the prosthetics. Use of electronics has become more prevalent in artificial limbs; these are now fitted with microprocessors which can analyze signals coming from patient's body or nervous system and act on it, enabling the user to easily control the limb.

Moving on from replacing outer organs to growing internal organs, we stumble upon an exciting area of research – stem cells. Stem cells are basic biological cells that can grow into any type of cells in our body – right from heart muscles to neurons in the brain. Based on the ongoing research, it may become possible to generate healthy heart muscle cells in the laboratory and then transplant these cells into patients with chronic heart disease, thereby obviating the need for a complete heart transplant and the interminable wait for a donor heart. In Type-1 diabetes, the insulin-producing cells in the pancreas are destroyed by the patient's own immune system. Researchers have recently developed artificial pancreas for such patients. However, if a patient wants organic pancreas it would be possible to develop pancreatic cells using stem cells and then transplant these into the patient. Many other diseases like macular degeneration (vision loss), spinal cord injury, stroke, burns and rheumatoid arthritis (pain in joints) are expected to be addressed using stem cell research. Stem cells are being used to regenerate tissue and literally rebuild organs. Research team at University of Wisconsin has successfully grown functional vocal cord tissues in the lab using stem cells. These can be implanted in patients who have lost their vocal cords due to cancer surgery or other injuries. Companies like United Therapeutics and Synthetic Genomics are working on being able to regrow a set of lungs within this decade, and soon thereafter, any organ that a patient may need.

Going further inside the human body, we encounter our building blocks – the chromosomes inside the cells, genes (which are bits of chromosomes) and the DNA, the ultimate building block of biological systems. DNA is made of two helical strands coiling around each other (double helix). Each DNA is made up of smaller units viz. deoxyribose, phosphate groups and nucleobases named Cytosine (C), Guanine (G), Adenine (A) and Thymine (T). The two strands inside a DNA stick to each other due to bonding of Adenine (A) with Thymine (T) and that of Cytosine (C) with Guanine (G). There are 3 billion of such base pairs in human genome. As we discussed earlier in part 1 of this book, genes and DNA store biological information of an organism. Mapping the positioning of C, G, A & T along the entire DNA of an organism is called mapping the genome of the organism. Such mapping would give us an idea about each and every enzyme and protein the organism is likely to produce. Already scientists have figured out the functioning of many of the genes in human genome and are on their way to figure out the hitherto unknown parts. Human Genome Project, which first mapped the complete human DNA

sequence started in the 1990s and ended by 2003. It required collaboration amongst twenty universities across three continents and the cost was about US$2.7 billion. Today, with advances in computing technology and biotechnology, the cost has dropped to about US$1000 and within next five years or so the cost is likely to fall to around a hundred dollars. Already it has come within the reach of a common man and this genome information is about to revolutionize healthcare in an unprecedented manner. Any person can get his/her genome checked for markers of potential genetic diseases like hereditary Cancers or Alzeimer's or Parkinson's disease and start proactive treatment. Some people are genetically more disposed to blood-clots formation; genome screening allows doctors to put such patients on special preemptive medications. Future research on genome will allow scientists to map all potential traits based on DNA. In case of children, this will include their potential intellectual level, inclination towards particular subjects and any potential anti-social behavior. Such analysis will be helpful in taking pre-emptive actions as appropriate. Reprogramming the DNA for medical or cosmetic benefits is already being done but we will discuss that in the chapter on genetic engineering.

Technology is making its mark in non-invasive therapies, too. An automated speech analysis program developed by researchers at the Columbia University Medical Center was found to be more accurate than practicing psychiatrists at predicting psychosis (a severe mental disorder) amongst young people. The computer program analyzed patterns of speech including semantics (meaning, staying on topic, etc.) and syntax (structure of sentences, phrase lengths, etc.) to predict future psychotic behavior and was found to be 100% accurate in its prediction. This research has opened a new door in the area of psychological research where computer programs can help doctors in correctly diagnosing mental disorders in patients.

Apart from diseases, there is one area which worries the common man the most and that's old age and eventual death. Other than personal preference for a long life (arising out of GeMax, of course), there is another important issue related to old age and that is the social and economic impact of older population. Like we saw in case of Japan, many countries have rapidly growing number of elderly which increase the burden on healthcare and retirement costs. US government alone spends about 30% of its budget on social security and Medicare. At the same time, falling fertility in the society

is causing the number of younger contributors/payers into the system to shrink. That's why healthcare innovators are now focusing on increasing healthy lifespan and not just life extension. Adding extra years to the life of a person already on deathbed will just increase costs and suffering and will not be really useful. If old age can be delayed and 'healthy adult age' can be stretched, people can work longer, contribute more to the society and live a healthier, happier life. We have already seen that with better nutrition, hygiene and disease control human lifespan has increased from 30 years to about 80 years over last thousand years and the progress is still continuing. However, prima facie, there seems to be a natural limit to it. Even the best of the humans don't last much beyond a century. The key question on everyone's mind is: can humans live beyond 100 years? Research is focusing on what makes a person old and what happens inside each organ, at the cell level, at the genetic level during old age and how it can be countered. Many private and public research entities like Calico (Google), Stanford Center on Longevity and Buck Institute for Research on Ageing have dedicated themselves towards anti-aging research. There are two benefits of anti-aging research. First of all, these therapies are preemptive in nature and are far less expensive than treating the diseases post facto. Secondly, these therapies will keep people healthier for longer timespans so they will not be seekers of medical support from the state but they will be contributors to the state finances.

One example of such therapies is the ongoing research into Rapamycin (also known as Sirolimus) which is an antifungal compound produced by bacteria found on Easter Island. Currently it is used mainly after the organ transplant operations (like kidney transplants) to reduce the rejection rate of the new organ by the patient's body. Even certain stents put into coronary arteries during Angioplasty procedure are coated with this drug. Recent experiments in mice have shown that Rapamycin can substantially extend lifespans. The lifespans of mice fed with Rapamycin were increased between 28 to 38% from the beginning of the treatment and more importantly, this result was seen even in mice which were 20 month old which is equivalent to 60 years of age in humans. These experiments have given hopes for delaying aging in humans and human experiments are already on. Another potential life-extension drug can be Metformin. This drug is currently part of the first line of treatment in diabetes as it is very capable at controlling blood sugar levels in human body. Given the fact that higher blood sugar levels lead to damage

and deterioration of various body organs, Metformin may have some impact on extending human lifespan. The team at Albert Einstein College of Medicine just recently got the USFDA approval for conducting clinical trials on Metformin as an anti-aging drug. The ‘free radical theory of aging’ proposes that free radicals (atoms with unpaired electron) adversely affect various types of human cells and their constituents like lipids, proteins and DNA and thus higher exposure to free radicals leads to faster aging. Anti-oxidant supplements are likely to counter the impact of free radicals and hence anti-oxidant therapies are gaining prominence. A good thing is that almost all of these promising anti-aging candidates are relatively inexpensive to manufacture and distribute and hence once they are established, they will benefit people of every class in every nation.

Healthcare today is like an old car that frequently needs a mechanic. Tomorrow it will be like a car that never breaks down.

Chapter 2.3: Technology in our daily lives

'Technology is the knack of so arranging the world that we don't have to experience it'. – Max Frisch

Technology, though the name sounds fancy, is nothing but application of scientific knowledge for practical use. Humans are born curious and tend to conjecture and experiment to find out the reasons behind the way things around us work. It is not just laziness, the basic tendency of humans, that gave rise to technology but the subconscious mental arithmetic of reducing the time and energy spent into less essential work so that the same resources can be put to use for gene propagation. Be it the invention of wheel which reduced the energy spent in moving bulk from one place to another or be it the invention of fire which helped by breaking the proteins in raw meat so that human body can absorb it efficiently, technology has always helped humans save their time, energy and efforts for other goals. The pace of technology has picked up with time. In early times, when people had to spend most of their time hunting or farming, researchers or scientists were hard to come by. Only when humans formed large societies and the work of finding/growing food was delegated to specific groups, dedicated technology developers came into existence. The early technologists were the artisans like carpenters, potters and blacksmiths. Later, some Kings maintained magicians in their courts to practice magic and alchemy (converting iron into gold). Farming, housing and most importantly, warfare technology developed rapidly when long distance conquests started taking place, such as Mongol invasion of the west, about eight centuries ago. By combining the technologies of gunpowder, rockets and siege weapons from various civilizations, the Mongols developed the best warfare technology. The Renaissance was the next boost for development of technology. The spirit of Martin Luther who questioned the teachings and practices of the Roman Catholic Church in 1517AD spread to all facets of life and even the layman started to analyze things in a new light. The great artiste Leonardo Da Vinci had dissected more than thirty human corpses to study the structure of internal organs so that he could depict those accurately in his drawings and sculptures. Such thirst for knowledge and desire for invention soon spread all over Europe and it was a precursor to the industrial revolution which came about two centuries later. By about 1830AD, the industrial revolution had brought in mechanized cotton ginning, cotton spinning and power looms for

textile sector, steam engines for faster transportation and furnaces & mills that could produce sturdier iron. This industrial revolution also brought in a need for more raw materials to feed the industries and started the race for colonizing underdeveloped but resource rich countries and that, as you know, changed the history of mankind through the World Wars.

We are fortunate to be present in an era when wars are not the norm but even without wars, technology development is progressing at a rapid pace. It has revolutionized many factors of production – land, labor and material. New technology has made inaccessible areas, right from deepest oceans to driest deserts, amenable to human overtures. Technology has produced machines that can free up thousands of workers from mundane work. Technology has brought down costs of extracting crude oil from deep underground and it has drastically brought down costs of making metals from ores (you would surely find it amusing if I told you that a few centuries ago Aluminum was so costly that Napoleon the Third served his state dinners on aluminum plates whereas rank-and-file guests were served on dishes made from gold and silver). Information technology is the latest and most prominent child of the last century and it is helping advances in all fields, ranging from super-materials development to biotechnology.

Graphene and carbon nanotubes are two super-materials that need a special mention here. Graphene is a two-dimensional hexagonal arrangement of carbon atoms whereas carbon nanotubes are cylindrical tubes made from a similar hexagonal arrangement. These materials are very lightweight but exhibit immense mechanical strength. A square meter sized graphene hammock can support a cat weighing four kilos but would weigh only as much as one of the cat's whiskers! And a cable made from carbon nanotubes with just one square millimeter cross section can support weight of three cars! Graphene is expected to be used in various different applications, for example, in making better medical/diagnostic devices, microprocessors, flexible electronic displays, efficient solar cells, fuel cells, super-capacitors, batteries and contaminant removal. Carbon nanotubes are expected to be used in next generation biomedical applications, electrical circuits, power and data transmission, batteries, solar cells, super-capacitors and water treatment. These breakthroughs would make most of today’s machines smaller and much more capable. Just to take one example, a widely used electronic part called a solenoid could be scaled down to nano-size using Graphene nano-

coils; it is not possible through any other technology available today.

The machine that has seen the greatest size transformation is the computer. Over the years the size has come down and the computing power has grown; your mobile phone today has more computational power than the whole Apollo-11 moon-landing mission. Smaller processors and smaller electro-mechanical parts are giving birth to a new breed of machines. Unmanned air vehicles, also known as drones, were the monopoly of military till just one or two years ago. As the technology has become available to individual developers, we have seen an explosion in potential applications. Amazon is already working on a concept to deliver small packages within half an hour of purchase using a fleet of drones, under its Amazon Prime Air service offering. Miniaturization of machines and various developers' attempts to mimic nature have yielded some interesting results. Insect sized robots which can crawl or fly have been developed and are being used by various military outfits for reconnaissance and attack missions. Even on the civilian side, the progress is amusing – for example, Harvard John A. Paulson School of Engineering and Applied Science has recently developed an insect sized robot that can fly in air and swim in water. Researchers at Bristol University have developed a tiny robot named Row-bot which feeds on dirty water just like the aquatic insect 'water boatman' which feeds on algae and dead plants. The fluids and algae in the dirty water help run the tiny microbial fuel cell inside this robot and it is expected that such robots can effectively be deployed for environmental cleanup efforts where they can consume the contaminants.

Google Contact Lens is another potentially revolutionary product arising out of miniaturization efforts, especially for the rapidly growing diabetic population worldwide. This contact lens consists of a wireless chip and a miniaturized glucose sensor. A tiny pinhole in the lens allows sensor's contact with tears so as to measure the sugar levels and this obviates the need for the patients to visit the pathology labs frequently. The potential applications of this technology are truly mind-boggling. First of all, the lens may be able to measure other key parameters for the patients and in case any parameters are outside normal ranges, it can put the patient in contact with an appropriate healthcare provider. As you may know, Google has been working on Google Glass, an optical head mounted display which combines a camera, a screen, a miniaturized computer and a communication system. With the

way miniaturization technology is progressing, we should not be surprised if, within a few years, Google is able to offer the camera and the screen inside the contact lens. Advancements in wearable technology are anyway on their way to provide computers & communication systems that will be sewn into our clothes and can thus perfectly complement Google Lens.

Google had recently announced Project Jacquard which deals with wearable computers. By weaving conductive metal threads into fabric, Google can transform our shirts and pants into a touchpad. Even chairs and car seats can be made into touchpads. It would be controlled by a chip the size of a jacket button and will be able to communicate wirelessly with external devices. The touch fabric can be made out of ordinary materials like silk, cotton, and polyester and can be produced on the standard machines we use for textiles today. Google hasn't offered exact applications; just like their Android platform, it would be up to the app developers to build appropriate apps.

The pace of technology development has helped the society in one very important manner. Falling costs of sensors and related hardware have resulted into security cameras becoming so cheap that millions of them have now been installed across the globe. In many areas, crime rates have fallen drastically after cameras have been installed. Widespread use of technology in security and in tackling crime has now become essential for governments desirous of reducing crime rates and thereby improving the citizens' lives. Tracking people and property has become easier through use of networked CCTV cameras at every corner, health bands worn by increasing number of people and by tracking movement of mobile phones across transmission towers. Imagine a situation: a person robs a bank and runs away. Police arrive at the crime scene and find the CCTV footage which shows the face of the perpetrator or at least his getaway car. Once that information is fed into the computer, which can check the recordings and live feeds of all cameras in the city and it will quickly throw out information like 'this face/car is at traffic signal 'X', heading north'. Imagine the impact of a technology that can locate the perpetrators within a few minutes – it will act as a big deterrent and bring down the crime levels. This will of course need massive computing power at the disposal of police forces but it will soon become a reality. Better DNA analysis, better criminal information databases and other crime scene related technology are already allowing the police to nab the perpetrators in a shorter

timeframe. All this has helped in bringing down the crime rate, without too much extra cost in the form of extra police personnel.

Data analysis is the most rapidly developing tool in crime prevention and investigation as of today. An interesting example is that of Scotland Yard police who recently used electricity usage data to locate and destroy illegal cannabis farms hidden in housing estates and industrial areas. With digitization of data and better computing power, screening data to catch irregularities like disproportionate energy usage has become extremely easy. IRS has been using computer algorithms for catching companies that dodge their due taxes. US army is using machine learning algorithms on a database of 1 million soldiers to identify their potential for violence. Microsoft and the New York Police Department (NYPD) have jointly developed a counterterrorism and crime prevention system called Domain Awareness System (DAS) that will aid the police through actions such as notifying about suspicious packages and vehicles, and allowing NYPD personnel to search for suspects using technologies like smart cameras and license plate readers. Others companies are also bringing in comparable technology. Hitachi's Visualization Predictive Crime Analytics (PCA) system is able to process huge amount of data from a variety of sources and then processes it using machine learning to establish patterns of potential violent behavior that human eyes and minds might simply overlook. Security in future may not remain restricted to specialized computer programs sitting on police servers. As robots become more intelligent and versatile, one day they would be slowly introduced into the real world and some of them will surely end up in the area of policing and then 'Robocop' might not remain just a fiction anymore.

Robots have not yet become part of our daily lives but they are on their way there. In countries such as Japan, where the workforce is shrinking rapidly, robots are increasingly used for help. Robots need not look like humans; those who do are called humanoid robots; those who don't are called non-humanoid robots. Robots are available for many different roles – toys, vacuuming machines, receptionists and nurses who can feed and care for the elderly. Robotic teachers are also gaining acceptance worldwide. In Japanese schools, robots teach the art of calligraphy to young children. In Hutchinson, Kansas, a robot named Nao (developed by Aldebaran Robotics) works as a schoolteacher and can offer interactive lessons to schoolchildren. Kaspar is a

child-sized humanoid robot developed by developers at University of Hertfordshire to help autistic children develop their social interaction skills. In South Korea, where there is a shortage of English teachers, a humanoid robot named Engkey is used in many schools as English teacher. Robots are also helping in search and rescue operations after natural disasters such as earthquakes. On seashores, lifeguard robots are employed to save swimmers in danger. The newly installed order-taking machines in some outlets of McDonald's are also robots. A company called Momentum Machines has developed burger making robots – a machine that occupies just 24 square feet of space and can make 360 customized burgers every hour, meaning one every ten seconds. A café in Ningbo, China recently introduced robotic waiters who can take orders and serve food to any table within the restaurant and talk with the customers in Mandarin. A Singapore based restaurant-bar chain named Timbre has deployed robotic drones to carry customers' orders to their tables. Hollie is a bartending robot in Berlin, complete with two hands with five fingers on each hand and can make any cocktail. The trend seems clear; the day might not be too far when the food and beverage industry will stop employing humans.

Chapter 2.4: Transportation Revolution

A guy walks into a bar and demands to know "Who's the strongest in here?" The toughest guy looks at him and says "I am the strongest around here". The other guy politely asks, "Can you please help me push my car to the nearest garage?"

Today the automobile industry is one of the biggest industries, standing at US$2 trillion of annual sales in the US alone. Even though cars have made life easy for people, the shortcomings of automobile travel are substantial. Every year automobile accidents cause more than a million deaths globally. In the US, the annual toll comprises of more than 30,000 deaths and a million injuries. The cost incurred because of accidents is to the tune of US$230 billion. The people of US alone spend more than 50 billion hours in driving and this time is mostly unproductive. Can technology provide a solution here?

In the last chapter we saw that the cost of sensors and computing has gone down drastically in recent years. Even the traditional car companies are putting in lots of sensors in the cars (e.g. collision warning systems) and more computing and decision making power (e.g. the onboard computer sensing a collision and applying breaks automatically). Some companies, namely Google, Tesla and Uber, have taken a completely different approach called 'driverless' cars. In these cars, the onboard sensors are able to sense all relevant parameters like speed of the car, distance from other cars, traction, GPS location, etc. Google car contains a 64-beam Velodyne LIDAR sensor (laser imaging radar) that, combined with cameras, sonar and GPS, is collecting and analyzing 750 MB of data *per second*. The car can be said to be aware of everything that's happening within about 30 car lengths in all directions. The onboard computers are so powerful and so well programmed that they can navigate on their own and can break, accelerate or reverse as the situation demands. Google has been at the forefront of driverless cars technology and Google cars have driven for more than a million miles on US roads without causing a single accident and without breaking a single law. Tesla has already put out the software update that can make its electric cars run in the driverless mode. Apple recently announced their plans of jumping into the arena for driverless cars. Once the legal and regulatory approvals are in place, we may soon see driverless cars and taxis ferrying people

everywhere. The introduction of driverless cars may change people's behavior in one key area. If you are not driving the car and you are just the passenger, the concept of ownership starts getting diluted. How would the experience change if you are a passenger inside a self-driven muscle car running at 45 miles per hour versus if you are a passenger inside a self-driven minivan running at 45 miles per hour? That is exactly what is scaring the traditional car manufacturers. The introduction of driverless taxis may severely dent the trend in car ownership. Already Uber has demonstrated the way to unlock spare capacity that is already in the system. Today, if you have a car and some free time, you can just download the Uber app for drivers, get regulatory approvals depending on your jurisdiction and start earning some money by ferrying passengers. Traditional car companies cannot fight the trend of technology being put into cars because they themselves are putting it. So their plan of action is to push for autonomous cars rather than self-driven cars. By autonomous cars, they mean cars which will have the capability to drive themselves for most of the period (like the cruise control mode) but the ultimate driving decision will be taken by humans. Because of precisely this difference, autonomous cars may not really achieve the benefits that the self-driven cars can.

The biggest downside of automobiles, as we saw, was accidents. Scientific research shows that accidents are, most of the time, the result of the driver being unable to drive because he is either tired or sleeping at the wheel or drunk or distracted by activities such as talking on the phone or texting. In some cases, the driver may not have the right judgment required for driving through a narrow patch or for overtaking within a small window of time. The combination of sensors and computers in the self-driven cars will be able to obviate all these key causes of accidents, like what we see in case of Google cars.

Once the non-crashing nature of self-driven cars is well established, they can do away with the sturdy build. Today, one to four passengers weighing about seventy kilos each are ferried by a car that is upwards of two thousand kilos in weight. One key objective of such heftily built cars was to provide us mental security and comfort. This might not be required once car crashes and associated casualties become a thing of the past. Reduced car weight can bring in immense savings in the form of saving in metals required to build those and fuel required to run those. This will drastically cut the greenhouse

gas emissions, too.

Apart from saving lives and energy, self-driven cars will help in save land, too. Erratic nature of human driving does not allow full use of the road capacity. Disciplined driving by self-driven cars will lead to compact driving and better use of roads. It may be possible to fit about eight times more vehicles on the same roads and thus this will obviate the constant need for the local governments to build new roads. A lot of urban land needs to be dedicated to cars in the form of parking lots and garages; this land will be freed up when self-driven taxis gain acceptance.

People who hitherto used to spend time in driving themselves can become users of self-driven taxis and can use the commuting time more fruitfully. They can either do their office work or personal work or pursue any hobby that's possible under those circumstances. This can mean a sudden surge in the output and improvement in the quality of life for billions of commuters worldwide.

Coincidentally, the technology of self-driven cars is just preceded by electric cars; today we find electric cars by Tesla, Nissan, GM and a few other car companies that have become viable alternatives to fossil fuel cars. The battle going on today between electric cars and fossil fuel cars is not whether we will have electric cars or not. The battle is about when we will all be using electric cars. The vibrations, the noise, the grease, the overheating engines, the maintenance and the engine oil changes would all become history when electric cars become the norm. The key breakthrough required to make electric cars viable is to bring down the cost of battery storage. We will discuss this in a more appropriate context in the next chapter.

Chapter 2.5: Renewable Energy and Electricity Storage

In our previous discussion, we have seen the importance of resources and how energy is one of the most fungible resources. We also discussed the conventional energy sources in brief viz. wood, coal, petroleum based fuels, etc. If we want to predict mankind's future, we need to predict the scenario for energy availability. Future of energy availability is most vigorously driven by development in renewable energy sources. In this chapter we will discuss some key aspects of renewable energy.

Renewable energy is nothing but energy from a source that can be renewed (replenished). These are typically natural sources such as solar radiation, wind movement, tides & waves, biomass and geothermal heat. If a vehicle runs on ethanol or biodiesel, even that can be called as application of renewable energy because sources of these biofuels (corn, molasses, vegetable oils, etc.) can be regrown easily. The benefits of renewable energy sources over conventional energy sources are twofold: first, they are not concentrated in just a few geographies (like petroleum in the Middle East) and secondly, they are easier to harness (no need for deep drilling etc.) This improves energy security for almost every nation on earth and creates economic benefits for almost every person on earth. United Nations' Secretary-General Ban Ki-Moon has said that renewable energy has the ability to lift the poorest nations to new levels of prosperity. Another big benefit from use of renewable energy is the reduction in greenhouse gas emissions and pollution. Pollution itself kills millions of people worldwide through respiratory and other diseases and costs billions of dollars in healthcare. The key source of greenhouse gases and pollution is burning fossil fuels like coal, gasoline, diesel, naphtha, aviation turbine fuel, etc. for two main uses – electricity generation and transportation. This produces many harmful gases such as carbon dioxide, sulfur dioxide and oxides of nitrogen. Renewable energy is the clear answer to these problems.

The most prevalent renewable energy source today is hydroelectric power. It is one of the oldest and easiest technology for generating power and is already used by more than 150 countries worldwide. In many countries, it is already 10-20% of total power usage. Hydroelectric power is harnessed by building a large dam or by putting up run-of-the-river generators. In recent times, building large dams has become an uphill task in many places due to

the issues related to rehabilitation of humans and wildlife displaced during the dam construction. Technology for smaller sized hydroelectric power, namely wave power and tidal power, is now coming to the fore. Wave power captures the energy of ocean surface waves whereas tidal power captures the energy from high tide and low tide. Ocean thermal energy is another area of research which aims to use the temperature difference between warm surface water and the cold water in the deep but it has not yet achieved economic feasibility.

Geothermal energy is derived from the thermal energy stored inside earth. As you know, the core of earth is still at about 5000 degree centigrade and molten rock called magma is filled under earth's crust. Scientists have developed means to harness this energy but even that is still at the stage of pilot projects.

Biomass energy is energy generated from biological materials such as wood, dried leaves, bagasse, rice husk, wheat straws and sometimes municipal solid waste. The easiest method to extract energy from these sources is to burn them and make electricity. It is already being done in many places but it is not clean energy. Burning such biomass creates pollution in the form of particulate matter and oxides of sulfur and nitrogen. The other way is to ferment the biomass through special techniques and make either ethanol (alcohol) that can be used in vehicles or biogas (methane) that can be used in industries.

One of the cleanest renewable energy is wind energy. Wind mills are typically found on mountains, near seashore and in open lands because that's where the wind speeds are higher and thus higher conversion efficiency can be achieved for the wind turbines (the power generation is proportional to the cube of wind speed). The technology has improved over the years – from 200kw turbines just about a decade ago, technologists have now developed turbines that are rated 5000kw. Another interesting development is the offshore wind projects. These can harness the ocean winds that are almost twice as strong as winds on land. Offshore wind projects are increasingly required as the key land-based windy sites in many countries have already been exploited and plans to upgrade existing windmills by increasing tower height and blade sizes (to get better efficiency) encounter many logistical bottlenecks on the ground.

Solar energy is not a recent discovery. For thousands of years, people on earth have been using solar energy for various purposes. The most basic and wide spread is the use of solar energy for drying food items like fruits, vegetables, fish, meat and spices so that they can be stored for months. In 212 BC, Greek scientist Archimedes had supposedly created a contraption which focused Sun's light using bronze shields to initiate fires in invading Roman navy made of wooden ships. Roman bath houses had South facing windows to let in the solar heat, as early as 1AD. Solar cookers and solar water heaters have been around for more than 100 years now.

Just recently, MIT researchers have announced invention of a material (azobenzene derivative) that can efficiently store solar energy through a chemical reaction and release it on demand in the form of heat. This material can be used to make transparent polymer films (for windows, car windshields) that can absorb sunlight during the day and can release it at night as required.

But there is another very exciting and more active form of Solar Energy and it is the Electricity made from Solar Energy! Taking inspiration from Archimedes, we can focus solar power onto a water pipe or water drum which would heat the water enough to make it into a high pressure steam which in turn would run a steam turbine and generate electricity. This is called as Solar Thermal Energy and power plants based on this technology are sprouting up in countries like Spain which receive strong sunlight most of the year.

There is an easier method to convert solar energy into electricity and that is using solar cells, also called as photovoltaic cells (photo means light in Greek). In 1876, two researchers, William Adams and Richard Day, discovered that illuminating a junction of Selenium and Platinum can produce an electrical current. This was the first demonstration of the fact that electricity can be produced from sunlight directly, without the need of any moving parts. The next breakthrough came almost 80 years later, when scientists working at Bell Laboratories, Calvin Fuller, Gerald Pearson and Daryl Chapin invented the first solar cell made from Silicon doped with Gallium. It could convert just about 2% of the sunlight into electricity but the ability to work by itself, in remote areas, without any maintenance had a great appeal in applications like defense and space research. Commercial solar

cells also became available soon thereafter but the cost was very high at about $300 for 1 watt (roughly the power consumed by a small night lamp). So the usage remained restricted to specific applications.

The oil crises in the 1970s were big jolts to energy industry worldwide and underlined the need for energy independence and sustainable sources of energy. Research into renewable energy like wind energy and solar energy picked up unprecedented speed. With better materials and better configuration, the cost of solar cells has kept on falling over the years and it is an exponential fall. In the 1950s the cost for 1w solar cell was about US$300 as we saw earlier but it came down to $77 in 1977, then to $10 by 1987, then to $6 by 1997, then to $4 by 2007, then to $2 by 2010 and currently it is just $0.4 per watt. Over the same period, the conversion efficiency has improved from 2% to about 20%. So the effective price fall per unit of output is even more. Just as an example, a 1w solar cell would give just 0.02w output in 1950s so with a price tag of $300, the final cost was $15,000 per usable watt. In contrast, today's solar cells, with a price tag of $0.4 and 20% conversion efficiency will effectively cost $2 per usable watt. That is 99.987% fall over just 60 years! This is just the beginning; the fun part is yet to come. The solar sector is just picking up speed. New technologies, breakthrough materials are just starting to get commercialized. Solar power has just achieved rate parity with conventional coal based power and is now overtaking it in the new capacity additions happening worldwide. The price fall that we saw in last 60 years might be repeated over the next decade itself due to the impact of these factors working in tandem.

The benefits of using solar energy are quite straightforward:

1. Clean Energy Source: Solar energy does not need burning fossil fuels like coal, naphtha or natural gas which in turn leads to emission of harmful gases such as carbon dioxide, carbon monoxide, oxides of Sulphur & Nitrogen and many others. These have many detrimental effects stretching from global warming to acid rains to respiratory tract cancers in humans. Solar energy involves a one-time activity of production, assembling and installation of solar panels which passively convert sunlight into electrical energy and hence zero pollution.

2. Renewable and Sustainable: Solar energy is a renewable and sustainable source of energy which means this infinite amount of energy is available ad

infinitum i.e. forever. Fossil fuels may expire in a few decades or a few centuries depending on our usage but solar energy will be available as long as the Sun is shining which will be another 5 billion years as per estimates. So there will *never* be a risk of us running out of solar energy.

3. Availability: Sunlight is available throughout the world and can be easily harnessed by almost every nation. The only drawback is that it cannot be harnessed during night time and during rainy seasons. Even after considering this drawback, the availability of solar power is phenomenal. The Land Art Generator website gives an interesting perspective. If we were to make earth free of all other types of power sources and rely solely on Solar Power, we will just need to put solar panels over about $1/10^{th}$ of the Sahara desert and be done with it. If it is done in a more distributed manner, we will need just about 500,000 square kilometers (about 200,000 square miles) of solar panels to power the whole world. This is just about 0.3% of land area on earth.

4. Low Maintenance: Modern solar panels require less maintenance as they don't involve any moving parts and last for 30 years or more. They just require cleaning a few times a year.

5. Silent: Solar energy produces power quietly as against that through fossil fuels, wind turbines, hydroelectric turbines which can be incredibly noisy. Given that sound pollution is linked to various health disorders, the silent solar power is favored by many people.

6. Power Remote Areas: Solar energy can be harnessed in remote areas without being connected to an electrical grid. This is a boon for remote towns and villages worldwide which could not develop due to economic infeasibility or governments' inability in making the national grid reach all the people. Another example of use in remote area is artificial satellites. These satellites are fitted with high productivity solar cells and can function for decades without any need for maintenance or replacement.

7. Water friendly: As per World Resources Institute, power plants in the US account for 45% of total water withdrawals. The statistics are similar in many other countries dependent on thermal power plants. This is extremely high and unwarranted given the fact that scarcity of water is becoming a global crisis. Solar power not only helps in conserving this water but it would go a long way in alleviating the water crisis. It is becoming increasingly feasible

to use solar power to run desalination plants which convert ocean water into drinkable water using membrane filtration techniques. Thus it can provide cheap drinkable water to millions of poor people all across the globe who presently need to travel many miles every day just to get a bucket of water. This idea can work even at the micro scale. Recently MIT and Jain Irrigation Systems have co-developed a solar power based desalination system which conducts electro-dialysis and provides drinking water.

8. Solar panels can be installed on Rooftops: Solar panels can be installed on any roof, big or small. The installation process is standard & simple. Once installed, the Rooftop Solar not only utilizes the hitherto unused roof area but also ends up saving a lot of money in the form of reduction in electricity bills; sometimes saving the whole of it. No other source of power source can match Solar in the area of household use.

9. Maturity from the financial angle: As we discussed earlier, the rates of solar panels have been falling over many years. Moreover, now there are options for getting your solar panels financed by financing companies who will put up the upfront capital required and share the subsequent profits with you for using your space. Homeowners can sell surplus electricity generated to utility companies to not only reduce their monthly electricity bills but also to make a clean profit. From the governments' perspective, falling prices have led to redundancy of subsidies which the governments were hitherto required to provide to make the sector stand on its own feet. Now solar has matured, need for subsidies has passed and the governments can use the savings for other purposes.

Unfortunately, nothing in life can be too good and even Solar Power currently has some drawbacks:

1. Initial Cost: We have discussed the fall in the cost of solar power but presently it is still somewhat above the threshold required for the common man to defect from the power grid.

2. Power in the daytime: Solar panels work only when the sun is out, so they are idle from sunset to sunrise. This may not be a deterrent in applications like office and industry use because offices and factories typically work during daytime. For the retail and commercial users, evening time is the peak time for power usage and hence solar panels going off-duty at sunset look

unappealing. The climate and weather patterns also influence the efficiency of solar panels – like cloudy and rainy periods, snowstorms or sandstorms will cause a big dip in solar power production.

3. Conversion efficiency of Solar Cells: This is the percentage amount of sunlight that a solar cell can convert into electrical power. Currently, the commercial solar cells have about 20-22% conversion efficiency. This means that about 80% of solar energy falling on the solar cells is just wasted. Research is on to increase the conversion efficiency of solar cells using different materials and different structural layouts.

4. Large Area for Setup: A thermal power plant of 1000 MW capacity typically requires about 1000 acres i.e. 4 square kilometers space for setup. Solar power, on the other hand, requires almost 5 times the land. A 1000 MW solar power plant will require about 20 square kilometers of open area. So a large potential user will need to decide if she would go for multiple small setups nearby or would she opt for a large setup in a desert or other open land / waste land because that will need an extra investment into a connecting grid infrastructure.

5. Expensive Storage: Solar power can be utilized to charge batteries for the home or business, so that during the evening hours the user can have access to stored power and would not need to draw it from the national grid. These batteries are currently heavy, large and costly.

Given these drawbacks, are we really on the path to having solar power as the ultimate solution to mankind’s energy needs?

Fortunately scientists and innovators view these drawbacks not as limits to innovation but as new targets to focus on. A global race is currently on for breaking earlier records and making new ones in unexplored areas.

It was just recently announced that Solarcity founded by Elon Musk has developed rooftop solar panels which have 22.1% module energy efficiency which is much better than 19-20% achieved by typical rooftop projects. Within a week of that announcement, Panasonic announced that their new solar panel has established a new world record with module conversion efficiency of 22.5%. Worth noting is that fact that these are not experimental cells, but a commercial prototype made using mass production technology.

Various new methods are being employed to reduce not only the solar panel costs but also the cost of associated infrastructure. Associated infrastructure includes mountings, cabling, installation costs, etc. Increased scale of manufacturing & cost cutting innovation is helping in bringing down these costs.

A new and economical solar cell is being commercialized by Oxford PV. It is made from a material known as Perovskite. Perovskite is a form of Calcium Titanate and its efficiency is just about 21% as of now – lower than the normal solar cells made from Silicon. However, what makes Perovskite a beacon of hope is that it is extremely easy and cheap to manufacture solar cells from Perovskite, about 15% cheaper than conventional solar cells. One problem that needs to be tackled before Perovskites go mainstream is how to make them moisture resistant because as of now, contact with humidity degrades these cells rapidly.

Bifacial solar panel is another technology that is being tried. In this, the lower side of the panel also has solar cells attached to it and they convert the sunlight reaching the back side, boosting the overall yield by 10-20%. Research labs across the world are in the process of hunting for the next breakthrough in solar and there is room to be optimistic on this count.

Batteries are also seeing a huge interest from the world over. The buzz in this field started just a few years ago when Tesla launched its electrical supercars and announced its entry into power storage solutions. Over last 2 decades, many other vehicle manufacturers have dabbled in the pursuit of hybrid electric or fully electric cars but Tesla has conquered all of them with launches of Tesla Roadster, Model S and Model X. Tesla has also gotten into battery packs for home and industrial uses. Amongst various types of batteries, the maximum traction is in batteries made of Lithium-Ion (called Li-Ion). Prices of Lithium-Ion batteries are dropping each year and are likely to move along the cost curve followed by solar panels for last 30 years. The demand for batteries is expected to easily double by 2020AD, bringing the manufacturing costs down substantially. Battery storage costs are measured in terms of Dollars per kWh (kilo-watt-hour) and currently batteries cost about $300/kWh. A recent research report by Jefferies, a Wall Street research firm, about Tesla Motors, Inc. talked about how advances in R&D (meaning use of better materials) can lead to cell-level cost coming down to about

$90/kWh. The report goes on further to point out that once the battery factory of Tesla (called as the Gigafactory) starts in 2016, the benefits of large scale production, increased automation and optimized supply chain can bring down the costs further to below $40/kWh by 2020.

A groundbreaking innovation by Tesla is their charging stations. Tesla has already built a large network of charging stations (called superchargers) across North America and plans to replicate it across the world. It is envisioned that these charging stations will eventually run on just solar power (plus battery packs) and the users are allowed to charge their electric vehicles without any charges. Just think how cool this is, you buy a car and never ever will you need to pay for the fuel!

Batteries need not be limited to just electric cars and home use going forward. Public transportation may very well shift to solar or battery powered vehicles. Proteraa, a US based manufacturer of electric buses has already got orders for more than 400 electric buses which are not just environment friendly but also economically viable, thanks to rapidly falling battery prices.

If the prices of solar panel are falling and the prices of battery are falling then when might we see a shift away from traditional grid power into fully independent solar plus battery power? An average US household needs about 1kW power rating. Various analysts today project the cost of 1kW solar plus Li-ion battery installation to be about $1300-2400 by the year 2020. With this one-time cost, the user can say goodbye to the grid power permanently. Thereafter not a single penny needs to be paid for electricity – ever! Of course, there might be some small maintenance and replacement costs but they would be quite insignificant, looking at the rapidly falling price curves.

With mobile communication, the knowledge dissipation rate in human societies has risen exponentially. It makes the common people aware about what can benefit them. By some accounts, there are already more mobile phones in Africa than toothbrushes. It is very common for a new technology or idea to leapfrog over generations of old ideas and that is quite easily possible with solar power.

We will increasingly see consumers of electricity defecting from the national power grid and that can bring in a new set of problems. The power utility companies in the field of power generation, transmission and distribution are

already facing issues concerning lower power demand and increasing environmental awareness. As and when more rooftop solar panels are installed and users defect from the grid, the power utilities will need to spread the cost of their assets over a smaller pool of users, in the form of higher electricity bills. That, in turn, will entice more users to defect, putting utilities in a vicious cycle. If this deathly spiral continues, a time might come when the governments will need to tax the citizens more just to support the power utilities. Australia is a case in point where the bountiful solar energy is now clashing with the expensive grid. About 6% Australian households have already defected from the grid and in some Australian states the defection rate is as high as 25%. There are already proposals floating around which talk about introducing higher grid connection charges, exit fees for exiting the grid, higher network charges, etc. In Spain, the solar energy production exceeds demand by 60% and the new solar policy there has proposed zero payment for extra energy put into the grid by solar producers (up to 100kW size). Forward looking governments should recognize the significance of this threatening issue well in time and should build traditional power plants only after a thorough analysis of this financial consideration. In my opinion, coal fired power plants will be the first casualty in the onslaught by solar. Increasing environmental awareness and falling cost competitiveness of coal based power vis-à-vis solar based power will sound the death knells for coal based power within a decade.

Why have I been harping about the solar energy? Simply because it is the greatest gift mankind has ever received. Solar energy is not about just saving some money from our monthly electricity bills. It has the potential to transform the whole world in a manner we could never imagine.

In earlier chapters we have come across the importance of resources. We have seen how a resource crunch can lead to fiercest of wars and how a civilization with enough resources can prosper without conflicts. Energy is not just a resource but an all-rounder resource because of the Law of Conservation of Energy. This law is a law of science that states that energy can neither be created nor be destroyed, but only changed from one form into another or transferred from one object to another. In the real world, the conversion process is not perfect and some energy is lost to environment. A diesel engine inside a car which converts chemical energy (burning diesel) into mechanical energy (rotating the wheels to move the car) is just about

55% efficient. That means about half the energy of the fuel is just wasted; in this case (and in many cases) the wastage is in the form of heat which goes into the atmosphere.

Now comes the interesting part. To get any work done, we need a certain amount of a certain form of energy. For example, a car moves ahead when the chemical energy stored in the fuel is released by combusting it. The efficiency of the conversion process and the cost of the original energy will decide if you can carry out the whole process economically and achieve your target i.e. get the work done. If not, then your work remains un-done. If I need to go to the next village to close a profitable business deal but if all modes of transport are inefficient and hence costing beyond my available budget, then I will be forced to forego the impending business deal. Mankind has foregone a lot of profitable deals over the centuries due to unavailability of resources but finally the situation is changing.

Solar energy, as we discussed earlier, is on its way to become an energy source which is clean, silent and will cost next to peanuts. Being electricity, it can be converted into various forms of energy and can be used to carry out various works. Due to its very low cost, we will be easily able to deploy it on a gargantuan scale to carry out the most daunting tasks.

Let me start with drinking water, which we briefly discussed earlier. In much of the developing world, water is a scarce resource and people need to walk miles every day to get drinking water. Why this situation has prevailed for centuries? Various reasons are possible. Maybe there is groundwater available but no electricity or fuel to run bore-wells. Maybe the local government does not have the budget to build and run desalination plants or water purification plants (the running cost of such plants has hitherto been mainly energy cost). With solar energy it would become very easy to run bore-wells and purification plants and the poor people can benefit.

The potential doesn’t end there. With solar pumps, water can be sent to farms which were previously dependent on unpredictable rains and thus, agricultural yields can be increased and the poor can eat better.

Global warming and pollution are caused mainly due to burning fossil fuels like coal, natural gas, gasoline, diesel, naphtha, etc. Global warming, in turn, causes erratic weather patterns and rising sea levels, threatening coastal cities.

Air pollution causes health hazards like asthma, diseases of respiratory system, cancer and stroke. Noise pollution disturbs psychological health. With spread of solar energy across houses, industries and vehicles, these polluting factors can be brought under control.

In earlier chapters, we have seen that all the wars in human history were for grabbing resources. Even today, many of the conflicts across the world are for resources, the topmost amongst those is petroleum. With global spread of inexpensive solar energy, there would be a much lesser need for petroleum and we may see conflicts diminishing. Solar energy may even help in improving availability of another resource: food. Deserts can be converted into farms if water can be made available.

A more innovative method of solar based farming is proposed by a Spanish company named Forward Thinking Architecture. This company has designed a concept called Smart Floating Farms (SFF). It is a solar powered, 3 layered vertical farm that floats on pontoons, off a coast or in the open seas. The top level carries solar panels, rainwater collectors and skylight openings for plants. The second level features a greenhouse and hydroponic systems (i.e. growing plants without soil). The ground level is designed for fishery. It is estimated that each such SFF can produce 8,000 tons of vegetables and 1,700 tons of fish every year. The energy requirement for workers' accommodation, machinery, food processing, etc. would be met through solar power. The key reason for deforestation is food production and use of innovative food production techniques like SFF can help in reducing deforestation.

In summary, solar power and storage technology becoming inexpensive would prove a boon to mankind because widespread use of this technology will help in tackling many of mankind's agonizing problems like global warming, pollution, water scarcity, deforestation, hunger, poverty and conflicts over resources. The key to success is to put more focus on research and development of solar energy applications and bring the costs down substantially.

Chapter 2.6: Molecular Manufacturing and Genetic Engineering

Today scientists are getting more and more insights on the structure of matter through discovery of particles like Higgs-Boson and the buzz around the applications that can be derived from these insights is high. Nowadays, terms like molecular manufacturing, molecular assembler, nanotechnology, nano-robots, genetic engineering, nano-factories, etc. are flying around in almost all popular science magazines, movies and books. It can be really confusing at times. So let us first clear the fog by defining exactly what is meant by each of these terms and the scales at which these operate. Nano comes from the Greek word for Dwarf. A nanometer is a *billionth* of a meter. A micrometer is a *millionth* of a meter. For comparing scales, the width of human hair is about 100 micrometer. Hydrogen atom is about 0.1 nanometer in size and a water molecule is about 0.3 nanometer in size.

Though nanotechnology seems like a recent technology, the seeds were planted long back. In 1959, physicist Richard Feynman gave a lecture at an American Physical Society meeting at Caltech titled ‘There’s plenty of room at the bottom’. He talked about the possibility of direct manipulation of individual atoms as a more powerful form of synthetic chemistry than those used at the time. Either the talk was not noticed or nobody pursued the subject due to paucity of appropriate technology at that time but nothing happened till 1974 when the term ‘nano-technology’ was coined by Tokyo Science University professor Norio Taniguchi to describe the precise manufacturing of materials with nanometer tolerances. Even that went nowhere till the currently foremost name in the field of molecular manufacturing, K. Eric Drexler, arrived on the scene. Drexler published a book in 1986 named ‘Engines of Creation: The Coming Era of Nanotechnology’ and in this he first used the term molecular nanotechnology. This book talked about the idea of a nano-sized assembler (machine) which would be able to build a copy of itself and other items or machines of similar scale. The proposed method to be used was guiding chemical reactions by positioning reactive molecules with atomic precision. This is almost exactly what happens inside the living cells; manufacture of new proteins happens when messenger RNAs read the ‘code’ from the DNA and assemble amino acids (the building blocks of proteins) in the right order to build a full protein

molecule as planned. Drexler modified the idea a bit in 1992 when he introduced the better understood term ‘Molecular Manufacturing’ which is defined as the programmed chemical synthesis of complex structures by mechanically positioning reactive molecules with atomic precision. The typical objections to these thoughts of molecular level assembly have been mainly two-fold viz. ‘fat fingers problem’ and the ‘sticky fingers problem’ as mentioned by Professor Richard Smalley (who had in fact won the Nobel prize for nanotechnology in 1996 for the discovery of carbon spheres called buckminsterfullerene or bucky-balls). Fat fingers problem means we cannot make the assemblers of very small sizes and sticky fingers problem means the molecules would stay attached to the assembler parts. Drexler and his team had successfully countered these arguments by proposing theoretical ways that take care of both these problems.

Till now, scientists have not been able to develop a real nano-sized molecular assembler, but there have been some breakthroughs. In last few decades, scientists have progressed a lot in dealing with tiny substances – the latest scanning electron microscopes can not only see the viruses (the smallest known organisms) but also the DNA and RNA inside. This has inspired the scientists to go a step beyond and use the tool to build nano-scaled 3D structures. The researchers at Department of Energy’s Oak Ridge National Laboratory have been able to use scanning transmission electron microscope for precision-sculpting of nanometer sized 3D features in complex oxide materials. Also, recently, chemists at the University of Illinois created a molecule making machine that can automate the synthesis of 14 classes of small molecules. Think of it as a 3D printer but at the molecular level. Scientists at the Rice University have recently built a molecular scale submarine. This ‘submarine’ is composed of 244 atoms and its propeller is powered by ultraviolet light. It is hoped that one day, a modified version of this submarine will carry medicinal drugs inside human bodies. The researchers at Institute for Integrative Nanosciences at IFW Dresden, Germany have built a motor made of special polymer, which is small enough to fit around a sperm’s tail. It may soon help slow-moving sperms to reach the female egg and obviate a key cause of male infertility. Researchers at the Cockrell School of Engineering at the University of Texas, Austin have developed a technique called bubble-pen lithography that can handle nanoparticles using a laser beam and micro-bubbles and arrange them without damaging to form any desired nanostructures. This molecular

manufacturing technology can finally open up the doors to forming novel materials and devices at the nano scale.

The ability to tinker with substances at the molecular level can have numerous potential uses in various areas. Better and more efficient solar panels and more efficient batteries can be developed using nanotechnology. Very light but immensely strong materials can be manufactured which may, one day replace all the bulky metals we use today, right from steel girders inside buildings to airplanes in the skies. Cancer cells can be specifically targeted without harming the normal cells and this can bring down the cost and duration of cancer treatment. Faster computers can be designed and manufactured as nanotechnology is helping in reducing the size of transistor assembly on the processor chips.

Some results are already here. University of California has developed surgically implantable artificial kidneys which use silicon nano-filter that can remove toxins, salts and other molecules from the blood, just like a natural kidneys do. Graphene based nano-water-filters are being developed which are more efficient than the membrane filters. Scientists at the Queen's University in Belfast have devised a class of liquids that feature permanent holes at the molecular level and these can be used for purposes like separating gases efficiently and for carbon capture from atmosphere.

The ultimate realization of nanotechnology would be in making a programmable swarm of nano-robots (also called as nanobots). These nanobots would be equipped with miniaturized computers and miniaturized propulsion systems. Other equipments onboard will depend on the planned use. The group of nanobots will be able to communicate and coordinate with each other and accomplish the objective more efficiently and hence it will be an intelligent swarm. Just like a group of ants or termites or bees, the swarm of nanobots will work coherently and loss of a few will not destabilize the system. Benefits of swarms are flexibility, robustness, scalability and decentralization. In real world, such swarms can be used for collecting weather data over a diverse area or for cleaning up oil spills in oceans or for other uses where an intelligent but distributed system is required. The most interesting application would be nanobots inside our bodies, working as doctors, diagnostic tools and medicines, all rolled into one. One may be able to ingest a capsule full of such nanobots and then these would spread into the

bloodstream and monitor the status of key components such as levels of blood glucose, cholesterol, thyroid hormones, etc. The nanobots would report any abnormalities and if feasible, they may tackle the abnormalities through blood chemistry. Keeping in mind that blocked arteries is the key health risk in many patients, nanobots may also be able to keep the arteries clean by scraping off cholesterol or destroying it through chemical reactions. Nanobots will be able to attack cancer cells and destroy them efficiently. Nanobots may also be able to sound a warning signal about entry of a harmful foreign body like a virus or bacteria and will have the arms and ammunitions to destroy such intruders. For any special type of diseases, the onboard computers in the nanobots can be reprogrammed wirelessly and they can be modified to tackle the new threat. Just like we update the anti-virus programs in our laptops, the nanobot swarm will be updated regularly to develop capabilities against the latest threats such as new types of viruses, bacteria and pollutants.

What Molecular Manufacturing can achieve for mankind is really endless. From an economic perspective, much of the manufacturing will become localized using nano-assemblers and hence the need for international trade will fall in the future. There will be less need for traditional materials derived from petroleum. As you know, the insatiable need for petroleum gave birth to onshore & offshore oil exploration, geopolitics, arms races and naval one-upmanship to secure trade routes. Hopefully all these will become irrelevant when localized manufacturing through nano-assemblers becomes the mainstay.

Genetic engineering is also a part of nanotechnology and molecular manufacturing but with a different objective. Genetic engineering means changing the structure of the DNA so as to produce a desired trait in the organism. But to change the structure of the DNA, you need very precise tools that will edit the exact, desired part of the DNA efficiently & quickly and not damage the other parts during the editing process. Think of these as ‘molecular scissors’. One such protein that has been extensively used is CRISPR/Cas9 and recently scientists have developed a new, more precise protein named CRISPR/Cpf1. Cas9 use is already widespread in research labs worldwide and even a layman may soon have it. A researcher at NASA is working on sub $200 genetic engineering kits based on Cas9 which anyone can use at home to tinker with bacterial DNAs. Under recombinant DNA

technique, scientists change some portion of the DNA of a bacteria so that it can produce a specific new protein; example of this is bacterial cells modified to manufacture human insulin which can then be extracted and supplied to patients. On the extreme side of genetic engineering, there is synthetic biology. Synthetic Biology is a branch of molecular biology where scientists can *manufacture new genes and resultant organisms right from scratch*. Last year, scientists at NYU created a whole new DNA for yeast and created a wholly new, synthetic yeast right from scratch, inside their lab. The day is not far when human genome can be made to order. For example, you may be able to pick and choose the traits for your child before it is even conceived. Obviously there are some potential risks if such technology falls in wrong hands and we will discuss these risks in a later chapter.

Currently genetic engineering is used to mass-produce various biological products such as human insulin, monoclonal antibodies (mabs), vaccines, etc. Genetically Modified (GM) crops like maize, cotton, etc. have become quite common worldwide by now. Further research is on to make the crops or grains carry higher nutritional content. For example, soybeans and canola are modified to produce healthier oil. Rice DNA can be modified to develop higher vitamin A content. A genetically modified variety of Salmon has recently been approved by USFDA after twenty years of waiting. It's called AquaAdvantage and it is genetically modified to grow very fast even in adverse conditions. Such fish can be used to address food problems in many areas. Dairy and farm animals can be genetically modified to give more milk or meat as the case may be. Scientists in California have used gene editing techniques for creating a new strain of mosquito that genetically resists becoming a carrier of malaria. These genetically modified mosquitos can mate with other mosquitos and spread their malaria blocking genes worldwide and thus help in controlling malaria from spreading.

Worldwide, millions of humans today are on the waiting list for organ transplant. Some need kidneys, some need livers, some need hearts and the list goes on. The bottleneck is the supply side of such organs. The number of donors is already very small in comparison to the people on the waiting list. Moreover, because organ transplant involves putting a foreign substance inside the body, there are chances of the body rejecting the new organ. Researchers at the Harvard University are trying to use genetic engineering to develop an interesting solution to this problem. They took the pig DNA and

modified 60 genes in that (the number of genes modified in one go is a record in itself). With these modifications, they have tried to put human DNA signature inside the pig DNA so that pig's organs will not be rejected by human bodies as a foreign material. If this approach succeeds, the patients waiting for organ transplants can breathe a big sigh of relief.

Another interesting area of genetic engineering will be to extend human life span through DNA modification. A research team from the University of Washington and the Buck Institute for Research on Aging has recently identified 238 genes in yeast cells, which when removed or deactivated, can lead to extending life span by up to 60%. It is estimated that many of the pathways through which these genes work are also present in humans and hence this research is quite relevant to humans. With improving gene modification techniques, this procedure may one day become a mainstream therapy for life extension.

With shocking changes like new organisms, made-to-order babies, pig organs for humans and DNA based life extension procedures in near future, one may obviously think of the ethical implications. A few years ago, a section of the society was protesting against scientists who they claimed were playing God by trying to clone animals or trying to make new species. Within just a few years, research has surpassed these basic steps and has gone on to creation of a whole new DNA but there is no hue and cry this time. The reasons can be two-fold. One is a better understanding of what the scientists are trying to do. Around the time when the first cloned sheep was demonstrated to the world, the protesters feared that the research will lead to human cloning and that will cause unprecedented harm. This fear turned out to be baseless because with so many advances in medicine, humans have no need for cloning themselves (even in order to maximize their genes). The second reason might be that the benefits arising out of such research are far outweighing any potential threats.

A lot of thought and action has to go into analyzing and neutralizing the potential threats arising out of nanotechnology and genetic engineering. The possible risk is that one day a rogue, anti-social person or group of persons might develop a virus or a nanobot that can destroy the whole humanity. Such risks deserve to be considered seriously and appropriate countermeasures need to be put in place. The most promising countermeasure possible would be to have protector nanobots present inside human bodies

which can identify and preemptively destroy such invaders. On the prevention side, the authorities, supported by intelligent softwares, might be able to analyze the genetic and social makeup of individuals for any potential anti-social tendencies and counsel them proactively. This might sound like Steven Spielberg's movie 'Minority Report' but such technology is already knocking on our doors and if used properly, it can go a long way towards preventing crimes.

John was driving along a freeway when he noticed a chicken running alongside his car. He was amazed to see the chicken keeping up with him because he was doing 50 MPH. He accelerated to 60 and the chicken stayed right next to him. He speeded up to 75 MPH but the chicken passed him up and then John noticed that the chicken had three legs. So, he followed to chicken down a road and ended up at a farm. At the farm, he got out of his car and saw that all the chickens had three legs. He asked the farmer "What's up with these chickens?" The farmer said "Well, everybody likes chicken legs, so I used genetic engineering and bred a three legged bird. I'm going to be a millionaire." So John asked him how the chickens tasted.

The farmer said "Don't know, haven't caught one yet."

Chapter 2.7: Artificial Intelligence (AI)

'The human brain is amazing. It functions 24 hours a day from the time we were born, and only stops when we take exam or when we are in love.' – Anonymous

Whenever someone mentions the words artificial intelligence, we typically imagine scary robots like the 'T-800' and 'T-1000' from the movie Terminator or the likeable 'Data' from Star trek: The Next generation or the evil system named HAL 9000 from 2001: A Space Odyssey. Hundreds of books, TV serials and movies have dealt with the concept of Artificial Intelligence and robots and have shaped our hopes and fears regarding these.

Let's first clarify a difference between AI and robots. The term AI (Artificial Intelligence) was coined in 1956 by an American computer scientist John McCarthy and it refers to 'intelligent software'. Robots can, and typically do, contain AI but please remember that robots are the outer shell, the Hardware whereas AI is the Brain, the Software part of it. We can have some AI program (like data processing) sitting peacefully inside a computer and not involved in any physical work. In cases like the iOS Siri, Microsoft Cortana and Google Now, the AI is the software inside the phone and the voice is the personification of the AI. For the sake of simplicity and flow, I will use the words AI, system, software, computer and machine interchangeably.

Currently we have two different types of AI systems amongst us. The first is a system which can perform a certain task in a very efficient manner. You would have surely heard of 'Deep Blue' – the computer that famously defeated World Chess Champion Gary Kasparov in 1996. The software can analyze millions of chessboard scenarios which humans are nowhere close to even attempt. Japanese scientists have recently developed a rock-paper-scissor robot which can win against humans 100% of the time. There is a fine print, though. The robot doesn't play independently but it studies the hand movements of the human opponent and based on that, literally within a fraction of a second, comes up with its reply. So there is a bit of cheating involved but the ability of an AI system to accurately analyze human hand movements, recognize the pattern and come up with the appropriate solution is worth praising.

There are various narrow AI systems all around us. When we execute a

Google Voice Search on our mobile phones we are talking to the AI which deciphers our voice commands and provides us answers. The email spam filters we use are also AI systems. They look for patterns in emails that we read and emails that we junk and use those patterns on incoming emails to keep us spam-free. In fact, if they make a mistake and we undo the mistake, the system learns from it and applies the knowledge correctly from next time. Video cameras in some offices have AIs that stop recording and save memory when there is no movement in the office. As soon as somebody enters into the camera's coverage field and trips the motion detector, the camera starts recording.

When we purchase something online, the website recommends some items that typically go with that purchase (like mobile and mobile cover), items that people typically buy together or items that we regularly buy from that website. The brain behind this is the AI sitting on the website server analyzing consumer purchase patterns and deciding which type of customers buy which type of items under what circumstances. If you buy kids' nappies, it is not very difficult for the AI to offer you everything from baby food to baby toys. Some AIs are said to go even a step further and price the products differently based on the customer's history and propensity to pay.

AI systems have conquered the world of finance, too. As of today, more than half the shares traded in the US equity markets go through algorithmic trading systems which trade within a millisecond whenever the requisite conditions regarding prices or volumes are fulfilled.

Google's self-driven car is another example of AI. The road maps and the requisite driving rules broken down to the last tiny detail are fed into the on-board computer and thus the AI is capable of driving the car under any circumstances. It is believed that the car would soon be officially allowed to be driven on the US roads. The humanoid robot recently unveiled by Yamaha which can autonomously ride motorcycles at very high speeds is another AI which is optimized for the given conditions. Battlefield robots by DARPA also fit in the same class.

These AI systems have one downside, however. They can just do one thing very, very well. Hence these are called Narrow AI systems. The other type of AI systems is called General AI systems. These systems are, or aspire to be, as intelligent as a human, in all aspects. Professor Gottfredson describes

intelligence as a very general mental capability that, among other things, involves the ability to learn, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. A real General AI will be able to do all these as well as any human being. As you can imagine, it is an uphill task to teach a computer to do all these things and the progress is slow. But recently there have been some breakthroughs. There are now some systems that can be called as early prototypes of General AI.

Just recently, the Chinese media was floored when the Chinese social and gaming giant Tencent unveiled a newspaper ‘reporter’ named Dreamwriter – an AI system that can write flawless news articles within a minute. Interestingly, such systems have become common in western world now. The softwares that ‘write’ these stories use algorithms designed to collate data, find patterns and pull quotes from sources by sifting through reams of material, including that found online. The algorithms also learn to identify "turning points" - the most dramatic moments in a sports game or a business transaction, and highlight them. Now that, certainly, is a system on its way to being General AI; until you read about Watson.

Watson by IBM is the most interesting general AI aspirant that I have read about till now. This computer system was specifically developed to answer questions on the quiz show Jeopardy! In 2011, Watson competed on Jeopardy against former winners Brad Rutter and Ken Jennings and received the first prize of $1 million. This supercomputer is able to hear, observe, interpret, evaluate and decide. It can interpret data to expose patterns, connections and insights. When used in the field of Oncology (cancer research), Watson can digest vast amount of medical research and extract key information from patient records to come up with tailored treatment options. Watson has been used in culinary application, too. It was fed thousands of recipes all over the world, made to study the various food ingredients and ‘invent’ new recipes. Some recipes invented by it, like the ‘Bengali Butternut BBQ Sauce’, received many positive reviews.

Google DeepMind is another such Artificial Intelligence system. It was created after Google bought a company named DeepMind for about 400 million pounds in 2014. The researchers at DeepMind plan to make machines capable of learning new things without the help or programming by a human. They are creating a set of powerful general purpose learning algorithms

which are fed into DeepMind. Just recently it was announced that DeepMind has been able to achieve human level performance in many games video games like Space Invaders. The system started from scratch with just one objective – maximize the score. The self-learning algorithm figures out that if it hits certain buttons that happen to kill enemy ships then the score increases and then it does more of that action and builds proficiency by itself. It can handle other work, too. Scientists have been hard pressed for decades on how to make a computer understand simple day-to-day things like what a cat is. DeepMind is good at processing images and can identify the objects in the pictures as accurately as a human. But the crowning glory for DeepMind was its recent victory (5-0) in the complex game Go over the human champion Fan Hui. Go is played on a 19x19 board and the resultant gigantic number of board configurations make it an overwhelmingly complex game. Most programmers felt that it would take decades for a computer to beat humans in Go. But the self-learning capability of DeepMind has proved them to be wildly off the mark.

But are these systems, or will these systems ever be, as ‘smart’ as a human? There is an interesting test called ‘Turing Test’ which tells if the system is as smart as a human. It is named after the genius Alan Turing who proposed it in 1950. In this test, a human evaluator conducts a text-only chat with two other participants; one is human and the other is the machine (software) that is being tested. If the ‘machine’ exhibits intelligent behavior (responses) equivalent to, or indistinguishable from, that of the human then it passes the Turing Test. More accurately, Turing Test is successfully passed if a computer is mistaken for a human more than 30% of the time during a series of five-minute keyboard conversations. Scientists have been coming up with new AIs for the Turing test and the best known attempt was in 2014 when a computer program called Eugene Goostman (which simulated a 13 year old Ukrainian boy) was said to have passed the Turing test organized by the University of Reading by convincing 33% of the judges. There was another participant named Elbot which tried fooling the judges with provocative answers or impishly hinting that it was, in fact, a machine. "Hi. How's it going?" one judge began. "I feel terrible today," Elbot replied. "This morning I made a mistake and poured milk over my breakfast instead of oil, and it rusted before I could eat it." With so much progress in AI development, scientists say that the question is not ‘if’ such system will arrive one day but ‘when’ such system will arrive. What makes scientists so sure about the

General AI when no real contender exists today?

The main problem in going from a Narrow AI to General AI is conquering the ‘cognition’ aspect. Dictionaries define cognition as ‘understanding through thought, experience and senses’, a ‘perception’, an ‘intuition’. We will all agree on this point – current systems can give us answers to any mathematical problems but they are not able to ‘understand’, ‘think on their own’ or ‘perceive’. How can software be made ‘aware’? This is the biggest bottleneck today in developing an AI that would be as ‘smart’ as humans. We have discussed some interesting and astonishing examples of AI but you are still skeptical of the view beyond this boundary. But believe me, ‘beyond’ does not require us to just naively assume that one day AI can think and act like humans. Here are the logical steps that lead to ‘beyond’.

The first thing that needs to be achieved is immensely faster computational power. This means more and faster microprocessors, RAM and other accessories. These should be enough to at least match the human brain’s computing power. Computing power is typically expressed in terms of calculations per second (cps) and human brain’s computing power is roughly 10^16 (10 quadrillion) cps. Such computing power has been achieved by many supercomputers in the world. The fastest supercomputer in the world is Tianhe-II in Guangzhou, China. It is made up of 3,120,000 cores as against the 2 or 4 or 8 processors in our mobiles and laptops. This supercomputer can theoretically perform computing at 55 quadrillion cps, meaning more than 5 times human brain. So, does it make it feasible as the General AI candidate?

The answer is a partial yes because two problems still remain – the scale and the cost. Tianhe-II needs 720 square meters of space (as much as 12 houses), needs 17.6 megawatts of power (as much as what 14,000 US houses typically need) and it needed some 400 million dollars to build. How soon can the scale and cost for computing power fall to practical levels?

World’s first electronic general purpose computer was ENIAC, built in the 1940s. It cost half a million dollars to build, it weighed 27 tons, it occupied 167 square meters of space and consumed 150kW of electricity. And the computing power was… 500 cps! In comparison, even a basic processor in a basic smartphone today carries computing power of a few billion cps; more than the whole computing power used by NASA to send a man on the moon!

Over last few decades, as the computer hardware technology has developed, the processors have become faster and the cost has kept coming down. What really matters is how much computing power you get per dollar of your money and it is typically measured in calculations per second per $1000. Around the year 1960, you could get 1cps per 1000 dollars which kept on growing exponentially to about 10 million cps per 1000 dollars by the year 2000 and it currently is at about almost a trillion cps per 1000 dollars. These processing speeds correspond to brains of small animals like a mouse, for example. Human brains are a million times faster but looking at the growth trajectory of processor speeds, we may reach there in a few years. You may have heard of 'Moore's law' which was proposed by Intel's co-founder Gordon Moore. This law states that the number of transistors in a dense integrated circuit doubles in approximately two years. In simple language, it means that the processors are becoming doubly efficient in terms of speed and cost in every two years. And the world has seen it happening for the last fifty years.

On a side note, the Moore's law can be said to be a subset of 'The Law of Accelerating Returns' proposed by Ray Kurzweil in his book "The Age of Spiritual Machines". This law states that 'the rate of change in many evolutionary systems (including technologies) tends to increase exponentially'. This happens because one positive development in an evolving system makes the system more efficient and more capable of producing the next positive development, which builds onto the first and so on. Internet, in its infancy was run from a few hundred servers. As it grew, the number of servers grew which led to more information availability and more stability. This improvement brought in more users and then more servers catering to more users, thus forming a virtuous cycle growing exponentially. Law of Accelerating Returns has been observed not just in technology but also in biological systems. If you are thinking about the dramatically rising curve in the example of deer's feet mutation then you are absolutely on the right track. The small positive impact of better feet structure grows slowly in the beginning but after certain time, the growth rate just explodes.

Researchers are trying to find new ways to improve on Moore's law. One way is to look at materials other than the basic silicon based semiconductors. IBM is looking at making transistors and processors from carbon nanotubes

that are far smaller & robust.

Other way is to scratch transistors altogether and start with a completely new paradigm. Many scientists are today working on a technology called Quantum Computing which works using principles of Quantum Mechanics. A Quantum computer, when operational, can have the ability to massively outperform a traditional computer in areas which need parallel computing prowess, such as conducting millions of parallel searches for potential solutions. A Canadian company named D-Wave Systems has created two quantum computers, named D-Wave One and D-Wave Two respectively (very creative!). These are not full-fledged quantum computers but can solve a narrow set of problems as of now. NASA and Google are currently using D-Wave Two for researching machine learning. The potential for quantum computing is immense. IBM researchers have recently said that if one could build a computer with just 50 quantum bits (cubits), no combination of today's TOP-500 supercomputers could successfully outperform it.

Some scientists are working on what is called as DNA computing or bio-molecular computing which is based on the idea of using DNA as a medium of data processing. As per theory, a DNA computer with just one liter size and containing six grams of DNA can potentially have a memory capacity of 3 billion gigabytes (GB) and a processing capacity of 1000 petaflops, about 100 times that of the human brain! Like Quantum computers, DNA computers are also expected to be very good at tasks which require high amount of multiple parallel computations. But as of now DNA computing is still in its infancy.

Based on these developments, there is a fair chance for the processing power comparable to the human brain becoming available at a reasonable prices (say, $1000) within a few years' time and step one of our plan will be complete. But would that mean the computers would become truly intelligent then?

Efforts are on to make computers 'truly intelligent' or 'smart', like we saw in the case of IBM's Watson and Google's DeepMind where self-learning is being used. Let us discuss a few other broad strategies that are being tried for this. The first strategy is to understand the 'wiring' inside the human brain and replicate it onto the computer. Prima facie, human brain seems just a small organ weighing less than 1.5 kilograms, made up of a bunch of cells

and neurons and the concept of ‘copying’ the ‘wiring’ inside a human brain might sound simple. In reality, it is a herculean task given the fact that human brain is made up of a 100 billion neurons communicating with each other differently based on different stimuli. This network of connections is called the Connectome. The ‘Human Connectome Project’ is a research project launched by NIH, Harvard University and few other entities in 2009 with a goal to build a network map that will shed light on the anatomical and functional connectivity within the human brain.

There have been a few breakthroughs. Scientists have been able to map the complete connectome of a roundworm named C. elegans (though it hasn’t provided a direct link to its behavior). This worm lives in soil and is just 1mm long. It has 302 neurons in its brain and about 7500 synapses (i.e. neuron connectors). In comparison, a fruit fly has 100,000 neurons and 10 million synapses; mice have 70 million neurons and about 100 billion synapses and ultimately, humans have about 80-100 billion neurons and about a million billion synapses. The data storage requirement for the process will also be huge – the connectome for C. elegans worm requires 12 terabytes of storage and the human brain might need two million terabytes. For the sake of scale, one can compare this with Google Maps – the whole world mapped by Google took about 20,000 terabytes storage (in 2012). So the Human Connectome project, as we said earlier, is a herculean task but with processing speeds becoming faster and memory costs coming down, the task should reach fruition in a few years’ time. Just this year, researchers at Harvard University have had some progress in mapping the mouse connectome using a new brain imaging technology with electron microscopy.

Separately, under the Human Brain Project, a team of researchers from École Polytechnique Fédérale De Lausanne (EPFL) completed a first-draft computer reconstruction of a piece of the rat-brain neocortex — about a third of a cubic millimeter of brain tissue containing about 30,000 neurons connected by nearly 40 million synapses. They simulated the electrical behavior of the virtual brain tissue on supercomputers and found them to match with the behavior observed in a number of experiments on the brain. This is an extraordinary breakthrough.

To mimic the functioning of the brain, scientists have tried another approach called ‘artificial neural networks’. In this, the system starts as an

interconnected bunch of transistors or artificial neurons. Various different types of inputs are provided to this system, which processes the inputs randomly to arrive at results and based on specific guidelines, it ‘learns’; meaning it ‘remembers’ and in future ‘replicates’ those ‘steps’ which guided the system to an acceptable result. The learning of an Artificial Neural Network system can be supervised, unsupervised or reinforcement based (open ended) learning. I will try to explain this ‘learning’ with an example. Let’s say we want our system to learn to identify cats. We will make the system ‘watch’ or ‘study’ millions of pictures of cats. The system will then try to find commonalities across the pictures and remember them for future reference. These can be factors like two eyes, two ears, whiskers, etc. and these attributes will be saved in the memory with a certain weightage for each. Next time the system is shown a picture of a dog and the system tries to identify it as a cat (because it has two eyes, two ears, whiskers), the human supervisor would tell the system it is not a cat and then the system will learn that it should look for ‘pointy ears’ and should disregard ‘droopy ears’ or it should give more weight to the length of the nose when deciding between a cat and a dog. The key point here is that the system should be capable of changing its own programming based on its learning and thus try to grasp the human thought process.

A revolutionary idea in making computers smarter will be to build a computer with the ability to incorporate the AI research findings from across the globe into its own hardware components and software programming. For example, as the connectome research progresses and more neuron connection data becomes available, this supercomputer (let me call it ‘Braino’) will be able to add processors and memory unites to itself in a superior configuration based on the neuron data. Braino will also be able to incorporate research from neural network research and can incorporate learnings from those programs into its own programming. To my knowledge, this has not happened yet, but is theoretically possible.

The progress will happen slowly, step by step. One day, scientists will figure out the structure of an ant’s brain and replicate it on a computer. One day, it would progress to a slightly bigger brain, maybe a mouse or a pigeon. One day the monkey brain will be replicated and then the day is not far off when computer matches human brain in terms of functionality.

What will happen when machines become as intelligent as humans? Would the development stop there as it would be the best the world has ever seen? I think the answer is a resounding NO. Human intelligence can be a landmark for us humans but for computers, it will be just a milestone to pass by while on their way to ‘SuperIntelligence’.

Oxford philosopher Nick Bostrom has written a superb book called “SuperIntelligence: Paths, Dangers, Strategies”. He defines SuperIntelligence as “an intellect that is much smarter than the best human brains in practically every field, including scientific creativity, general wisdom and social skills”.

The reason why computers will surpass humans in intelligence is pretty simple. Processing speed of machines will not plateau when they reach near human intelligence levels; in fact they might be able to figure out ways of how to improve on it. Computers need not have a limited memory space like human brains; they would be connected to the internet, the ocean of information. Computers are inherently more robust at work; humans lose concentration in a few hours whereas computers run non-stop. Computer programs can be upgraded and modified; this is not true for human brains. Humans have progressed over other animals due to their ability to share information and act on shared information. Computers will be miles ahead of humans in sharing information and improving their own hardware and software architectures based on useful information. Thus, once the computers achieve the stage of human-level intelligence, it is just a question of time for a SuperIntelligence to emerge.

But for now let’s end this chapter with a funny one on robots:

A ventriloquist doing a nightclub gig with his dummy on his knee tells a ‘dumb robot’ joke.
A beverage service robot stops and shouts at the ventriloquist, “What gives you the right to stereotype Artificial Intelligence that way? You should be ashamed of yourself.”
Flustered, the ventriloquist begins to stammer an apology.
“You keep out of this, buster!” the robot yells, “I’m talking to the little idiot on your knee.”

Chapter 2.8: Singularity

'When your kitchen toaster knows more about quantum physics than all the professors at MIT combined, the Singularity has happened!' – Anonymous

No discussion about Singularity can begin and end without making a hat-tip to Futurist Ray Kurzweil and his book 'The Singularity Is Near'. Almost a decade ago, this genius predicted things that seemed outrageous at that time but which have been coming true one by one, in line with his predictions. In this book he has talked about the future evolution of machines and their interactions with humans. I suggest readers to peruse this book at the earliest opportunity.

Singularity typically means a situation in which normal rules do not apply. Imagine you are told to repeatedly divide a number by a denominator that is halving with each step. Pretty soon, the denominator is almost zero, though it never becomes zero because it is just half of its previous (finite) value. With a denominator that is almost zero, the answer you get by dividing will start taking galactic proportions but will be increasingly pointless; the normal rules don't apply now. Imagine a black hole that can be as small as a tennis ball but can have the gravitational pull of a thousand Suns. That is also a Singularity where normal rules don't apply.

From a technological perspective, Singularity would happen at that point in future when our technology's intelligence exceeds our own intelligence. Singularity means the phase after the birth of SuperIntelligence. Our life will forever be changed after that and normal rules will not apply. It is not possible to predict the exact timeline for Singularity but various scientists and thought leaders expect Singularity to happen between 2030AD and 2100AD (the broad range indicates the level of uncertainty).

One may think that we can just look at human history and human behavior millions of years ago and study how that behavior changed as humans became more intelligent. Then we might be able to use the same logic to predict how machines will behave as and when they become more intelligent.

This logic might not work due to the sheer scale of intelligence that will be covered by the computers. Today they are as intelligent as an ant in some aspects, as intelligent as a mouse in some and in some cases, similar to or

better than humans. But the jump from Narrow Intelligence to SuperIntelligence is going to be orders of magnitudes higher than what the humans have seen from the Cro-Magnon man to current man. We humans typically deal at IQ levels from, say, 70 (which is a very low IQ) to 140 (which can correspond to a genius). If an intelligent machine sets to improve itself, it may end up with an IQ of 100,000 or a million! Imagine how superior the machine would be when compared to human geniuses. You, I or even the best AI expert on earth cannot make a guess as to the outcome.

Try to imagine some ants looking at a group of people playing cards. Would it be possible for anyone to make the ants understand what the humans are doing? Scientists predict that in case of SuperIntelligent machines, the scale of thinking of the machines will be equally beyond human comprehension. Consequently, no amount of efforts will give us any idea of how the SuperIntelligence will behave with us. They might eliminate us within five minutes or they may just ignore us and let us be. There is no point in even guessing – it will be as good as some ants guessing about people and their playing cards! Our governments will have no say and no power whatsoever in front of SuperIntelligent machines. Just like a pack of dogs or chimps have no say in how we humans rule this earth, humans of the future will have no say in how the machines will rule the earth.

This unpredictability is what breeds uneasiness and the worry about AI. Many heroes of our time – Stephen Hawking, Elon Musk, Bill Gates – are rightfully worried about this potential threat. Stephen Hawking had said, "The development of full artificial intelligence could spell the end of the human race". More recently he has expressed his worries in the following words: “A SuperIntelligent AI will be extremely good at accomplishing its goals, and if those goals aren’t aligned with ours, we’re in trouble. You’re probably not an evil ant-hater who steps on ants out of malice, but if you’re in charge of a hydroelectric green energy project and there’s an anthill in the region to be flooded, too bad for the ants. Let’s not place humanity in the position of those ants.” Bill Gates, while speaking on the dangers of artificial intelligence, has clearly said, "I don't understand why some people are not concerned". Elon Musk of Tesla and SpaceX thinks that “AI can be more dangerous than nuclear weapons” and "With artificial intelligence, we are summoning the demon". Many thinkers demand that we should either stop work on General Intelligence or we should first figure out ways as to how we

can tackle threats arising out of it. Elon Musk, proactive as ever, has now created a non-profit entity called OpenAI which will do cutting edge research on deep learning and share it with everybody (this would reduce the risk of one bad actor controlling a potential SuperIntelligence).

I think there are two ways to look at emergence of SuperIntelligence. The first is to ask what would happen if the machine intelligence takes off like a rocket and we are left behind? Let me call this Scenario Alpha where AI turns into SuperIntelligence without any human control. Then the worry would be about how the SuperIntelligent machines will treat humans. This situation seems familiar if we look back into human history. What happened between humans and the saber-toothed cats called Smilodons? As per scientists, possible competition between humans and Smilodons for food may have caused their extinction around 10,000 years ago. What happened between humans and whales? Hunting whales for their oil and meat became such a lucrative business that humans took whales to the brink of extinction. Just recently when the demand for these products is coming down and hunting ban is enforced, the relationship between whales and humans has become peaceful. What happened between humans and dogs during human history? Eating dog meat was prevalent in certain times like war and famines but now it is almost a taboo worldwide; in fact dogs are the most preferred pets worldwide. There is a common thread in these examples and it is nothing but competition for resources. In earlier chapters we have seen that each and every war in human history has been about GeMax and about resources. A superior intelligence would not mind exterminating a weaker organism if it comes in the way of gathering resources that are required for existence and growth. Will humans come in the way of resource gathering by the SuperIntelligent machines? That, to me, seems unlikely because the machines, in all probability, will be able to gather energy from sunlight through efficient solar panels and convert it into whichever form of energy they prefer. That bit of luck may help humans in staying safe from the machines. Using the logic of dogs and humans, it’s even possible that machines might keep us humans as friends.

One approach is to build rigorous safety and preventive measures during the AI development itself. Such measures should ideally include concepts like altruism and non-violence which are workable in a resource rich world. A SuperIntelligent machine can obviously change its own programing but still,

such measures should be made a de facto part of machines' thought process. On a side note, if we humans expect machines to practice altruism and non-violence then we humans have to start practicing it ourselves before the machines start to observe us and learn from our behavior. Fortunately, the scientific advances that we discussed (resource of cheap solar energy & in-vitro meat) can help mankind in actually following altruism and non-violence towards all organisms.

There is another, more exciting scenario of how the future of humans and machines might look like. This is a more active version and in my opinion, a version which we should all strive for and fight for. Let me call this as Scenario Omega. It involves active collaboration between humans and machines whereby the learning and the progress will not be for the machines but for the human-machine combination. Rather than machines becoming SuperIntelligent, humans would become SuperIntelligent human-machines through a fusion of human brain and machine brain. There have been experiments where brain-machine interface (BMI) has been established in cats, mice and monkeys. Now the focus is on humans. Researchers at University of California at Irvine have been successful in using BMI in a patient with a spinal cord injury. In this case, the BMI bypassed the damaged spinal cord to send signals directly to a robotic exoskeleton around the patient's legs, culminating into the bed-ridden patient being able to walk by his own will. Remember the movie 'The Bone Collector' in which Denzel Washington plays the role of an investigator who is bed-ridden due to a spinal cord injury? The BMI research mentioned above will be immensely useful for such patients.

Research in the area of attaching electrodes to neurons in the brain is also progressing. Currently used flexible electrodes have a problem that they can't maintain their shape when implanted, which is why they have to be attached to a solid chip and that limits their flexibility and irritates brain tissue, eventually killing surrounding nerve cells and making signals unreliable. Researchers at Lund University have recently developed implantable multichannel electrodes that can capture signals from single neurons in the brain over a long period of time, without causing brain tissue damage, making it possible to better understand brain function in individuals; thus making them much preferable to currently used electrodes.

In his book ‘The Singularity Is Near’, Kurzweil has predicted a seamless interface between human brain and machine brain. In his version of the future (by about 2030AD), all human brains would be connected to the ‘information cloud’ which will become the channel for communication as well as for storage of thoughts and memories. In his opinion, brain-machine interface (BMI) will be through nanobots floating in our brains, able to participate in brain’s organic functioning through synaptic interactions as well as in communicating with the cloud around us through the computers onboard the nanobots. Research in this area is in very early stages.

If the machine (and I mean one universally interconnected machine made of thousands of computers, something like the internet today which is made up of millions of servers but we can think of internet as one entity) is in coherence with the human brain then any advance by the thinking machine will become part of human intelligence. Humans anyway have a proven tendency of utilizing new knowledge for their own enhancement and hence the increased intelligence coming from machines would let humans continue a virtuous cycle of co-development.

In such a future, I feel that nanobots would obviously not just be restricted to human brains; they would be spread out throughout our bodies in different forms as the need may be. And this is the potential point of take-off for mankind, the potential for an infinite future. Hang on tightly!

First of all, there would be nanobots moving throughout our bloodstreams looking for harmful bacteria and viruses and killing them as they go. Any new threat can be tackled quickly as the nanobots can communicate with the ‘information cloud’ which has the near infinite intelligence to figure out how to tackle any kind of threat like a new form of a bacteria or a virus. The nanobots will also check the health of our arteries, muscles and bones. Currently heart attacks and cancers are amongst the topmost reasons for human deaths. Nanobots inside our bodies can be programmed to remove or dissolve cholesterol blocking our arteries and they can be programmed to look for cancerous cells inside our body and to selectively kill these cancer cells.

These advances will greatly help in reducing aging – which is mainly deterioration of body parts, inefficient cell growth and impact of agents like cholesterol and carcinogens (cancer causing substances). If the nanobots can

counter the impact of these factors, then the process of aging can be delayed; in fact, it can be reversed! It would be very much possible to have all the people on earth living happily in their 30s forever!

Scientists have already theoretically designed nanobots which can replace red blood cells which carry oxygen and carbon dioxide inside our body. These nanobots are called Respirocytes; these are micron sized spherical robotic red blood cells, running on a motor powered by glucose in the blood. 3D nano-scale fabrication technology will help in manufacturing such nanobots in unlimited quantity. These artificial red blood cells can theoretically carry 236 times more oxygen and carbon dioxide than our normal red blood cells and these nanobots can make a person run 15 minutes at the top speed or remain underwater for four hours on a single breath. Similar nanobots can be developed which will carry glucose from the digestive system to various organs in a more efficient manner. In fact, it is quite possible to have another energy source entirely, like our clothes layered with solar power modules which will provide energy for our bodily functions.

Come to think of it, if you have Respirocytes carrying oxygen and carbon dioxide and nanobots carrying energy source (and both being self-propelled using nano-scale motors) then would you need lungs and heart? You would not! And that is the take-off point. A person may get rid of various organs, like liver, pancreas, kidneys, intestines whose functions can either become redundant or which can be taken over by special purpose nanobots or customized machines. It’s just logical.

The next phase might be where nanobots can be used to replace human building blocks like skin and bones? Going by the logic used above, that could be very much possible. However I am leaning towards another potential advancement that might be possible within a decade or two. As we discussed earlier, efforts are on to replicate human brain into a computer. If that is successfully achieved, humans may even get an option of transferring their memories, their thoughts and their personality into a body made from metal and plastic which will be infinitely more durable. Some very aged people, for whom reversing age will be a prolonged process, may embrace this option willingly.

And here is the ultimate thought… what would you call a person whose mind and body – either an organic body supported by nanobots or an inorganic

body made of metal and plastic – are able to withstand eternity? He or she would be Immortal! That is the goal of many thought leaders for mankind post the threshold of Singularity.

Some people think that by making humans immortal we are trying to go beyond laws of Nature and there is no way that the age-old cycle of life and death can be broken. To address this query, let's look at some interesting data on human lifespans over the ages. The Co-Magnon man, which lived about 45,000 years ago, had an average life span (same as life expectancy at birth) of 18 years. People in ancient Egypt (about 5000 years ago) had a lifespan of 25 years. Europeans in 1400AD lived about 30 years whereas Europeans and Americans in 1800AD lived to be about 37years. By 1900AD the life expectancy at birth in Europe and US jumped to 48 years due to advances in early medicine. As of now US citizens could expect to live till about 79 years whereas the number is even higher at 82 for people of France, Norway and Canada. The huge jump in life expectancy is obviously attributable to further advances in the field of healthcare. It is interesting to note that in early societies, the risk of death was at an early age and very few people lived to be old. A main cause of death was infectious diseases like smallpox, polio, measles, plague and many others. Scientists have developed vaccines which immunize humans against some diseases and there are preventive and curative steps for other diseases. Today the instances of death are more in the old age as the reasons of early age mortality have been tackled. In the old age deaths, the typical causes are non-communicable diseases like cardiovascular diseases or cancer.

We clearly see The Law of Accelerating Returns at play here. The life expectancy improved by just 7 years during 40,000 years from Cro-Magnon to ancient Egypt but it jumped by 31 years in the last century. If better medical research and healthcare facilities are the reasons for this jump and if these reasons are growing qualitatively and quantitatively every day due to further research and development then, extrapolating the trend, it would not be impossible for a human in not-too-distant future to have a life span of hundreds or thousands of years. In other words, he or she would be practically immortal.

This and many other presently unimaginable things are possible if humans were to develop BMI and latch early on to the unstoppable train of the

Artificial SuperIntelligence. That would help humans to be in command or at least partners with machines when Singularity happens.

It is very important to contrast the two scenarios of Singularity, Scenario Alpha and Scenario Omega. Scenario Alpha is where SuperIntelligence takes off without humans and Scenario Omega is where the humans will be in the driver's seat when it takes off. If humans let SuperIntelligence develop without parallel advances in Brain-Machine Interface (BMI) then machines would be able to program and enhance themselves without the help of humans and humans will be left out of the development completely as they may not have anything to add to the process. Pretty soon, the machines would ignore humans like we ignore ants and monkeys today.

The key difference between the two vastly different scenarios Alpha and Omega is simply the Brain Machine Interface. Crack that and we will have a Utopian future; miss that and we will live under fear of machines forever. All my best wishes are with the BMI researchers.

Part 3: Social and Economic aspects of our future

By now we have seen how mankind evolved and how mankind behaves under various circumstances. We saw what mankind is doing to address its various issues and how it might be possible to solve today's problems with emerging technologies. We also saw what might possibly happen in the future by extrapolating the trends in technological advances.

What now remains to be seen is how our society will transform when subjected to these technological changes. The discussion about mankind's future cannot be completed without analyzing socio-economic angle. Society is made up of various factions – people from different strata, government (which may or may not be the representative of the people) and corporate entities (which employ people to create products and services for the society). All of them have their own set of problems and aspirations. All of them are reacting to rapidly changing technology and many a times we fail to make sense of what they are doing and why they are doing it. In this section we will try to make sense of these social angles and try to guess how mankind is likely to evolve socially.

In this section, we will look at how various social aspects will shape up, how the role of the government will change over time, whether the governments will have the wherewithal to deliver on their new targets and how would their budgets look like. We will also analyze how a new social structure would develop and what role education will have to play going forward. We will also see how the financial world would look like given the trends in savings, investments and asset bubbles. We will discuss the behavior of the new generation corporates and the future of innovation. One note of caution here – though I have tried to create separate chapters for different themes, the interplay between various factors is so strong that you will find some of them popping up in each other's chapters.

"In theory, there is no difference between theory and practice... but in practice, there is" – Jan van de Snepscheut

The dichotomy of theory and practice is the key hurdle inherently present in Socio-economic sciences. Socio-economic sciences like economics, finance and civics study behavior of people under different incentives and come up with implementable policies that would optimally benefit different factions of

the society. Examples of such policies include land and labor laws, taxation policies and various formal and informal code of conducts. Social sciences are not pure, deterministic sciences like physics, chemistry, etc. These are complex, chaotic systems with multiple parameters affecting each other through feedback effects and even the quantum of impact on each other being a function of time and other factors. The number of people, the type of people and the interplay between different government policies make this an extremely complex system. Such complex systems are quite likely to become unstable when faced with external shocks. For unstable systems, a tiny change in any action or any parameter can have a huge impact on the final outcome. The theories in socio-economic sciences are nothing but simplified models created with logic, data and analysis and given the fact that we cannot yet model such complex systems in one go, simplified models is the only path for now. The problem arises when policymakers apply learnings from the simple models to real systems while missing some crucial elements. These would be honest mistakes but they end up costing a lot for the society. For example, a few decades ago, it was fashionable to support Malthusian view which said that the world population is growing at exponential rates whereas the world food supply is growing at linear rates and hence the world will run out of food if population growth is not controlled. Prima facie this logic was sound and available data was also supporting the logic. Many countries introduced family planning measures and China went a step ahead to compulsorily implement Single Child policy. What the policymakers were unable to build into their theory (honest mistake) were two things – one is that the new wave of research and development in food technology would improve yields significantly and secondly, the global population was already on its way to slow down significantly. Today, China is facing the reverse problem; within a decade it would be an aging society and will need to worry about having enough working population. Given such idiosyncrasy in predicting behavior of complex systems, I request the readers to view the upcoming discussion and predictions in the appropriate context as applicable. I feel most of the predictions would come true over the time horizon of next 10 to 30 years but further pinpointing of timelines in many cases is tough. We are obviously not getting into Singularity and the predictions about mankind’s socio-economic future after the invention of the SuperIntelligence; as we discussed earlier, it is simply beyond any person’s ability.

At the end of this analysis we will have a better understanding of how

mankind’s future will look like and we will also discuss some ideas about what you, I and the whole society can do to prepare for the future. Surprisingly, there are just a small number of actionables that can get us home.

Chapter 3.0: How Economy Works

Before jumping into the endless stream of economic parameters, let’s briefly visit the basics of how an economy works. The topic is so vast that millions of pages have already been written about it and more are in production. I would only touch upon the key concepts of economics very briefly and the specific concepts will be dealt with in detail in the subsequent chapters as required. The readers who remember Economics from college can directly proceed to the next chapter.

The key concept related to any economy is the annual production and consumption in the economy. One measure of this is the Gross Domestic Product (GDP). It is the total value of goods and services produced in the country (during a year). It can be calculated in two ways. In the first approach, it is the sum total of compensation to employees, gross profits of companies and taxes minus subsidies. In the second approach, GDP is calculated as the sum total of consumption, investment, government spending and net exports. GDP, meaning the overall production in the economy can increase through three ways – either more people in the economy go to work or they work for more hours or the productivity per person per hour is increased through innovation. Gross National Product (GNP) is the value of goods and services produced by the citizens of a country. If you are trying to calculate GNP from GDP, just subtract the domestic production owed to foreigners and add foreign production owed to citizens. GDP is place specific whereas GNP is ownership specific. National Income (NI) is another key concept for measuring the activity in the economy. NI is actually GNP minus the depreciation (wear and tear) of fixed capital like plant, machinery and buildings. So National Income is typically about 10% lower than GNP.

Secular growth in GDP is important because it increases the wealth of the nation. Secular growth in per capita GDP is even more important for any economy because it typically improves the living standards of the people in the economy. Growth in GDP also brings in more taxes to the government.

Taxes form the key income stream to the government which it can spend on providing various things like healthcare, education, law & order, pension, social security to the citizens, etc. Consistent growth in the economy leads to better utilization of production capacity in the economy and creates more demand for additional factories, land, buildings and equipments. When the new factories start, there will be more demand for workers. Land, labor and capital are traditionally considered as factors of production. Job creation by new factories improves the incomes for people and this leads to these people consuming more goods and services, which in turn leads to more demand for these, leading to further job creation and the cycle continues.

GDP growth is not uniform across all geographies, across all sectors and across all people. Almost 30% of US workers were working in the agricultural sector 100 years ago whereas today just about 1% of US workers are employed in the agricultural sector. A large part of GDP of many economies today is made up by the services sector, followed by manufacturing as the distant second and agriculture as the smallest contributor. Income and wealth are also not uniformly distributed in the society. In almost every country we find billionaires on one end and homeless people at the other end of the spectrum. The most common measure of income inequality is Gini Coefficient, named after the Italian sociologist Corrado Gini. Lower values of Gini Coefficient (meaning more income equality) are observed in developed countries with good social welfare policies, such as Nordic countries.

Economies intermittently experience shocks that are internal or external. Natural calamities and wars are examples of economic shocks. Such shocks impact the demand, supply and prices of various commodities. Shocks can be positive, too, like a new technology suddenly improving the supply and bringing down the price of a certain commodity in demand. Under the conditions of shocks, producers and consumers try to adjust their plans and possibly shift to substitutes so as to minimize the impact of the shock. Sometimes the whole economy or some specific portions of it (like real estate) may overheat and high inflation (price rise) is observed. Sometimes, economies slow down due to external shocks or purely due to fatigue. In all such scenarios, there are mainly two entities in charge and their two types of responses are sought by the economy. On one hand there is the central bank (discussed later) and on the other hand there is the government with its

Finance Minister (or Treasury Secretary or equivalent) in charge of making and realizing the budget for the economy for each year. This involves mainly collecting revenues by taxing incomes and consumptions of various entities in the economy. On the expenditure side, the government has to decide on how much they will spend on various programs like education, healthcare, infrastructure, law & order, social subsidies and also salaries and pensions to government employees. In most of the cases, the budget has a shortfall that the government bridges by either issuing more currency or by taking loans from various entities. Issuing too much currency can bring down the value of the currency and cause widespread inflation and instability in the economy. Taking too much debt is also risky because it is a two-pronged problem – on one side, high debt will mean higher interest outgo from the government budget thereby reducing the government's ability to spend on basic necessities, leading to social instability. On the other side, higher debt pulls down a country's credit rating and it makes taking new debt even more costly. The government can use its budgeting powers to encourage certain useful segments of the economy by giving tax exemptions or it can try to revive slowing economy by doing more government spending in infrastructure projects or it can put brakes on overheating economy by increasing taxes. Such measures are known as fiscal measures and are very important part of conventional economics. The other type of measures are called monetary measures and the entity in charge of these is the central bank of the country. Some key central banks in the world are Federal Reserve in the US, Bank of England in UK, European Central Bank in the EU, People's Bank of China, Bank of Japan, Swiss National Bank and the Reserve Bank of India. The main task of these Central Banks is to control the money supply in the economy (hence the term 'monetary' measures). This they do by regularly setting the rates at which the central bank will execute lending/borrowing operation with the banks. These rates then percolate down into the economy as banks can keep a small cut and pass on the money into the economy in the form of new loans like mortgages, vehicle loans, education loans, credit card loans and loans for consumer durables. The main sources of funding for the banks are the savings and current accounts and the fixed deposits made by the customers. Banks take the risk of possible defaults and the risk of lending for longer durations for earning a spread between their borrowing and lending. Banking has become so deeply entrenched in our economies that the central banks need to closely control the activities of the

banks. The Central Banks dictate how much the banks can lend out to various sectors. They make banks maintain a certain part of their book in the form of government securities (which are supposed to be riskless securities) and in the form of cash. The phenomenon that banks can keep a small reserve and lend out a large part of their deposits in the form of loans is called fractional reserve banking system and it is practiced all over the world. Through such system, banks act as financial intermediary, meaning they bridge the gap between the savers and the borrowers and the resultant money circulation helps in growing the economy. The Central Banks also make banks maintain an adequate level of own capital so as to reduce the risk in the lending side. If a Central Bank feels that certain sectors of the economy are overheating then it can ask the banks to maintain higher capital against such loans and thereby make it unattractive for the banks to lend to such sectors. Central Banks also maintain a treasury book where they buy and sell government bonds to control the money supply in the economy. When the economy overheats and inflation threats rise, the treasury sells government bonds to suck the liquidity out of the markets. In times of weak growth or economic crisis, it buys government bonds and thereby pushes money into the broad economy to make it grow faster. With the increasing globalization worldwide, the Central Banks have to face a new challenge – that of managing the foreign capital flows. Today rich individuals, companies and countries don't want to be confined to investing in their own countries and increasingly look at investing in faraway countries offering better investment opportunities. Sometimes the foreign investment is in the form of direct investment like putting up a factory but most of the times, the foreign investment is in the form of portfolio investment i.e. into stocks, bonds, etc. If an economy is doing well, foreign money will flow in and the increased money supply may threaten the price stability meaning it will cause inflation to shoot up. Also, the increased demand for local currency may make it appreciate in value and too much currency appreciation will be detrimental for export focused industries. The Central Bank will need to intervene in the market by buying the foreign currency flowing in by selling local currency and then mopping up the extra liquidity in the local system by issuing more bonds. In case the economy is not doing well, foreign capital outflows threaten the exchange rates and the Central Bank will need to judiciously manage the foreign exchange reserves and the exchange rates so that the economy will not face a shock in the form of severely low liquidity in the system and depreciating local currency

causing import prices to shoot through the roof.

Different economic schools of thought offer different theories about how different fiscal and monetary policies should be managed, how and when the government should intervene in the economy and how different shocks in the economy should be handled to minimize the damage. But even after two centuries of economic theories, the right formula for managing an economy remains elusive. Being in charge of the fiscal or monetary measures in any decent sized economy would be one of the most intellectually challenging jobs on earth today. Given the complex nature of the 'Economy' as a system, each decision would need to be discussed ten times and sometimes tens of times to make sure it will not result into some unexpected, unforeseen complications, as has sometimes happened in the past. We need to remember that while ending this chapter here with this amusing quote by Lawrence J. Peter:

'An economist is an expert who will know tomorrow exactly why the things he predicted yesterday didn't happen today.'

Chapter 3.1: Changing role of the Government and Social Welfare

"I don't make jokes. I just watch the government and report the facts." – Will Rogers

What is the job of the government? Government is nothing but representative of the citizens, so the government's basic job is to look after the wants and needs of the citizens. Citizens desire everything that we discussed in Maslow's Need Hierarchy theory – right from personal security to self-actualization needs. Hence the government needs to design and execute plans for the well-being and prosperity of the citizens. How much the government actually fulfills those plans depends on various factors like availability of resources, ability and willingness to reallocate resources as required and citizen's control over the government. In cases where there is scarcity of resources and small surpluses to go around, it has been quite natural for governments to be unable to provide even the basic necessities like food, water, roads, electricity, healthcare, law & order and school education. Countries that are flush with money (mainly coming from sale of abundantly

available natural resources), have governments that not only take care of the basic necessities but also provide extra resources to various strata of the society as per their needs, sometimes even in the form of cash donations. Efficient governments like that in Singapore come up with innovative schemes for citizens, like the affordable housing scheme whereby the government provides cheap but good quality housing to every citizen at a very low upfront payment. Then there are a few countries in the world where the resources are logically sufficient but the government and administration is so inefficient at planning and distributing that the common man is left destitute. You might recollect Arab Spring / Jasmine Revolution in the Middle East a few years ago. At the root of it was the dissatisfaction with the rule of local governments, especially by the youth who are unable to get jobs and provide a decent living to their families. Arab Spring was a wake-up call for the governments worldwide and the impact is seen today in the form of governments that listen to the common citizens and aim to provide for their needs. Social infrastructure, right from water and electricity supply, roads and railway lines, healthcare facilities and schools, is now being built by almost every government on earth at a rapid pace.

The importance of supply of bread and basic things for a stable government is not a recent phenomenon. For centuries and millennia, governments learn this lesson though the hard way and then forget it and then have to learn it again. Even the Roman satirical poet Juvenal wrote in 100AD about ‘Panem et Circenses’ meaning bread and circuses. These are the things that keep people content and occupied. If they get no bread they would revolt and overthrow the ruling elite. Too much free time in the hands of the citizenry was also counterproductive given the fact that idle mind is the Devil’s Workshop. Roman Emperors arranged circuses meaning fights between slaves and beasts (remember Gladiator?) which were a favorite with the Roman citizens. More than 100,000 Jewish slaves are said to have worked for more than eight years for making the Coliseum which could seat 50,000 spectators at a time. Such great expense indicates the importance of such social infrastructure at that time. The 19th and early 20th century Spanish intellectuals grieved the backwardness of Spanish society where ‘pan y toros’ (bread and bulls) had become the key foundations of society. In today’s world the circuses part is still alive in the form of politicians acting like clowns aiming to please the crowds but that is not the topic for this book. We will focus on the humble

bread which has already evolved into a long list of amenities the common people expect from the government and what might be the future of this.

We already talked about governments worldwide becoming serious about improving social infrastructure. In developing countries, where the upfront funding required for big projects like railways is a problem, many international agencies are providing low cost loans and thus helping in building the required social infrastructure. Governments are also going a step beyond and identifying the low income people and provide them extra help in the form of subsidies (food, fuel, fertilizers, etc.), healthcare, pension and reduced taxes. Such support program for the needy individuals and their families is called Social Welfare. Private entities are currently a very small part of the social welfare, so we will mostly talk about social welfare by the government. We find some type of Social Welfare programs being run in each and every country today, be it capitalist, socialist or communist. Pure capitalism dictates distribution of wealth as per free market rules whereas Social Welfare, by nature, is a program for redistribution of wealth by the government. In capitalist societies, over a long term, wealth tends to accumulate in the hands of a few individuals at the top and the lower classes become increasingly poor. The reason behind this is explained by the French economist Thomas Piketty in his book ‘Capital in the Twenty First Century’ which focuses on wealth and income inequality in Europe and the US since the 18th century. From his research, he found that when the rate of return on capital exceeds the rate of growth of the economy over the long term, the result is concentration of wealth and subsequently, social and economic instability. What it means is this: various assets in the society, right from cash and stocks to real estate are typically owned by the elite few rather than the commoners who are more dependent on regular income (wages or the profits of the businesses they own). In a year when the assets earn more than the increase in income for a typical worker, the increase in wealth for the asset owner will be higher than the worker. This phenomenon, if repeated year after year, will make the asset owners disproportionately richer than the commoners. This economic instability, the wide chasm between the ‘haves’ and ‘have nots’, will create a social instability and may lead to revolutions, overthrow of governments and civil wars depending on the situation in the given country. It is often said that the poor give votes to the politicians expecting safety from the rich and the rich give money to the politicians

expecting safety from the poor. Keeping the joke aside, it is true that the politicians in power, meaning the government will need to keep checking for the chasm between the rich and the poor and step in whenever the gap widens.

During the last century, amongst all the –isms, capitalism has been the most successful ideology, looking at the success of the western economies. There is no denying that it encourages entrepreneurship, innovation and risk-taking. The new products and services borne out of these qualities have made the world a better place. However it is also true that capitalism has increased the economic and social divide. Today less than 1% of the people own almost half the wealth in the world. The average wages are stagnating world over but the number of billionaires from each country is increasing every year. The number of homeless people in best of the cities, New York for example, is increasing at alarming rate. In such a scenario, even the pure capitalist countries are having a re-think and the governments there are spending more on social welfare. The socialist countries, especially the Nordic countries, have always followed the philosophy of greater redistribution of wealth and the model seems to be working very well. In these countries the rate of taxes is very high but the rich do not complain because the money is efficiently spent on the deprived and as a result, the social divide between the rich and poor is small. There are other benefits to social welfare which we will discuss later.

Social welfare is not a recent idea. First Roman Emperor Augustus provided congiaria (grain dole) every month to citizens who could not buy food. Since 7th century AD, a tax called Zakat (charity) is collected from all Muslims by their governments which is used for welfare towards the poor, elderly, orphans, widows and disabled. Song dynasty in China practiced social welfare a thousand years ago by building retirement homes and public clinics. Welfare payments to the poor were part of English Poor Law of 1601AD and the Poor Law Amendment Act in 1834AD. Even today we find some type of welfare system in each country. Europe, with its socialist bend, spends more on social welfare than other geographies. If we look at the spend on welfare as a percentage of GDP, it stands at about 28% for Germany versus about 16% for the USA. Nordic countries are said to be the best in terms of social welfare because of the noteworthy quality of free education, universal healthcare and public pension plans. Their model is based on the

concept of flexicurity (flexibility and security) which combines flexibility in the labor markets, social security and rights & obligations for the unemployed. This is of course supported through higher taxes on all and the average tax rates in Nordic countries stand at 40-50% versus rest of the Europe at 30-35%.

As one can expect, there is some opposition to social welfare schemes in every country and it comes mainly from the camps of the rich and the pro-capitalist economists. The grounds for opposing are mainly five points. First, there is skepticism towards the governments' ability to efficiently transfer the wealth without leakages. Secondly the number of the needy runs into millions (and growing every year) and is difficult to keep track of, given the frequent intra-city and inter-city migration. Thirdly whom should we consider a needy person? Any arbitrary income or wealth cut-off would not suffice given the different parameters at work, like the cost of living, number of family members, education and income potential, etc. Fourthly the list of facilities to be provided under social welfare is open ended and there seems to be no end to what should be provided. Till recently it was free (or greatly subsidized) food for the needy. Today governments in certain geographies are providing free water, free electricity, subsidized housing, free kitchen appliances, and many more to the citizens. The latest is free Wi-Fi in public places and many countries have already started providing it. I can think of free local transportation that may become a reality given the falling cost of solar and battery power. But beyond all these also, we will surely see some creative freebies for the poor being designed by the some clever politicians. The fifth and the biggest objection to social welfare is the burden on government budget. If the subsidies are small it wouldn't dent the budget much but in many countries where the list of needy runs into millions the budget deficit arising out of subsidies and welfare programs can be really alarming. The governments will then have to do a tightrope walk to fund the deficit – they can either raise taxes, borrow money from the domestic or international markets or they can print more currency notes. The key is doing this in such a manner that the global and local rating agencies rating the government's debt should not feel so uncomfortable with the rising debt to announce a rating downgrade. Rating downgrades mean higher rate of interest to be paid on the money to be borrowed and generally results in a weaker currency, too. Funding this higher interest outgo by boosting economic growth under such difficult circumstances becomes the next headache for the governments.

Many governments have fallen in the trap of announcing obscenely expensive social welfare programs which led them into the classic disaster pit of larger budget deficits, higher borrowings, rating downgrades, higher interest burden and weaker currency retarding economic growth.

Let us first tackle the problem of leakages. Leakage means that the intended beneficiaries don't benefit because the people who implement the program or other middlemen skim away the benefits. It is quite rampant in developing countries all over the world. You might have come across a famous joke involving two fictional Presidents, one from an African country and the other from an Asian country. The African President visits the palace of the Asian President and is surprised at the opulence. He asks for the secret behind this wealth and the Asian president takes him to a window overlooking a river dam and says, "Do you see the dam? I took 20% out of the grant we got from the World Bank for building that dam!" Next year, the Asian leader happens to visit the African President. It is now his turn to be astounded at the opulence of the African leader. He obviously enquires about the secret and the African leader takes him to a window and asks, "Do you see the river dam?" "No," said the Asian, puzzled. "That's the secret! I took 100% out of the grant we got from the World Bank for building that dam!" Though developing countries have big leakages, some leakage is found in developed countries, too. There have been allegations of billions of dollars of fraud in British NHS and there are research papers on how doctors are inflating the US healthcare costs by ordering unnecessary tests and treatments.

Luckily, better information technology is helping towards reducing the leakages. Welfare providers can today invite global tenders for almost each and every type of project. Logistics has become quite streamlined so that suppliers from any country can easily send in their goods or services efficiently. This global competition is the key to reducing leakages in social welfare. Firstly, the items to be supplied under social welfare are quite generic and there would be hundreds of manufacturers and suppliers for these items. Collusion becomes difficult amongst such a large number of suppliers. Even on the customer side, the leakages can be brought down using information technology. A good example of this is the subsidized kerosene provided in India. As the poor tend to use kerosene stoves, the government runs a program of providing subsidized kerosene to the poor through public distribution system. However most of it was pilfered or misreported and sold

to black market buyers like restaurant operators. The poor waiting in lines at the government distribution centers were sent back empty handed. The government has now run pilot programs in some states where the kerosene is sold at normal market rates. The people eligible for the subsidized kerosene have provided their bank account numbers to the government and there is one-to-one linkage between a person (though biometric information) and his/her bank account through a concept called Aadhar number (it is a Universal Identification number for the person). The government directly transfers cash subsidy to the recipients' bank accounts. Thus now there is very less chance of a leakage of the subsidized kerosene. This concept is expected to be used for other forms of subsidies like fertilizers for farmers at reduced rates, subsidized food, free water & electricity for the bottom strata of the society, etc.

The discussion about Universal Identification number brings us to another problem area about social welfare. The number of people and the size of budget provisions for providing welfare are the key deterrents. The tragedy is that the governments that are failing at improving the standard of living for poor people are mostly the ones in developing countries. Developing countries have traditionally had relatively higher birth rates and hence the number of people seeking government support had been continuously increasing. Governments worrying about these ballooning numbers and worrying about the rising leakages were skeptical of taking the onus on their shoulders and the vicious cycle continued. But now the tide is turning. The birth rates are coming down (as we will discuss in a later chapter). The human population is likely to stabilize at about 9-10 billion in a few decades and once there is some anchor, some visibility on the number of people that need welfare governments can feel comfortable in shouldering the responsibility of social benefits because these will now be finite and predictable. Making a database of all people in a nation is now possible for the governments. In India, a database based on a universal identification number called Aadhar (means 'support' in Hindi) is being built and by next year, it is likely to cover 1.25 billion people, meaning almost all the residents of India. This number is not just a social security number, it also contains biometric information about the person (meaning iris scan and fingerprints), his/her mobile number and his/her bank account. Once the database is complete, all financial information like income, income tax filing, financial transactions, etc. will be captured using Aadhar number. By using such three

dimensional coordinates the welfare schemes can be properly designed to reach specific segments of the needy people and the execution will also be better because the subsidy is released into the receiver's bank account directly. Leakages through identity thefts would reduce due to the use of biometric verification route. Many developing countries are now taking this approach of building a biometric+mobile+bank account database for their citizens and will use it to route social welfare schemes efficiently.

The third, fourth and fifth impediments to social welfare mentioned above are basically these questions: what all things should be given free and to how many people and does the government have enough money for this? Let me start with the ideal answer and then move to the realistic one. We started this chapter saying the government's job is to fulfill as many human needs as possible. Human needs, as explained by Abraham Maslow, are finite and are classified as physiological needs, safety needs, love/belonging needs, esteem needs and self-actualization needs. For the time being, leave aside the self-actualization needs as achieving those become possible after fulfilling the first four needs – the deficit needs. If the government wants to provide for all these needs, what will the ultimate list look like? It will be free food, free house, free water, free electricity, free transportation, law & order, justice and a job that gives esteem and income. You will be surprised to know that the governments in almost all countries are fulfilling some of these needs of their citizens already. Food stamps for the poor, government funded low cost housing, cheap drinking water schemes, cheap or free electricity and government lawyers for the poor are already quite common in many places. Government of course could not provide spouses to take care of the love/belonging needs of the poor people. This may seem like a point in lighter vein but it has some serious implications. It is generally said that the three Ws are the reasons behind all crimes – Wine, Wealth and Women. Actually data on crimes from various police departments indicates that majority of the crimes can be classified under these three broad categories. Based on our earlier discussion, you will agree that there would always be conflicts over Wealth and Women because of their being the key 'resources' in the subconscious mind running the GeMax program. Wine (or any other substance affecting the brain) impairs the civilized part of human brain and then the subconscious mind (the animal spirit) takes over; which by natural evolution is still defensive, vicious and belligerent. To make a peaceful society, can the government tackle all these Ws, the sources of all crimes?

Control of narcotic substances has been tried by many governments but victory is still not in sight. Prohibition failed miserably in the US in the last century. This century is already seeing drugs being decriminalized and cannabis being legalized. So obviously more openness about narcotics seems to be on the cards. This will at least free up the government's budget that is used on police, prisons and judicial systems and can be used for better purposes such as educating the people about the adverse health consequences of such substances and about the legal consequences if they hurt others while under influence. This, to me, seems the only possible way to tackle the first W. The second W is a bit easier to tackle as wealth is mainly a tool, a resource for achieving the basic needs. If the government can provide the basic needs, the explicit need for wealth would wither away and so would the crimes for wealth. First generation of companion robots is already on its way to the markets and if such kind of robots become available to the needy at reasonable prices, then even the third type of crimes might diminish and help in building a peaceful society. This is certainly far-fetched but not impossible.

Based on the discussion till now, 'what the government should provide to the citizens' can be broken down into two broad segments (there is a product/service overlap in some of these but this is a broad breakup). One is products – food, water, house, electricity, transportation, internet, companion robots and appliances. The other basket is services – healthcare, law & order, justice, education, firefighting, sanitation, etc. A key component of social safety net is pension but in actuality, pension is required for procuring the products and services mentioned above. If the government can provide these products and services, it can do away with separate pension payments. So let's discuss how realistic and feasible it would be for the governments to provide all these for free to every citizen? This is where the discussion on technological progress in part two of this book comes in handy. Just to recap, food technology is advancing reasonably well with hydroponic farms and genetically modified seeds, fish, etc. Drinkable water will be becoming a reality thanks to solar powered filters. 3D printed houses at unforeseen speeds and unforeseen prices are almost here. Solar based electricity at dirt cheap rates will be reality before 2020. Combination of cheap solar plus battery storage will bring in electric taxis, buses, trains that may cost just a few pennies per ride. In case of internet, companion robots and appliances, the technologies have settled down so well that equipment suppliers will be

cropping up in every city, leading to huge competition and corresponding fall in prices. The cost of a TV or a smartphone has fallen multifold in last five years, for the same or better functionality. The trend is likely to continue given the advances in manufacturing and cheaper financing becoming available. So even though it feels like sacrilege to talk about a government providing all these products for free, it would not be a tall task in near future. Also, use of technology such as biometric identification will help in reducing the leakages so the authorities can make sure that a person X is not taking more than one TV from the scheme and selling those in the market to earn some cash (as is the basic human tendency).

Now we come to the services. Services are difficult to administer because of three reasons. Unlike products, which can be distributed once (or the distribution system can be set up once) and be done with, services require continued efforts. Students go to school every day and some patients need to visit hospitals every month. Also, unlike products, services have a subjective component and hence quality control is the trickiest part. Lastly, services require involvement of people at the touch-points. Managing the big number of employees resulting out of this condition is a herculean task. The different types of stakeholders involved have their own agenda and unequal bargaining powers, ultimately leading to inefficient outcomes or unsustainable cost structures in many cases.

Let us start with the social healthcare. Every country has some schemes for providing social healthcare and due to better penetration of hospital networks and health insurance companies, the coverage is increasing. In countries like UK, Canada, France, etc. the healthcare services are provided completely free of charge by the governments. In US, the healthcare is through two channels – government paid healthcare support is through schemes like Medicare and Medicaid and healthcare support provided by private insurance companies where the insured person pays annual premiums. Please bear in mind that the second form (private insurance) is not social healthcare. In case of privately insured patients, insurance companies decide how much they will shell out for any treatment proposed and the rest is to be borne by the patient. In a developing country like India, 80% of the healthcare spend is out of pocket for the patients whereas in the developed countries, just about 10-20% of the healthcare spend needs to be borne by the patient. In countries where the patient has to pay out of pocket or through a private insurer, many a times a

lot of crucial time and energy is spent in finding a hospital that the patient can afford or a hospital that has a tie-up with the patient's health insurer. Such instances underline the importance and utility of fully government run healthcare systems in countries like UK where a patient can just go to the nearest hospital and is assured of getting the best treatment at no cost whatsoever. Such a system gives a comfort and also the visibility to citizens that they will not need to save money for a medical emergency. Obviously the people will need to pay extra taxes to the government to manage such a social healthcare system but the issues like last minute hassles, wasted time where timely treatment was required, mental stress, etc. are avoided in this system and that is of great importance.

If that is the case, then why don't all government offer free healthcare? The budgets for social healthcare runs into billions of dollars for any decent sized country and it remains one of the biggest drains on government finances. Secondly, healthcare field has developed from the bottom-up in bits and pieces contributed by different stakeholders unlike the space exploration field which has developed top-down with a central entity NASA defining the goals, charting out missions, developing vendors, focusing on research for specific technology, etc. In healthcare, family doctors (also called as general practitioners) have been around for centuries in one form or another. Surgeons descended from barbers just about a century ago (amusing but true!) and now surgery has become one of the key services at every hospital. Many therapies like chemotherapy, radiation therapy, physiotherapy and many other have been developed in the last few decades. The production and quality control of medicines has been formalized and brought under government entities like US Food and Drug Administration (USFDA) in just the last century. Equipments like CT Scan, MRI, X-ray are also the outcomes of technology developed in the last century. The point here is that the different pieces of the system developed and spread independently, based on either technological breakthroughs or due to patient requirements. The pricing was based on the paying capacity of the patients and was not under purview of the governments. Moreover, given the fact that these are all niche areas and require large upfront investment of time and capital to develop the technology, there have been few suppliers in each field, keeping competition down and giving the incumbents a good pricing power. The technical knowledge involved is significant so that the company which develops a new medicine or a new equipment has to deploy a field force to educate the

doctors on how the new invention is superior to the current treatments used on the patients. Own health is of utmost importance to every person and hence any and every patient would pay whatever the service provider asked for. Thus the system developed in such a way that the patients have very less understanding of the technology and also very less bargaining power. The system naturally grew towards enriching the service providers – doctors, hospitals, insurance companies and manufacturers of equipments and medicines. Especially in the US, where staunch capitalist ideology dictates the government to not interfere with the free market pricing and not to control profits, the enrichment is evidently visible. Now, if a government wants to take over the healthcare system and provide free, good quality healthcare to all, it will need to pay all these stakeholders involved for their services but the key is in controlling the costs for these services and bringing them down using the large volume the government can offer; that has proven to be a herculean task till now. If the government cannot control the costs it will need to enforce higher taxes on the population which the citizens will not like. Moreover, the cost control has to be of an ongoing nature. The system is so complex that the people involved always come up with new ideas for siphoning off money from the system. For example, the doctors treating the patients may be incentivized by some companies to order unnecessary tests and MRI scans, etc. which may not really add any value to the diagnosis. Tackling such problems on the ground is currently very difficult. A research article I came across mentioned that US has been found to have the highest healthcare spends versus other developed countries, arising mainly out of very high obesity rates, lower supply of physicians and hospital beds, higher prices of drugs and procedures and higher use of costly technologies like MRI scans. It mentioned that Japan on the other hand has lower healthcare spends and it achieves these through aggressive price regulation.

When the payment systems are convoluted, there is more chance of leakage. The system of patient-insurer-hospital is the best example. The patient undergoing the surgery is not bothered about what it is going to cost because he knows that the insurer is going to pay it. Hospitals know this and include a lot of unnecessary tests, scans, consultations, doctor visits and ancillary charges to bulk up the bill. Given the fact that medical treatment is still not an exact science, the need for and the contribution of each of these actions is debatable; some will see a merit and some won’t. For example, a person I know was admitted in a hospital for malaria. She was recovering well, all the

test results were benign and the discharge was planned for the next day. The doctor came for a visit, saw the patient chart and went back. This half a minute visit was charged at Rupees 1000 in the final bill (just for reference, the average income for an Indian is Rupees 300 per day). An anecdote in an online magazine mentioned a female patient in the US who was charged $1300 for blood tests while erroneously assuming she had insurance coverage. When it became clear that she did not have coverage, the bill came down to $370 and when the lady insisted that she had only $145 to spare and nothing else, that is where the hospital settled the bill and closed the chapter. Even if we ignore the last bit about bargaining, what is definitely shocking (and true) is that healthcare providers are charging extravagant amounts to the insurance companies or the government owned payers.

This is the real reason for the burden on the healthcare system today. Governments do not have infinite budgets; if they could, they would offer completely free, top notch healthcare to every citizen. The governments are left with just two options – one is to let the people handle their own healthcare or to work towards reducing costs to manageable levels. One way to make systems more efficient while simultaneously reducing costs would be using the advances in computing technology. Today's machines are capable of crunching vast amounts of data and identifying patterns that human doctors physically cannot. Specially developed self-learning softwares can help doctors in real time to take full advantage of electronic medical records, right from diagnosing the symptoms to suggesting new medicines which worked in similar cases. Given the fact that about 98,000 patients die every year in US alone due to human errors, a diagnosis and treatment suggested by computers may be welcome. Today hundreds of research journals are published every month which talk about new research, diagnosis and treatment but the doctors are in a quandary – they have to decide if they want to allocate their finite time to treating patients or to read these hundreds of magazines to improve their knowledge so that they can treat the patients better. Some recent softwares are capable of reading through hundreds of articles and make a concise gist which the doctors can peruse. Such softwares would make the doctors more capable without spending much extra time. The next phase will be through better use of Artificial Intelligence. Recent research has shown IBM's Watson supercomputer is better at diagnosing patients and predicting the tests and treatments required, with 30-35% increase in positive patient outcomes over real doctors and this comparison

was done using real patient data. So there is a clear path available to improve quality and reduce costs: AI to help doctors today and AI itself as doctors tomorrow (at least in the straightforward cases).

Now we come to the other key services: law & order, justice and education. We have already seen in the chapter on technological advances how the computing technology is helping law & order enforcers in areas like solving crimes, nabbing criminals, maintaining real time surveillance and timely prevention of crimes. Computing technology can also help in legal matters. To prepare for any court case, thousands of pages of legal material, old cases, etc. need sifting through and currently it is done by the armies of paralegals employed by each law firm. Softwares are now becoming available which can do the sifting in a few minutes instead of weeks and thus save valuable time and money during court proceedings. Hopefully the new social structure will greatly lessen the burden on the judicial system as we will discuss in a later chapter. In case of education, we have already discussed the use of robots for substituting teachers. Another, more potent trend is in the making and it is known by names like online education and e-learning. Due to internet connectivity and high data speeds becoming available even in the developing world, watching videos and even conducting video conversations has become very easy. This is obviating the need for physical infrastructure like buildings, classrooms, libraries, etc. that was required for education. A good teacher can just record his lectures using a simple smartphone and upload them on video-sharing websites like youtube which interested students can watch and/or download for free or for a fee. The audience will not be restricted to the local population; students from every corner of the world can participate. One interesting example is Udacity, a for-profit, massive open online course university founded by Stanford University Professor Sebastian Thurn in 2012. He used to teach computer science at the university but left his job and started Udacity after he came across over 150,000 students enrolling for his 2011 fall online class on Artificial Intelligence. Today the online university offers more than 26 courses in 203 countries and the number of students is more than 300,000. They offer courses (called nano-degree programs) such as making machine learning programs, developing android and ios apps, building complex web applications, data analytics, etc. Georgia Institute of Technology tied up with Udacity in 2014 to offer MS in computer science degree program for US$ 7,000 which is just a fraction of the cost for a normal, offline degree. Such

technological breakthroughs in education can bring down the costs and efforts incurred by the government to provide good education to students. It will also save the future students from the big college education loans that force them to take any jobs just to service the debt. Today, US has a trillion dollars of student loans outstanding and about 12% of them seem to be on their way to default. The student loans are ultimately guaranteed by the government so any defaults have to be paid by the government, meaning the common people will need to cough up this USD 120 billion over next few years in some form or other. But hopefully, with better spread of online education, the student loans will not grow much going forward.

Our discussion over various products and services shows a common trend. The betterment of technology has made almost each of these things easier to manufacture, procure and disseminate. Given the fact that cost considerations have always dissuaded governments from fulfilling all the deficit needs of their citizens, we seem to be standing at a turning point. Some green shoots are visible. Finnish Social Insurance Institution is considering a proposal to give 800 euros, tax-free, per month to every citizen of Finland from 2017. This will replace all other benefit payments but will be available to all people irrespective of whether they are working or jobless. This system will cost about 48 billion euros but will create a safety net for every citizen including the 23% unemployed youth population. Swiss government and Utrecht, a Dutch city are also considering introducing some basic income. Within a decade or two, we may actually see governments in all countries taking care of all basic needs of their citizens and such fulfilment of basic needs should lead to an immense reduction in conflicts amongst humans and make the world a better place.

Chapter 3.2: The Grey Tsunami

'The young feet can run faster but the old mind knows all the shortcuts!' - Anonymous

In earlier chapters, we discussed how improving healthcare standards and rising healthcare awareness are contributing to extended life expectancy. Just one to two generations ago, we saw people dying in their seventies and eighties but now we find people dying in their eighties and nineties. We also briefly touched upon the idea of lower fertility as a result of increasing lifespans. The GeMax based analysis provides the logic for this phenomenon. The lower the lifespan of the animal, the lesser the care and protection it can offer to its offspring. This leads the animals with short life-spans to have as many offspring as they can. If parents are not around, the offspring are left to their own fate, but if the starting number is fairly large, there is a good chance that some of them will survive this harsh world and will grow and procreate and pass on the genes, thereby fulfilling the GeMax logic. Frogs and fish lay hundreds of eggs with the same subconscious logic. More evolved animals that have longer lifespans and can take care of their offspring are seen to be having lower number of babies and the relationship between the two is quite secular. Dogs and cats have four to six babies and provide some initial care but on the other hand, animals like horses and elephants which are larger and live longer have one baby at a time and the mother provides far more care for to the offspring. Even in humans we have seen the same trend. About a thousand years ago, when humans used to live just about thirty years and there was very less visibility about how the kids will turn out, it was natural to have eight or ten or even more kids. Unconquered demons like infant mortality, epidemics and infections took away maybe two or three babies out of those ten kids even before they reached adulthood. Today many of the healthcare demons have been conquered and people have a much better visibility about how their lives will pan out. In such a scenario it is a better strategy to focus on the health and education of just one or two kids. That is what is happening worldwide; it would be very rare now to find a couple with more than three kids in any decent city.

There is another factor at work, I think, influencing people's decision to have children. *Knowledge and education strengthens the conscious mind and helps it overcome the biases of the subconscious mind.* From the scientific research

of last hundred years, we now know that earth is just an insignificant planet in an insignificant solar system in an insignificant galaxy. The goal of continuing the bloodline, continuing the family name looks pointless and puny in such context. I am sure there are some young couples in your social circle who are focusing on their careers or other pursuits and are deferring to have babies or are planning not to have kids at all. For love and affection, they might keep a dog or a cat which requires far less care and commitment than a human baby. Our world has become very fast and things are changing so rapidly around us that people are now disinclined to commit to long term relationships. Japan is a country where marriage and family system had been very strong but now people in their twenties, thirties and forties are uninterested in marriage. Various surveys indicate that work pressures, financial pressures (husband has to become the primary and sometimes the only breadwinner in the family after having kids), fear of loss of freedom and fear of extra responsibilities are dissuading these people from marrying and having kids. As per a survey by Japanese government, more than a quarter of unmarried men and women between the ages of 30 and 34 are virgins. Fifty percent of men and women in Japan said they were not "going out with anyone". A comment during one survey is very telling: “I’m married, but, honestly, I think it’s better not to be. Except for the kids… I like my kids.” Some GeMax seems to be at work here explaining the love for children but did you notice the absolutely zero thought and concern about the marital partner? With better technology, the need for human contact is plummeting. In Japan, there are about one million ‘Hikikomori’ (meaning shut-ins); these are young men who spend their days and nights locked in their rooms, playing video games, reading comics and shunning any ‘offline’ contact with people. Divorces are shooting up everywhere in the world because people do not want to commit to each other for the long term. Our whole culture is shifting to ‘short and exciting’ type experiences; about two decades ago Cricket matches used to be a five day affair, a decade ago one-day matches became the mainstay and today, most of the matches played are the ‘short and exciting’ three hour affair, similar to a movie experience. All in all, there are quite a few factors that are swaying people to have lesser number of kids.

Any society is made up of children, young adults, adults and the elderly. If the elderly are living longer and at the same time, the number of children is going down, the average and median age of the society will shift higher and higher. This is called aging of the society and it is happening in each country

on earth. In 1950, there were 335 million children in the 0-4 age group and just 131 million people above 65 years of age in this world. As per United Nations (UN) estimate, today the population below 5 is about 655 million and the population above 65 is about 608 million. By 2020, the 0-4 population is expected to stagnate at 650 million and the 65+ population is expected to be about 714 million. Many research reports are focusing on the key culprit involved – the falling birth rates in our society. Birth rates are analyzed using a parameter called Total Fertility Rates (TFR) and it measures the average number of children a women will have in her lifetime. To maintain the population at current level, the TFR required is about 2.1. This ratio is also called Replacement rate and it can be broadly visualized as two children required for replacing their parents in the world population when they die (plus a 0.1 meaning some extra births required for compensating factors like infant mortality, higher male/female ratio, etc.) TFRs used to be in the 3 to 7 range for various countries a few decades ago (world average was about 5 till 1970) and the world population was growing like never before (because for every couple, five children were born on an average). The world average has now fallen to about 2.4 and for many developed countries it is already below the replacement rate. In countries like Japan the TFR is about 1.4 and hence the Japanese society is aging rapidly. Just last year, adult diaper sales overtook the baby diaper sales in Japan. Japan's current population of about 125 million is expected to fall to about 100 million within next thirty years and continue declining. Though this trend is worrying it also brings out a very positive point. The Malthusian fear of human population explosion leading to unprecedented scarcity of food and other resources is not likely to happen. Human population should stabilize at about 9-10 billion in a few decades' time and that is what gives a better visibility and comfort in planning the social welfare, as we discussed in the previous chapter.

A UN report expects the number of older persons (aged 60 years or over) to more than double, from 841 million people in 2013 to more than 2 billion in 2050 and expects the number of old people to exceed the number of children for the first time in 2047. Sociologists have put countries in four different buckets based on their 'agedness' meaning the percentage of people older than 65 years in the society. Countries with less than 7% population above 65 are called 'young', 7 to 13% range gets the name 'aging', 14 to 20% gets the label 'aged' and if a country has got more than 21% of its population above 65 years, it deserves the label 'super-aged'. Currently only Germany (21%),

Italy (22%), and Japan (26%) are super-aged societies on earth. But within five years Bulgaria, Finland, Greece and Portugal will join that group. Within a decade after that, Canada, Sweden, France, UK, South Korea and many other countries will join the same group. Within a decade after that i.e. by 2040AD, US, China, Singapore and other countries will become super-aged and the club will be having almost 80 member nations. What is scarier is that the rate of aging has increased immensely for the global population. Based on historical population data, France was a 'young' country till 1850 with just about 7% people being older than 65. In 1850, it became an 'aging' country. Then it took 130 years for the old population to increase from 7% to the next threshold i.e. 13%. France became an 'aged' society in 1980. France is expected to be 'super-aged' by 2023 which means the increase in the aged population from 14% to 21% would be happening within just four decades! Another example is South Korea, which became an 'ageing' society in 1999, will become an 'aged' one in 2017 and will be a 'super-aged' one by 2027. So the aging of South Korea will be happening within less than three decades as against almost two centuries for France. The title of the chapter (the Grey Tsunami) has materialized out of this rapid, irreversible, tsunami like transformation of our society in front of our eyes.

Will there be any problems if the society is aging so fast? Yes, the problems are two-fold; the first is that the elderly have a diminished ability to work and that would affect a country's output and the national income. Today's aging Japan cannot be the manufacturing juggernaut like the young Japan in the 60s and 70s. The second reason is the diminished consumption of goods and services by the elderly. They typically don't spend on things like bar-hopping, partying, movies & entertainment, exotic vacations, etc. like the young earners do; they typically spend more on healthcare or save for the old age. Government earns through the taxes it imposes on the income of people and their consumption of various goods and services. These government inflows are used for running social welfare programs. You can imagine this as the government taking money from the young workers and using it for the benefit of the elderly. If the income and consumption patterns change adversely, this equation will become unbalanced (less working hands, more mouths to feed) and the basic role of the government may come under threat. A recent research paper from OECD pointed out that the Global Economic Growth will fall from the current 3.5% per annum trajectory to about 2.5% within about four decades.

The classical solution for dealing with growth slowdown caused by lower working population has been to allow immigration. Right from small countries like Singapore to large countries like the US screen thousands of applications every day to filter out the foreigners they should welcome to their countries who will contribute towards the growth of the country through their talents and will add more to the government kitty through the taxes they will pay on their income and consumption. Today hundreds of thousands of well-educated people in emerging economies are ready to do anything to get a chance of settling in the developed world because of the higher pay, better security, better social infrastructure and better quality of life offered by the developed countries. But if immigration rates don't keep pace with the aging, the situation will exacerbate very rapidly and irrevocably; on one hand, the falling consumption by the aging population creates lower number of jobs and on the other hand, deteriorating government finances force the taxes upward and the quality of social welfare downward. With falling or stalling national income growth, the income levels for immigrant workers also come down and become less lucrative when viewed against the income levels in their home countries. In such a scenario, the immigrants will be less willing to move to the developed countries. An anecdotal example here – when US was a country with young people, consumption of cars was very strong and the jobs with the car manufacturers were well-paid. As US population is aging, the car-manufacturer type jobs are vanishing and there is growing demand for jobs like caretaker for the elderly, which happen to be not-so-well-paid jobs. There was a time when a joke was very popular – "Why doesn't Mexico win medals in the Olympics?" "Because whoever can run, jump or swim has already done so to get into the US!" This year has marked a turning point in that trend and the flow of Mexican immigrants into the US has reversed for the first time. If and when the immigration into US and other developed countries stops completely, the rapid aging of the local population will be a root cause.

This is where the relevance of the anti-aging research we discussed in part 2 comes in. if the healthy life is prolonged, the elderly people will remain fit even at the age of hundred and will be able to work and consume various goods and services just like the young do. There is an unprecedented need today to channelize government and private resources into anti-aging research and quickly achieve breakthroughs that can be applied to this Grey Tsunami.

Chapter 3.3: The Future of Jobs

'I'm looking for a job where I am politely ignored and left to my own devices… with unlimited Internet access, doughnuts and coffee.' – Anonymous

About four years ago, Foxconn founder Terry Gou had announced that one million robots (he called them Foxbots) would soon be working at the Foxconn factories building iPhones and iPads and will replace more than a million-odd human workers then employed in the factories. Today the number of Foxbots working in Foxconn factories is about fifty thousand; far less than the million envisaged but the trend is confirmed. Robots are not experimental toys in the laboratories anymore, they are good enough to come out of the labs and grab jobs from the humans.

Of course, there have been many such proclamations about job losses caused by machines and they never came true till now. First such fears started circulating in Britain during the industrial revolution in eighteenth century. A youth named Ned Ludd supposedly smashed two stocking frames in 1779 to protest against the job losses caused by mechanized stocking frames. After this, textile workers started destroying industrial machinery with such fervor that an act called Protection of Stocking Frames, etc. Act (1788) was passed by the parliament. Such anti-mechanization protesters came to be called Luddites. Even today we find Luddites amongst ourselves who preach control on deployment of robots so as to save human jobs. In this chapter we will try to find out if humans will be able to save their jobs against the onslaught of the ever more capable robots this time.

Humans are inherently lazy and use their God-given brains to figure out ways to reduce the workload. This process drives technological development and results into inventions and innovations which then affect the nature of jobs that humans do. For example, about a hundred years ago, 30% of US work force was employed in agriculture whereas today it is just about 1% of total work force; the reason is purely the development of machines which can work tirelessly in the fields without heeding the Sun or the wind. Where did the farm-workers go? They went to the cities where more employment opportunities were opening up. Cities were becoming centers for industries making goods like fabrics and garments, metal objects, machine tools, chemicals, glass, paper, etc. and this is where the farmers sought work.

Moreover, manufacturing clusters always create opportunities for service jobs like tailor, laundryman, barber, repairman, plumber, etc. Typically each manufacturing job creates about 1.4 service jobs and hence when the developed world was growing through manufacturing boom, the service sector was outpacing manufacturing; today more than two third of the national income is contributed by services sector for any developed country. Technological innovation reduced human labor in each job and destroyed some of the jobs completely but there was always something new to do. When one industry collapsed, another industry picked up in its place and provided employment. About a hundred years ago, when horse carts were the primary medium of travel within a city, it used to provide a lot of employment to various people – right from the cart driver to the person cleaning the horse manure from the streets. When these horse carts started getting replaced with cars, there was a lot of hue and cry about job losses (just like the recent protests of local cabdrivers against Uber – history repeats itself!). But as the automobile industry settled down, it started creating lots of new jobs – right from drivers to mechanics and even traffic police! So the opposition died slowly.

What seems different this time is that machines are evolving at an unprecedented speed. In Part Two of this book, we saw how machines are becoming as intelligent as humans and we discussed the prospect of Singularity where machines will achieve SuperIntelligence. In last few decades, computers have eliminated jobs like telephone operators and airline ticket booking staff. The key reason was the drastic fall in computing cost and that trend of falling cost continues vigorously even now. Today new autonomous machines are replacing the current combination of humans and (relatively) inferior machines in many industries. Soon machines would gain enough intelligence not only to fix themselves when broken but learn from their experience and modify themselves (like adding components) as the given task would demand. So it is quite likely that as old jobs are destroyed, new jobs will become available but… for better machines and not for humans. Already we are seeing jobless recoveries all over the world; each recession is causing loss of thousands of jobs but each recovery is not bringing those jobs back due to economic pressures. An anecdotal example I read about the US oil industry mentioned that before the recession, each company executive used to have a personal secretary and now after the recession, executives share only a small pool of secretaries. This is nothing

but a jobless recovery with few people managing more work with the help of efficiency enhancing machines.

In coming decade, product innovation and use of new manufacturing technologies like 3D printing and robotics will cause a large human work force reduction in product industries. Innovations in services design and distribution and use of artificial intelligence will cause a large human workforce reduction in service industries. Let's look at the exhaustive list of professions compiled by the US Bureau of Labor Statistics (US BLS) and using our knowledge about automation let's try to figure out the professions which will lose out to automation and which will hold out. As per BLS list of occupations that will create maximum jobs in future, the occupation of healthcare assistance stands out. This includes sub-categories like personal care aides, registered nurses, home health aides, nursing assistants and practical & vocational nurses. Given the rapidly aging nature of our society and the prevalence of lifestyle diseases like diabetes, high blood pressure and heart ailments, it stands to reason that there will be demand for people in patient care. The key characteristics of these jobs are that they require frequent interaction & deep involvement with the patient, ability to assess situation & take action and need for compassion & patience but not very rigorous educational qualifications. Even though Japanese scientists have developed robots for nursing jobs, the skillset mentioned above is very difficult to program into a computer (at least in the near future) and given the relatively low wages in these occupations, automation does not make much commercial sense. US BLS is right in projecting these segments to be the biggest job creators going ahead.

BLS projects 'retail salespersons' as a major job-creator but given the strong trajectory of e-commerce players and the rising tendency of people to shop online, the typical brick and mortar retailers are finding it difficult to meet the rent and salary expenses, let alone make profits. To me, it seems like a difficult road ahead for retail salespersons. Another category that BLS mentions as top job creator is 'food preparation and serving workers'. Remember the automated order-taking machines now being installed in McDonald's and the automated burger making robots, cocktail making robots and serving robots we discussed earlier? It puts a question mark over the future of humans currently doing these jobs. Truck-drivers and freight movers are two categories featuring in the top-20 list of BLS. It is true that

the recent technological progress in global procurement, rising global trade and efficient logistics systems have led to many new jobs in the logistics industry. Last mile delivery requirements of the likes of Amazon have added to jobs in the local delivery segment. Almost 800,000 people in the US alone work in logistics related jobs today. But a lot of these jobs in warehousing and transportation will be lost when autonomous warehouse robots (like those by Locus Robotics) and self-driven trucks are deployed and that's possible within next five years. We have already seen Google Cars and other self-driven cars already on their way to decimate cabbie jobs. Now a self-driving truck named Actros, developed by Mercedes, is making trial runs on Autobahn. Truck-driver jobs in city transportation are not the only ones under threat from automation, it's also the truck-driver jobs in the mining segment. Rio Tinto, one of the biggest mining company in the world, already has 69 driverless trucks operating 24 hours per day, estimating a saving of 500 work hours per truck per year. It is also experimenting with unmanned trains and robotic drilling systems to automate its mining operations. Automation technology is spreading like wildfire – artificial intelligence based newspaper reporter program named Dreamwriter (made by Tencent in China) may one day make human reporters obsolete. Dragon TV, a news station in China, has already started using Xiaoice (pronounced shao-ice, a computer program developed by Microsoft's AI team) that delivers the weather forecast in a female voice, without any human intervention. The garbage collection robots created by Volvo may one day make even the human garbage collectors obsolete. The Ponsse Ergo timber harvester – a machine that converts a fifty foot tall tree into piles of neatly cut logs in just 20 seconds will make human woodcutters obsolete. Customer service representatives are getting replaced with automated voice response systems. Janitors are getting replaced with automated cleaning robots. Even armies and militaries will see job losses. First there will be focus on lowering number of troops (to cut down on budget) and building capability in operating advanced machines like drones. Later, as the probability of armed conflict diminishes either due to countries becoming more docile or due to the warfare shifting to economic and cyber channels, the number of human troops would be curtailed further.

Jobs like construction workers are difficult to automate due to task flexibility and physical dexterity needed in these jobs but they are still not safe from technology. Innovations in sharing assets (like sharing car rides through Uber and sharing houses though Airbnb) will improve utilization of existing assets

and diminish demand for new assets (like new car factories and houses). This will lead to lower demand for workers in construction and allied activities. Managers, office clerks, accountants, secretaries, carpenters, childcare workers and maids are the professions that make up rest of the top-20 list of the BLS. These jobs are also difficult to automate but intelligent systems will cause the demand for these type of workers to crawl down every year. Recent advances in Big Data, meaning use of computers to sift through loads of data and pick patterns is threatening some of these jobs. The advent of Big Data is finally making it possible to computerize many of the non-routine cognitive tasks. Translators have been in great demand due to rising global trade and the diversity of languages in the business circle, right from English, French & German to Chinese, Japanese and everything in-between. Computer based translation programs developed through Big Data analysis are becoming so effective and cheap by every year that very soon they are likely to make translators obsolete. You have already been introduced to IBM's Watson supercomputer. Oncologists at the Memorial Sloan-Kettering Cancer Care Center are using Watson to sift through 600,000 medical evidence reports, 1.5 million patient records & clinical trials and two million pages of text from medical journals and come up with cancer treatment diagnostics for new cancer patients. Symantec has developed a software called Clearwell that can sift through legal documents, grasp legal concepts, can arrive at useful results and present the results graphically. Given the fact that it is capable of analyzing and sorting more than 570,000 legal documents in just two days, you can imagine how thousands of paralegals might lose their jobs when this software is put into wide use. The story doesn't end with office-work automation; General Electric has in fact developed robots to climb and maintain wind turbines! If we imagine putting all jobs in the form of a pyramid with the rare, highly skilled, high earning jobs at the apex and the numerous, manual, low wage jobs at the base then we find that job losses caused by mechanization and computerization begin at the middle of the pyramid and will reach the upper and lower levels at different speeds. A research report named 'The Future of Employment' by Frey and Osborne gives a useful framework for estimating the vulnerability of any job to the threat of automation. This framework considers three factors viz. social intelligence, creativity and perception & manipulation. Example of a job with very low social intelligence will be a launderer and the chance of automation in such a case is very high. A public relations consultant, on the other hand,

exhibits very high social intelligence and the chance of his job getting replaced by a machine in near future is quite low. Creativity required is very low for a data entry operator but the creativity required by a fashion designer is very high. The first can easily be replaced by an intelligent machine but the chance of a machine replacing a fashion designer is certainly lower (though, just to be fair to machines, I must mention two programs, Iamus and Melomics109 developed by researchers at the University of Malaga. These programs can 'create' music that, as per blind tests, is as good as the music created by human composers). Perception and manipulation is the third part of the framework. A telemarketer and a surgeon are at two extreme ends of this parameter and you can imagine which one is at higher risk due to impending automation. The authors conclude their report with the estimate that 47% of US employment today is facing high risk from machines in the near future. Separately, a report by McKinsey Global in 2013 estimates that sophisticated algorithm based systems can eliminate about 140 million knowledge worker jobs in this world. We can conclude that if we are looking at next one to two decades very, very few jobs that we see around us today are going to stay the same.

A trend of jobs with lofty job titles but without any meaningful work or pay involved is spreading throughout the world already. David Graeber, Professor of Anthropology at London School of Economics and one of the leaders of the 'Occupy Wall Street Movement', had written an article in 2013 named 'On the Phenomenon of Bullshit Jobs'. His most biting remarks include: *"Huge swathes of people, in Europe and North America in particular, spend their entire working lives performing tasks they secretly believe do not really need to be performed. The moral and spiritual damage that comes from this situation is profound. It is a scar across our collective soul. Yet virtually no one talks about it."* He talks about how the famous economist John Maynard Keynes predicted in 1930 that by the year 2000, technology will be so advanced that people may be working for just about 15 hours a week. Technology has indeed advanced and automation is indeed being done, but the work-week hasn't shortened. I am not talking about the investment bankers and lawyers who clock 60 hours a week; even the most mundane jobs today require eight hours at work for five days. Most of these jobs involve more paperwork, more maker-checker systems, more administrative work, more auditing, more legal requirements and more compliance requirements than ever before. As can be seen from employment data

records, over last hundred years, farmers, servants and factory worker jobs have been replaced by new professions like telemarketers, pizza deliverymen, etc. but the administrative jobs have grown even faster than service jobs, as per Graeber. Jobs like accountants, professionals, consultants, technical support, managers and clerks come under administrative jobs. These jobs and the extra processing steps they add to a company's functioning are, to some extent, required at the large companies to control operational risks and frauds but it is not helping the output of the company and the employees. Another reason is that today's office jobs are more knowledge oriented and their intangible nature makes it difficult to measure the employee output effectively. The time required to build a certain piece of software code or to analyze a new business proposal is difficult to quantify. The person in charge of such knowledge workers has no way to decide who is contributing at full capacity and which employees are slacking off. So other parameters like attendance, personality, presentation, communication skills and being on good terms with bosses and colleagues start gaining prominence and start affecting employee's career progression. That is one reason why the talented and capable people are now getting out of the unproductive, stifling systems set up by the behemoths and joining small companies or start-ups where they can do some real work. Why are the rest still sticking there? The corporate jobs are mundane and intellectually unsatisfying but there are some undeniable benefits: real wages for today's clerical workers are far higher than they were for manufacturing workers a century ago, and secondly, the work, though boring, is not unpleasant. Administrative workers get to sit down in air-conditioned offices, tweeting, messaging, browsing the net and playing games at times. You should see the flow of messages on some of my WhatsApp groups – the eternal flood of comments on everything from politics to sports and tens of jokes makes me wonder whether some people really deserve the salaries they get if they spend most of their workday in messaging. Some countries have realized this and started taking action. France now has a 35 hour workweek, Sweden has moved towards 30 hour workweek and many other Nordic countries allow employees to work part-time. The expectation is that the employees can be in office for lesser amount of time but work diligently, then go home to their families and have a good time or join a gym or a music class or pursue other hobbies. This is expected to make the employees feel more satisfied and content with their lives and will improve the social fabric. In a few years, the 15 hour workweek

predicted by Keynes might finally become a reality, who knows?

The trend of job losses has another silver edge. The research paper named ‘Lousy and Lovely Jobs’ by Goos and Manning mentions a three-pronged trend in labor market polarization – middle income routine jobs vanishing, low income manual jobs sustaining and high-income cognitive jobs flourishing. The supply of educated workers is increasing but the demand for education has fallen in many jobs. This is causing some well-educated workers to move down the employment ladder. An example of this would be a college graduate taking up a job as a waiter or bartender. Less educated workers are moving further down the employment ladder and the least educated are being thrown out altogether. But the workers who are able to keep their jobs in knowledge industries are experiencing that the nature of jobs is shifting towards more intelligent work. General Motors employed 840,000 workers in 1979 for $11 billion profits whereas in 2012, Google employed 38,000 employees (less than 5% of GM) for earning $14 billion profit. You can imagine the change in the nature of work, the educational qualifications required and the type of involvement and output required – these have changed vastly during the three decades. Nowadays a company is not valued using the plant and machinery it owns but on the basis of the intellectual capital it owns. When Google bought Youtube, it had 65 employees and Google paid about US$25 million per employee. When Facebook bought Instagram, it had 13 employees and Facebook paid about US$77 million per employee. When Facebook bought WhatsApp, it had 35 employees and Facebook paid $345million per employee. This is the power of technology and human intellect. In coming decade, the number of people employed by each of such ‘knowledge’ companies will be very low but the quality and compensation for their intellect would be humongous. Many employees in new-age companies today own significant stock options and are worth millions already.

There is a logical reason why governments are hell bent on creating jobs. In the chapter on social welfare, we discussed that providing ‘breads and circuses’ to the citizens has almost always been on every government’s agenda. Once the ruler class, the capital owners and other upper classes of the society take away their share of the income generated in the economy, the lower classes are left with small incomes and a rising social inequality can lead to a revolution. Logically, revolution is any government’s biggest fear.

What is the sure-shot way to pre-emptively deal with a revolution? Provide jobs to people! This works in two ways – first, it gives people money to take home and feed their family. Second, and possibly more important aspect is that if working age people are actually working from morning to evening, six days a week then they will hardly have any time left to plot revolution. In some autocratic societies, there have been examples of projects like constructing a state-of-the-art airport in a remote village which, prima facie, don't make any economic sense. But the reason behind undertaking such projects is to create employment, meaning to keep the young population (coming into employable age bracket) occupied with work so that they would not have the time and energy left to attempt a revolution. In coming decades, as we discussed already, the costs of providing food and basic amenities will fall precipitously and the chances of empty stomachs causing a revolution would diminish drastically. This would be another reason for governments to *not* worry about creating jobs at the cost of executing projects that don't make economic sense. Governments will strive to provide basic needs; some governments may go one step ahead and may take up the onus of servicing the self-esteem needs of its citizens and provide them with some lofty job titles but without any meaningful work or pay involved. Even today we find governments trying to save jobs for their citizens. Since the big recession in 2008, governments all over the world have become very protective towards domestic industries and domestic jobs. Various measures have been adopted to save jobs and they include bailouts or state aids to failing companies, anti-dumping duties, countervailing duties, higher import and customs duties, non-tariff barriers under the guise of safety, environmental and other reasons. These harsh measures have succeeded so well that global trade has dried up and the trade barometer called Baltic Dry Index is at an all-time low. The irony is that such protectionism helps in keeping prices of goods and services higher in the economy and it actually channelizes money into the hands of domestic companies, which may be the ones cutting jobs through automation in the first place! I think the governments have to throw in the towel in this fight. Governments and each one of us should realize that any battle against the automation technology is a losing battle; like Victor Hugo said, "No army can stop an idea whose time has come". This realization will call for a sea change in government policies on creating jobs. Rather than spending the budget, time and energy on creating and maintaining various jobs in the industry, the governments all over the world should encourage policies of

more automation in all industries, resulting into sharply lower cost of all basic amenities. Once jobs are out of the governments' focus area, they will be better able to focus on social welfare (as we discussed in earlier chapter) and develop policies for the vast pool of unemployed humanity. Obviously, such great unemployment will have a big impact on the economy and we will discuss that in detail in a later chapter.

Chapter 3.4: Savings Tsunami

When the lodge meeting broke up, John confided to a friend. "Mike, I'm in a terrible pickle! I'm strapped for cash and I haven't the slightest idea where I'm going to get it from!" "I'm glad to hear that" answered Mike. "I was afraid you might have an idea you could borrow it from me!"

In last three chapters, we discussed the three biggest trends in the society today viz. higher level of social welfare, aging population and obliteration of jobs. The fourth megatrend that the world is likely to experience is a global savings glut. The world will see a great increase in savings by the world population in the future, as against consumption which has been the preferred option till now. The simple reason behind this is the combination of rising incomes and aging population.

Imagine a person who has just recently taken up employment and started earning a salary. It would be logical to assume that he will have less income initially and most of it will be used towards consumption, which can be food, rent, entertainment, travel, healthcare and various other things. So it is quite possible that the person will end up with miniscule savings in the initial years; in fact, if he is having a large education loan he may end up with negative savings (meaning taking temporary loans from family, friends etc.) But with advancing age, his salary would increase and the expenses will hopefully not rise so much; after all, he is not going to buy four TVs and consume four times the normal food just because he can afford it now. Thus he should end up saving some money. Savings increase with income and the people with highest income will end up saving the most, as proved by research in various countries.

The global economy is going through the same curve of higher income and stagnant expenses. About three centuries ago, the industrial revolution brought in a new age with higher productivity, more production, invention of new products and services and more jobs which started improving the income in the western world. The industrialization of China that started about five decades ago and the economic liberalization of India that started about two decades ago had a similar impact on the lives of billions of people living in China and India. There is still poverty in many pockets in the world but with better growth, technology and welfare schemes, the demon of poverty is slowly being defeated. With rising incomes, many economies are

experiencing rising savings, just like the salaried person in our earlier example would go through. Also, we have already discussed in an earlier chapter about how the world population is aging rapidly due to rising lifespans and falling fertility rates. As discussed earlier, the elderly and the young tend to have vastly dissimilar tendencies when it comes to consumption and savings and hence there is a double whammy on consumption and the savings are growing rapidly.

In future, I see a third factor coming majorly into play and boosting savings further. Keeping in mind that saving is income minus consumption, any factors that reduce consumption expenditure will, by default, increase savings. And I mean lesser consumption expenditure not because people will consume less quantity but the cost per unit itself will come down. I feel the cost of production of goods and services will keep on coming down drastically due to betterment of technology, rising competition across the world and cost cutting in salaries (as most of the work will be automated). The simple fact is that in any industry, once the product's novelty phase accompanied by low competition and pricing power is over and competition comes in, the focus shifts to reducing costs and passing on the cost savings to the customer so as to grab a larger market share. Today, I find three things happening simultaneously. One is that most of the consumer products have long been invented and commoditized. I am not saying 'everything that can be invented has already been invented' and I sincerely wish mankind to continue inventing and innovating but recent advances in consumer products are only incremental (we can't consider a 'pet petter' machine or a 'snowball maker' machine as great inventions of twenty-first century). Secondly, for most of the consumer products, competing companies have been putting in great efforts in terms of money and manpower to optimize the product and production process and to reduce costs in general. The humongous price fall in items like TV and smartphone and many other items that we saw over the last decade was a result of this process and it should continue for the foreseeable future, as competition is increasing every day. The third factor is the increased communication between engineers and innovators, not just within a city or within different departments of a company but across the globe. This is helping in spread of ideas that worked for one product or geography to be immediately tried and improvised by engineers across the world. This force is very potent in bringing the costs of products down much further.

Let us have a look at the key components of household spending globally. These are: rent, fuel, water and electricity (about 10-25%), food (about 10-30%), transportation (about 10-20%), recreation (about 1-10%), healthcare (about 2-20%), restaurants and hotels (about 3-8%), clothing and footwear (about 3-10%), furnishings (about 3-7%), communications (about 1-6%), alcohol & tobacco (about 1-8%) and education (about 1-6%). The percentages in the brackets are the spending on these items as a proportion of household income. Fuel, water and electricity costs will inch down in coming years as solar power makes new strides. New food production technologies we discussed will improve yields and bring down prices. Better storage and transportation technology will bring down wastages in perishable foods like fruits and vegetables and this will tantamount to great cost savings. Transportation costs will come down when solar or battery powered, self-driven taxis, supported by metros and battery powered buses become the norm worldwide. Healthcare, as we saw, is a sector where suppliers have great pricing power but with advances in data analytics for patient diagnosis, advances in stem cell therapy and preventive maintenance based on genome analysis, healthcare costs can move downwards. Increased competition through e-commerce portals are bringing down the costs for hotels, clothing, footwear and furnishings. In the field of education, open online courses, like those offered by Khan Academy are resulting in great savings for the students across the world. Increasing spread of microfinance institutions all over the world is making cheap loans available to small traders, farmers and entrepreneurs which were hitherto dependent on usurious moneylenders for their working capital needs. The falling cost of finance for these traders, farmers and entrepreneurs is expected to flow to their customers through lower end-product prices. Overall, there is little doubt that household expenses would fall substantially in the future and savings would grow.

In any economy, there are three segments that can consume or save as the need may be and these are individuals, corporates and the government. We discussed how individuals' savings will shoot up in coming years. The expenses incurred by corporates are under two main categories – operating expenses (like salaries & wages, raw materials, sales commissions, distribution expenses, insurance, etc.) and capital expenditure (like investments into new offices, buildings & factories, plant & machinery and other supporting infrastructure). Governments also incur operating expenses like salaries, pensions, subsidies, interest on debt, etc. The key item is

government spending in the nature of capital expenditure and traditionally this has been huge because in many countries governments build and own public infrastructure like highways, railways, ports, airports, infrastructure for oil exploration & production, water purification and distribution, canals and irrigation projects, hospitals, affordable housing projects and many more. Each of these is a big ticket item, running into millions and sometimes billions of dollars. In some countries the government has passed on the business of building and owning assets to private companies due to change in ideology (like 'owning assets is not government's business') or due to financial strain. The capital expenditure was incurred by the governments either to improve the living standards of the existing population or just to cater to the increasing requirement of the ever increasing population. In last three hundred years, governments world over have spent trillions of dollars in infrastructure. How much of it leaked out to enrich the politicians, bureaucrats and contractors involved is anybody's guess, but not the topic of discussion for this book. The topic is this – we are nearing the end of spend on infrastructure – on the government side and also on the corporate side and very soon governments and corporates will join the individuals in massive savings.

The investments into projects and infrastructure would reduce drastically as the currently existing and planned infrastructure might become quite sufficient within a decades' time due to adaption of new technology. New business concepts such as Uber and Airbnb are targeting better utilization of existing infrastructure like cars and houses through efficient sharing. This would have a negative impact on the demand for new cars and houses. Due to data communication costs coming down, corporates have already shifted from audio conference calls to video conference calls and may soon shift to holographic conversation. Once that becomes common, the need to travel for work, whether intra-city or inter-city, would reduce drastically and hence the burden on roads and airports would be much lower. Technologies like virtual reality may make business travel and tourism both obsolete (programs like Google Expeditions Pioneer Program will let you get a realistic experience of African jungles or coral reefs or Machu Picchu temple through your VR headset sitting right in your living room). This will further curtail demand for transportation. If one wants to travel still, then self-driven taxis and other efficient public transport concepts will be there to unburden the existing roads. Urbanization may remain a big trend over next decade, especially for

developing countries like India but with new technology like 3D printing even that would not require too much material or labor. Much of the urbanization expenditure will be for affordable housing for the weaker sections of the society where the designs are standard and buyers have less say. New manufacturing technologies like 3D manufacturing may diminish the current structure of one country producing everything and shipping it to customers all over the world. Hence the load on ports, roads and railways should come down. The impact of lesser transportation demand is two-fold. On one hand, lesser load on transportation infrastructure will reduce the need for future spend on the same. More importantly, fall in demand for petroleum based fuels will reduce the need to spend on building costly deep sea oil exploration & production platforms and refineries. As you must have noticed, cars, houses, roads, ports, airports, oil production platforms, refineries, etc. require humongous amounts of steel and other metals. Mining and metal-work industries are one of the biggest industries today and their demand will come down as the demand for infrastructure comes down. Additionally, metals in various applications will be replaced by other materials. For example, traditionally transportation industry has been using lots of minerals. Vehicle bodies were made from steel which ultimately came from iron ore and coal whereas fuels and engine oils came from petroleum. With rapidly accelerating research and development in the transportation sector, we already see the steel content in vehicles falling drastically, leading to superior fuel efficiency. Thus the demand for all these minerals is on its way down. I agree that some of the fall in steel usage is made up by vehicles having more aluminum and plastic parts which are also mineral in origin but there are indications that even these will soon be replaced by new materials such as carbon fibers and graphene which can be non-mineral in nature. This trend, combined with other factors mentioned above, will mean that industries like iron ore and bauxite mining, manufacturing of steel and aluminum will slowly shrink with time. The boom in metals and mining caused by China’s massive infrastructure creation drive from roughly 1990 to 2010 is unlikely to be repeated. As per a report by Standard & Poor’s on global capital expenditure from 2003 to 2013, almost 60% was in the areas of energy and mining. As of now both these segments are down due to oversupply and doubts over recovery in demand. The capital expenditure in these two segments has come down and that is affecting the equipments providers and ancillary service companies as well. Big companies like Schlumberger,

Halliburton, Caterpillar, etc. are experiencing eroding profitability and weakening future outlook.

Another big contributor to capital expenditure plans of governments and corporates is putting up power plants. In growing economies, increasing incomes, increasing mechanization and increasing power consumption go hand in hand and leads to the need for more and more power plants. However, it is likely that with better infrastructure sharing, power efficient equipments, power saving apps and the shift to more solar power, the expenditure on non-environment friendly power sources like coal based power, nuclear power, hydro power would come down in the coming decade. Corporates may not need much office space if employees are allowed to work from home. Many corporates may not need even factory premises if they shift to ‘distributed manufacturing’. Under this concept, as soon as a consumer buys a product online, the delivery truck starts for the customer’s address. It carries a 3D printer and the required raw materials. The product is manufactured in the 3D printer inside the truck while on the way to the customer’s address! This has not yet happened but looking at the progress in 3D printing, there is no reason why this will not happen quite soon. Or if you want a completely wacky prediction, an all-purpose 3D printer will one day become so versatile and so cheap that we will all be having one or more at our homes and will be printing everything from pants to pizza to a basketball using those machines and shopping will become unnecessary. Whichever option you prefer, it will involve extinction of many factories in near future. All these trends underline the same point that the capital expenditure will be very low in coming decades, both from the government and corporate side and this will lead to big savings.

One may argue that expenses will be down but incomes will also be down and hence savings may not be as large as predicted. If most of the people lose jobs to automation then they will not have salaries and they won’t pay any taxes to the governments. If companies have lesser demand for goods and equipments then they will not have much income and they won’t pay much taxes to the governments. In such a scenario, the fall in income will lead to lower savings for the individuals, companies and the governments. This is an uncharted territory for traditional economics and there is a clear need for some economists to research and create some pioneering models. To my mind, the overall global production and consumption are expected to grow

slowly and not de-grow from here. The patterns of consumption are changing but consumption is not dropping. We will not use roads but we will use videoconferencing equipments which will need to be produced. We will not use metals but we will use graphene which needs to be produced. So there will be companies which will earn revenues and pay taxes to the governments. Jobs will be lost to robots and the people on social welfare will not make tax payments. But governments will be able to tax the rich which will be earning returns from capital (for example, the dividends from their investments in various companies). The governments will also start earning taxes from what has hitherto been the black portion of the global economy. With increasing ease of tracking money transfers, black economy (which has been as high as 50% in case of some developing countries) will start shrinking rapidly and would boost governments' income ledgers. Governments (especially the large ones, in coordination with each other) will be able to clamp down the flow of money into international / untaxable territories. Acts like Foreign Account Tax Compliance Act (FATCA) in US would become increasingly common across the globe and tax havens would find it increasingly difficult to stay in the business of hiding money. Lastly and most importantly, the fall in expenses will be humongous compared to the fall in income due to a super-cycle of technological breakthroughs, as we discussed earlier. In conclusion, I think the savings from individuals, governments and corporates will balloon in coming decades.

The problem with savings is that savings go into various investments including various financial instruments and into real assets like gold and real estate. The masses world over have been making financial investments for social security which may not be required anymore. Typically the middle and low income groups in the society make financial savings for the emergency fund requirements and for retirement expenses. In developing and underdeveloped countries financial inclusion is poor and social security is weak. This means that loans would not be available to a poor person because of his weak or non-existent credit history – even if this emergency funding requirement is for just causes such as treating a family member who had an accident. These people also get very meager pensions from their employers post retirement and these are not sufficient to meet their retirement expenses and more importantly, the rising healthcare expenses during the retirement age. If, in the future, the government takes the onus of fulfilling basic human needs of every citizen for free then the masses would not need to save for the

emergency requirements (as the government will bear the expense for treating accident victims) and neither would they need to save for retirement expenses (as the government will provide all the basic amenities).

Traditionally most of the financial savings went into banks and banks lent to the retail borrowers, governments and companies. Governments and companies took loans from the banks because they needed to invest in long term projects like building factories, roads and other infrastructure and they did not have the requisite amount of money available upfront. As we discussed, we are becoming more efficient through use of technology and will not need big infrastructure for growth. Capital expenditure will collapse in coming decades. As governments see fall in regular expenditures (like healthcare) and capital expenditures (like building roads and railways) the need for raising money from the markets or banks through government bonds would diminish. Government bonds are the largest financial instruments in the world today and hence the fall in supply of these will be staggering for the financial markets. Even corporates would issue lesser bonds for the purpose of funding project expenditures.

If savings are rising but the bonds supply is falling, either the interest rates on the bonds have to come down drastically or the money has to go into real assets or find new investment avenues. In today's world each of these is happening. The interest rates on bank deposits have come down to zero in many countries and even negative in some European countries (meaning if you save and put money into the banks, there is a penalty now). In some Nordic countries today, banks pay you if you take a mortgage. Many government bonds in Europe and Japan trade at negative interest rates – for example, an individual or a bank can put money in three year German government bonds and be assured of losing money if they hold the bonds till maturity. A better idea would be to withdraw cash from your bank and put it under the mattress because unlike the bank deposit, cash will not lose its value. But there are two problems with this idea – one is that this idea is not scalable. A big investor or a big bank cannot hold onto a large pile of cash – it will require elaborate security setup with a vault and guards which itself will cost money. Secondly, many governments are encouraging a shift away from paper money to electronic money. The spread of internet banking, mobile payments, online and offline credit and debit card payments is already overtaking the use of cash. Today the common man uses cash mainly for

purchasing small ticket items but there is a big class of people who find cash convenient for illegal activities. By banning cash altogether, the governments can kill two birds with one stone – win the battle against illegal activities and allow negative interest rates in the economy. Andy Haldane, the Chief Economist at the Bank of England has recently talked about the need to explore negative interest rates to fight the upcoming recession and the need to abolish cash in order to properly enforce the negative interest rate regime.

Low interest rates and very few investment opportunities might make ‘asset bubbles’ a regular feature of the financial markets in coming decades. If bubbles become common, some investors might be willing to pay extra premium for supposedly risk-free assets like government bonds and that, in turn, can bring down the interest rates further for the government bonds. Government debts may come down due to lower capital expenditure needs and near zero or negative interest rates will certainly help the governments in reducing the interest payments on the outstanding debt. This will put the governments in a better position to focus on social welfare. There are some very interesting possibilities arising out of a massive wave of savings searching for investible assets and we will discuss those in later chapters.

Chapter 3.5: Secular Stagnation

'The economy is so bad, even hot cakes aren't selling like hot cakes anymore.' – Anonymous

By now we have discussed four clear trends for future – better social security, aging population, elimination of jobs and savings glut. The biggest and most worrisome impact of these trends is the slowing of economies across the world. Estimates on global economic growth, published by premier agencies like the World Bank and IMF have been trending down every year. The world may be moving towards a condition which economist have taken to calling as Secular Stagnation.

Secular Stagnation is defined as a condition where an economy grows at zero or negligible growth rates. Some economists opine that the key reason for secular stagnation will be the excess of savings over investments (into productive assets through capital expenditure). As we discussed in the last chapter, we are bound to see investments falling sharply and savings to exceed investments drastically in the coming decades. Slowing economy also means slowing production, slowing consumption and falling prices of goods and services. If the phenomenon of rising prices of goods and services is called inflation, the phenomenon of falling prices of goods and services is called deflation. Economists who are worried about secular stagnation are also worried about impending deflation. Falling prices entice the consumer to postpone his purchase because that item will be available cheaply at a later point in time. It is a bit like buying a mobile phone; the more you wait, the better model you will get for the same budget. A consumer may think the widget costing 100 dollars today will be costing, say, 99 dollars next year so he would have put his 100 dollars in a bank for a year and next year he would have got maybe 101 dollars from the bank, bought the widget for 99 and have 2 dollars in profit, too. But the problem caused by the customer deferring his consumption is manifold – lower consumption means lower production, the economy will grow less because less goods are produced, the companies selling the products cannot grow their profits, the factories remain underutilized and hence there is no incentive to put up new factories which would have generated demand for steel, cement, machinery, equipment, construction workers etc. and would have created so much more demand and so many more jobs in turn. Lower jobs, in turn, will mean lesser consumption

and continuation of the vicious cycle of stagnation. This is the reason why economists are extremely worried about deflation. This is one demon they want to fight and defeat at all costs. The negative bank deposit rates introduced by some European countries recently is a proof of this stance. The negative rates are to enforce the balance between savings and consumption in favor of consumption. If the 100 dollar deposit becomes 99 dollars by the end of the year (due to negative interest rates) and the widget costs 99 dollars, the consumer need not defer his purchase. That is the plan.

I think the problem of falling prices in the economy is not one-dimensional. One on side, the aging population will consume less goods and services and no amount of coaxing will make them splurge on things they deem unnecessary. Falling prices are also the result of technological breakthroughs that have drastically brought down the costs of materials, cost of production, administrative costs, marketing costs, distribution costs and other ancillary costs. Technology is not available to just the producers, even the consumers have access to it. Earlier you and I were at the mercy of the local companies or the local dealers of goods for the products we wanted. Today we can go online and check out prices and features to our hearts' content and order from the cheapest supplier without any hassles. This has squeezed the profit margins of the companies (producers) and it is the third reason for a continued price fall. The inflation or the price movements at the producers level is measured using Producer Price Index (PPI) or Wholesale Price Index (WPI) and these numbers are showing very weak trends everywhere confirming that the producer level prices are in a continued fall.

Labor has been a key part of the factors of production. Labor affects the economy in two ways – on one side, the salaries and wages paid to labor is a cost incurred and it increase the prices of products. Secondly, labor spend the same salaries and wages for consumption of various goods and services, propelling the economy ahead. With increasing automation in various industries, the bargaining powers of workers have fallen drastically and that is another reason for lower income growth in the economies worldwide. A study shows that between 1969 and 2009 there was a 28% fall in the US median male wages even though the economy did fairly well in the period (except for the oil shocks in the seventies). This trend is likely to strengthen going ahead and will cause lower prices and lower demand in future.

In his book ‘The Great Stagnation’, economist Tyler Cowen aptly describes the three low hanging fruits that US has irreversibly exploited viz. breakthroughs in agricultural production, rapid inventions in the first half of twentieth century and the improvement in productivity from educating children. This is very much applicable for many other developed countries and even the emerging economies in Asia, Africa and Latin America are expected to achieve these levels within a decade or two on back of faster spread of technology. As of now it is difficult to find any technological or socio-economic trend around us that can become as big as these three trends and give a new boost to the slowing economies.

But now a doubt arises – should we worry about economic stagnation? The world around us is increasingly exciting – we have new fashions and new gadgets every day. We have new arenas of entertainment and new stores of knowledge becoming accessible every day. We are increasingly dealing with our counterparts spread across the world and making friends from countries we didn’t even know existed. Life today seems to be certainly better than that in the last century or even a few decades ago. The world looks increasingly vibrant – then why the talk about stagnation? Where is the disconnect? The problem arises if we are looking at it from the viewpoint of GDP and GDP growth. Over last many decades and centuries, it is typically taken as a nice thing if a country is growing its GDP at a robust pace and there is a valid reason for desiring a good GDP growth. Assuming a decent population growth, a good GDP growth would mean a good per capita GDP growth. Rising per capita GDP growth has been associated with rising prosperity all over the world. The logic was simple – more production of products and services in the economy meant more job creation and more wages earned by these employees. More money in the hands of people would mean more demand for other goods and services and further job creation and wages. Corporates were earning more profits as the demand for their products and services was going up. These profits were given out to shareholders as dividends which would re-flow in the economy as more demand for goods and services. Or the profits were re-invested by the corporates in the business itself in the form of a new production facility or new office building. That in turn would generate employment and create profits for some other entity in the economy and the virtuous cycle of prosperity would continue. This is the simplistic model of the economy that worked for hundreds of years (albeit with booms and busts in-between). And given the fact that the common man

benefitted from this model over last few centuries and especially post the Second World War, it became the model to be emulated and GDP became the measure to be tracked without blinking an eyelid.

The problem, or the disconnect, arises when we are measuring social betterment via GDP and per capita GDP or the derived measure, National Income. Land, labor and capital are the traditional factors of production. Management i.e. the ability to efficiently manage these three can itself be considered as an additional factor of production but the concept is nebulous and has mostly eluded the economic theory. Also, for simplicity, let's consider land as part of capital then we have just two factors, labor and capital, to deal with. Income generated in the economy will be the return on investment i.e. the factors of production that went into generating income. So the return will be of two types – return on labor and return on capital. Historically, the labor and capital split in various economies is about 30/70. Return on labor is mainly in the form of salaries and wages to employees whereas return on capital is in the form of rent on land and buildings, coupons on bonds, dividends and capital appreciation in shares, etc. If Apple shares performed better than Google shares in a year, we would say that it was because Apple shares were more in demand, maybe because the company is expected to do well or for any other reasons. Similarly, there is no reason why the return on labor and return on capital have to be the same, the return will depend on what is more in demand. There have been periods in history when labor was in short supply, for example, after the plague in the fourteenth century or the World Wars in the twentieth century. In such scenarios, the return on labor was greater than the return on capital. Given the fact that labor is typically linked to lower classes of the society and capital is linked to upper classes of the society, it is easy to fathom that when return on labor is more than return on capital, wealth will flow towards the lower classes and wealth inequality will come down. When return on capital is more than return on labor, wealth will flow towards upper classes and wealth inequality will increase. Labor is not a stock quantity; it cannot be stored but only generated on demand. So to simplify matters, it would make sense to replace return on labor by the growth of economy, as done by Thomas Piketty. In his seminal book 'Capital in the Twenty First Century' he provides analysis of historical data in this regard. He says that the rate of growth of the economy (denoted by 'g') has typically remained lower than the rate of return on capital (denoted by 'r') throughout world history. During

second half of the twentieth century, it so happened that the rate of economic growth was better than return on capital and it led to falling inequality and emergence of the middle class. This also explains the real logic behind our deceptive assumption that growing GDP is good for improving prosperity for all. But he predicts the world will move back to the ‘r > g’ phase and the social inequality will increase in future.

Historically we have seen this happening – when humans were living in small groups some 10,000 years ago, all were equally poor. When groups became larger and social structure came into being for better management of the group, within a few thousand years, mankind reached the phase where Pharaohs were wearing gold masks and building pyramids. This became possible because as the human groups got bigger, the leader or the leading class of the group got the power to set policies regarding return on labor and return on capital. That is the key. We have discussed the inherent tendency of humans to accumulate resources including wealth and in my opinion, people cannot be faulted for amassing wealth for themselves and their children; it’s in our genes. At the same time, I am not denying that some people amassing disproportionate wealth puts other people at a great disadvantage. Now, given the fact that the moneyed class is typically the one with the power to set these policies, it is but natural to see this class setting policies that will encourage return on capital but restrict return on labor. The lower classes did not have the right to vote till very recently and so they had been at the receiving end of these policies and had to face a relative fall in income over prolonged periods. This led to intermittent revolutions all over the world (whenever the social inequality became unbearable). The French revolution which ended up introducing the royal family and all aristocrats to the guillotine was result of such policies on return on capital and labor. Today, we are in a tricky situation. On one hand the poor and the middle class can vote for getting favorable policies in their country. But due to advancement in technology and communication the labor and capital both have become fluid and can run across national boundaries in search of better returns. Due to automation, many of today’s labor might find themselves redundant within a decade or two and then the return on labor is likely to fall even more drastically.

And it is not just the return on labor that is falling. The return on capital, measured in terms of real or nominal rates, has also been falling for last many years (inflation causes the real return and the nominal return to be different. If

you earn 6% on an investment in a year but if the inflation is 4% then your real return is about 2%). The typical method for building expectation of returns from any asset is setting the risk free rate first and then add appropriate risk premium for the asset under consideration. Risk free rate is the rate of return you will earn if you take zero risk. In reality, there is no asset with zero risk so the next best option, the government bond, is chosen and return on a government bond is taken as the risk free rate. It is implicitly assumed that the government will continue to exist till the maturity of the bond, the government will not default on the money you lent them by purchasing their bond and there will always be ready buyers available if you feel like selling the bond. Any other investment (like bonds, stocks and real estate) may carry various additional risks like the risk of default, uncertainty of cash flows or inability to find ready buyers and hence you should get extra returns (called as risk premium) to compensate you for taking the extra risks. Various books and educational courses deal with the concept of actually calculating the right amount for premium for each type of risk and that is not the topic of this book. What is relevant for us is that the risk free rate and the risk premiums are both coming down. One reason is obviously higher savings chasing limited number of assets and we have discussed this point in detail earlier. The second reason comes from technology. Compared to the situation just fifty years ago, a lot of information is available today about every government and every company. If you invest in any financial instrument issued by these then you can keep a detailed track of the financial conditions of these and predict the chances of default much better. This has reduced the default risk premiums on many assets. Technology is more efficiently putting together buyers and sellers in any and every asset class; it can even find a buyer for my old cupboard. This has caused a fall in liquidity risk premiums on many assets. The net result is falling returns in many assets and investments and this shift is permanent in nature. There is another way to look at it. Any investor would want the asset to provide some real return over the prevailing inflation. Due to the factors we discussed previously, inflation (meaning the increase in prices of goods and services) is falling worldwide and hence the nominal return expectations have also been falling in line with inflation.

With that, let’s come back to the discussion of whether secular stagnation should be worrisome. Along with slowing growth in the economy, the return on labor and return on capital are both falling. The poor will face the problem

of vanishing salaries. The rich will face the problem of falling return on capital. People who are worrying about secular stagnation are worried about either the poor or about the rich or about inflation. The first type is hypothesizing that if the world economy stagnates, the poor will be devoid of salary and then devoid of food and other basic amenities and this will lead to a replay of the French revolution across the world. In my opinion, there is no reason for witnessing a replay of the French revolution if governments take action at the right time and ensure supply of all amenities to their citizens, which as we discussed, has become very much possible. The second group is worried that if the rich cannot earn enough returns on their capital, they may not remain rich. We will discuss the rich in greater detail in a later chapter. The third group feels that economic growth keeps a certain level of inflation in the economy and inflation helps the young earners reduce their debt burdens (like a mortgage, car loans, etc.) and come up in life. But today the problem is aging population which will not have many loans outstanding and hence the policymakers will not need to engineer inflation for them.

There is another reason why I am not worried about the idea of secular stagnation. It mainly deals with the idea of GDP not growing. Just like democracy is the best system available but is not perfect, GDP is the best way to express the production and consumption in any economy but it is not perfect. The biggest problem is that it fails to understand the concept of efficiency. If we spend two billion dollars to build an airport in a jungle which no one will use, the government's statistics department will not bat an eyelid in adding two billion dollars to the GDP figure. If people don't buy new cars but use existing fleet of cars more efficiently through use of an app like the Uber, their travel needs are still fulfilled but the GDP data will show an apparently worrisome trend in car sales. So it's clear that GDP fails to capture the difference between good growth and bad growth. The traditional measures of GDP fail to capture that new technology is causing prices to stagnate and costs to fall. Economist John Mauldin once wrote an article on the shortcomings of GDP where he raised doubts like how would one account for value accrued to common people by Google Maps? GDP measures can at best capture the advertising revenues earned by Google but the real impact on GDP can be multifold. A fleet owner re-routing his trucks on real time basis using Google Maps (avoiding traffic) might have the same revenues (or slightly higher if he undertakes extra runs using the time saved) but can earn higher profit through fuel saved. Another example is that of a person putting

up a rooftop solar power unit, going off-grid completely and not having to pay monthly electricity bills thereafter. What if that person used to employ a maid for washing clothes and utensils but has now purchased a washing machine and a dishwasher? Now there won't be any monthly payments to the grid or to the maid that used to get captured in the GDP earlier. The internet has revolutionized the culture of sharing data, media and ideas that end up boosting efficiency, savings and happiness levels for all participants. Unfortunately, none of these three are captured in the traditional GDP measures. The statisticians can manually add efficiency factors to correct the GDP calculations but most of the times such measures are too late, too little to be of any real help. We need to address real problems and not get misled by the illusory numbers. If every person is well-fed then nobody would worry about the agricultural GDP growth being 0%. But if people are dying of starvation, even a 10% growth has no value.

In conclusion, my view is that secular stagnation is quite likely to be a reality within a decade or two but we need not be too much worried about it. We and our governments need to focus on achieving complete social welfare at the earliest through the use of technology and that will prepare us for the uncertain, unknown future ahead.

Chapter 3.6: Today's & Tomorrow's Companies and Innovation

'If I had asked people what they wanted, they would have said faster horses' – Henry Ford

Dow Jones Industrial Average (DJIA) is a stock market index created in 1896 to keep a track of how the basket of the 30 best companies listed in US is performing. General Electric is the only company that was in that basket in 1896 and remains to be in that basket even today (it was out for a small period in-between). Other constituents of DJIA at that time were companies that did business in sugar, cotton oil, tobacco, coal iron, railroad, leather, rubber, etc. Those became smaller and smaller and eventually exited DJIA as these industries became commoditized and their share in the economy went down. New companies with new technology and innovative business models became large and entered DJIA. How did General Electric manage to protect its prominence and its place in the DJIA? Initially it was just into electrical equipments like electric motors, lighting fixtures, lamps and other electric devices. In addition to electrical equipments, today GE is present in various areas such as aircraft engines, finance, healthcare, locomotives, weapons and wind turbines. Awareness about the changes in the world and ability to innovate accordingly is what helped GE stay relevant in this dynamic world. In the future, faster technology and communication are going to make the world go even faster and today's companies will need to innovate swiftly and upgrade their business models on the go. For the simplicity of treatment, I am clubbing various activities like research and development, invention, discovery and innovation into one single term innovation. With that in mind, let's take a brief look at some of the present business models and some upcoming business models.

DJIA basket contains companies from growing sectors like financial services, information technology and healthcare. It still contains stocks from sectors like oil & gas, mining equipments and physical format retail that I think are at the risk of getting marginalized due to new technologies. Lower capital expenditure needs in the future will reduce the need for mining and mining equipments. Shift to solar energy will reduce the need for crude oil exploration and production. Online retail through mobile apps will obviate

the need for large, physical stores. Amongst the new business models, I am pretty impressed with Uber and Airbnb and we have already discussed how their business models of efficiently utilizing existing assets will lead to great cost savings for their customers. There are quite a few upcoming companies with disruptive business models that also deserve a mention here. These companies are spread across different segments – GoPro makes action cameras whereas Jawbone makes wearable products like fitness trackers. MongoDB, Palantir and Pivotal work in the areas of information processing, database management, data analytics, etc. Square and other start-ups work in the area of fast & secure mobile payments. Amazon and others offer cloud storage and cloud computing at very low costs so that new companies don't have to block capital in buying their own servers. Then there are messaging and sharing services like WhatsApp, Snapchat and Pinterest which fulfill the growing need of people to share thoughts, ideas, comments and pictures. Many start-ups have now taken up the financial intermediary role that was hitherto performed by banks and are finding worthy borrowers for lenders or arranging loans at peer-to-peer level. Ordering groceries, apparel, food and many other items is becoming so easy with all the new apps that brick and mortar stores are really feeling the pinch. Just to reiterate, the key difference between the companies on the decline and the companies on the incline is nothing but innovation – the way they are using the resources efficiently to provide maximum value at minimum costs. A good example will be WhatsApp – this multibillion dollar company can serve more than a billion users spread worldwide with an employee base of just 50.

Another noticeable difference is the change in business segments, the shift from manufacturing companies to services companies. Since World War Two, growth in manufacturing sector is what led to the creation of high paying jobs for the middle class (think of automobile companies) and these high paying jobs led to further demand in the economy. This led to countries such as United States, Germany and Japan emerge as Global manufacturing leaders and reap economic rewards like sustained strong GDP growth, wealthy middle class and strong growth in service sector caused by growth in manufacturing sector. Research conducted by US Department of Commerce indicates that every one dollar in manufacturing growth leads to 1.4 dollars of growth in other sectors, like services. This is known as the multiplier effect and because of this, even though manufacturing grew very strongly in these countries over last fifty years, the growth in services sectors was even more

buoyant and today, more than 70% of the economies of these countries are made up of services sector.

In recent decades, manufacturing has spread to other economies like Mexico, Brazil, South Korea, China, Thailand and India. The key reason for this has been the lower wages offered by these countries and the pressure on the manufacturing companies to cut costs. This shift has led to more job creation and a rising standard of living in the emerging economies. The next big shift in manufacturing is now underway and it is driven by the digital revolution. Earlier, innovations in companies happened through trial and error attempts or tinkering by the promoters, managers or shop-floor employees. Alternatively it happened through support from consultants like McKinsey who applied relevant information from one company or one sector to another. In today's world, there is lots of information available that can be analyzed and applied to other areas. The whole world is now connected through millions of servers on a 24x7 basis and the flow of ideas has never been quicker. The digital revolution is providing immense support to each stage of business – ideation, analysis of ideas, pilot projects, delivery, ramp up of scale and cross selling. A developer or a project leader can now think of a manufacturing or service network spread across the globe, bringing in the best ideas from appropriate specialists and at the same time, making the project viable from a cost competitiveness standpoint. Earlier, the barriers to entry for any business were reasonably high and a few individuals could never even dream of challenging established businesses. Now it is not just possible but actually happening every day. This in turn is pressurizing established companies to streamline and focus more on innovation. The typical focus for the traditional companies has hitherto been cost cutting which involved squeezing the vendors and shifting the back-end to low cost countries. Now the game is not about shaving off a few pennies from the product price but about taking a revolutionary step forward and offer a product delight or a solution (depending on the customer).

Companies have to fight on two fronts today. The customers, on one hand, are ever more demanding and ever more knowledgeable about the exact cost metrics of the vendors. This makes it very difficult for the companies to make supernormal profits from standard product offerings. On the other hand, jobs are getting polarized – the jobs that can be mechanized would have already been mechanized or would be done soon. Jobs that cannot be mechanized are

those jobs that have a specialized knowledge and skill requirement. These kinds of jobs are becoming even more crucial as these special knowledgeable and skilled employees would make the companies differentiated from the view point of their customers. These employees, in turn, have got a higher bargaining power and can extract ever more compensation for their services. This is the reason behind the headlines we see in the newspapers – a star performer from the marketing department of a company or a star performer from a hedge fund taking home tens of millions when the average bonuses are a few thousand dollars.

Companies narrowly focusing on existing assets like product lines, brands or knowledge base and desiring to forever earn profits from these will be in for a rude shock as the rapidly evolving technology would make these existing assets of a company depreciate very quickly. Companies have to change their attitude of protecting their assets and should adopt the attitude of changing status quo with new innovative ideas that can delight their customers; if they don't do it, the competitors will. Nokia and Blackberry offered great phones at one point of time but then they became oblivious to the changes in customer needs and paid a hefty price for it. Such rapid change of competitive landscape will make the product lifecycles shrink and companies will have to be very cautious about their reinvestment strategy, for example, constructing a dedicated manufacturing plant for making a product that might become obsolete due to change in technology. Large, multi-product companies that cannot focus on individual product lines are finding themselves overtaken by lean and focused companies that can innovate quickly. Private Equity funds and hedge funds will be far more active in breaking up such large conglomerates and making money by buying out smaller pieces, turning them around through focus & innovation and selling them to another buyer for a better price.

There is another reason for rising competition. In the old economy, it took twenty or thirty years for an entrepreneur to create a business and take it to a respectable level. That is changing now; Facebook, Uber and others took less than a decade to break into the multi-billion dollar bracket. In a highly connected world, a new business idea, if worthy, would need only a few months to spread across and grow to a sizeable level. As the new business ideas are typically less dependent on a physical set-up, the investments in terms of time and money are relatively low and hence the profitability can be

higher even at a low revenue base. Big revenues will be earned by revolutionary products or business ideas (the inevitable example is iPhone) and we will surely see some new millionaires every year who identified some need of the people and came out with a product or service (at a reasonable price) to address that. At the same time, there is a downside to the low investment (of time and money) needed to build & market a new product. The competitors would also be quick to assess a successful start-up's potential and come out with their own competing products and services, just like the bunch of smartphones spawned by the success of iPhone. The game would be fiercely fought and whoever improves the product faster, garners more market share and raises more funding would come out as the winner.

Large companies with a fairly long history have experienced various business risks firsthand during their growth phase, right from missed expectations to outright frauds. Hence these companies are more intent on curbing risks in all business segments than focusing whole hog on just growing the business. This is a sound thought for building long term business strategy but it makes some companies end up with bulky systems and processes and slow moving departments. You might have experienced this first hand or at least seen the famous comic strips of Dilbert. There are some large corporates today which have respectably fast processes and departments but they are more of exceptions rather than the norm. The new era would require companies to be equally agile at risk management as well as business development or face obsolescence.

We have discussed the implications of innovation but what is the driving force behind innovation? By nature, we humans are lazy creatures. Most of our inventions and innovations are for saving time, energy and money. Inventions like a TV remote with inbuilt bottle opener are proofs of our laziness. Apart from supporting laziness, innovation is generally the result of a wish to address a need or earn a reward. The foundation of innovation is research which can be broadly broken into two areas – theoretical research and experimental research. Theoretical research is also the precursor to experimental research. Theoretical research generally does not require anything except one or more brilliant people sitting peacefully and thinking. To encourage theoretical research, we need to give a free hand to thinkers, let them interact with other thinkers in the same or related fields and make the relevant data, research and publications available to them. The pinnacle of

such researchers would be Albert Einstein, who developed his Theory of Relativity while working as an ‘assistant examiner’ at the Swiss Patent Office. But the experimental research is a completely different animal altogether, much more difficult to manage and requiring a vast budget for laboratories, equipments, prototypes, etc. As you might know, the Large Hadron Collider, built by CERN in Europe for studying fundamental particles like quarks cost nine billion dollars to build. Governments with limited budgets are not able to allocate money for research and thus the onus of research and development falls on the corporates and the wealthy individuals.

The question about money brings us to a fundamental point of contention between capitalism and communism. Capitalism dictates that the entity doing the research, invention or innovation should be free to set its own price on the output. This assumes that due to market forces, the entity will end up charging an amount that will improve its profitability to the maximum but will not be so huge that it will attract competition (in Adam Smith’s words, the invisible hand of the market will maintain the balance). In reality, competitive forces can’t always come in to balance the scales and some innovators end up charging a lot for their innovations. An example of this is the huge price charged by large pharmaceutical companies (owning patents on anti-AIDS medicines) which the needy AIDS patients in Africa were unable to pay. Communism dictates that all intellectual property belongs to the people at large and hence nobody specific will make profits from it, the government will distribute the final product (theoretically) at cost to whoever needs it. In response, Capitalism demands to know how the innovation process can continue if innovators don’t get paid for their innovations. This is a very tricky problem but I have a few thoughts. Let’s first separate the corporate innovators and individual innovators because corporate innovators have profit maximization as a clear motive whereas individual innovators can have diverse motives. Let’s discuss some anecdotal examples here. Individuals who changed the world through their discoveries did not do it for monetary rewards. That was incidental. They did it chiefly to satisfy their curiosity, to solve a riddle, to solve a problem faced by humanity or to earn fame. Galileo, Newton, Einstein, Pasteur, Jenner, Alexander Fleming, Edison, Marie Curie and scores of other scientists have this same story. Even in recent times, teenagers and young adults in developed countries have developed many new technologies or softwares and have distributed them for

free. These innovations range from peer-to-peer file sharing platforms to new operating systems like Linux. Surely the innovators were aware about the potential profit angle but in my opinion they were more driven by the ‘sense of achievement’ provided by accomplishing something that could not be done by others. This spirit needs to be nurtured through better education. It also helps if the governments provide a social safety net to the citizens so that these innovators should not be worried about putting the time, energy and efforts into something that may or may not fructify. The social safety net would allow them to keep on doing what they like irrespective of the number of failures incurred.

And now let’s talk about the innovation from corporates. I don’t have an answer about how to set the profitability of corporate innovators at the optimum level but I can point out three trends that will support innovation going forward. First is quite obvious – ‘no other choice’. Due to competition and continuous evolution, the life cycle of the product or service is shortening. So even the best of the companies would need to innovate constantly. Such innovation will trickle outside, just like the special materials or technologies developed by NASA or Formula One teams slowly find their way into civilian applications.

Second trend will be a collaboration amongst competing companies to quickly develop the intended technology, get worldwide approvals and target all intended users in one go. This approach will help companies in cutting costs in R&D, liaising for approvals and marketing. A sector that needs huge investment for innovation is pharmaceutical sector. Developing a simple new drug will cost about US$ 500 million to a billion easily, though with better technology like faster and cheaper computing, these costs are also coming down. Today, a drug needs about 10-12 years in development and clinical trials. Getting the drug approved from various healthcare authorities is a time consuming process and educating relevant doctors about the new drug is also very time consuming. If innovator companies could launch their products simultaneously across the world and reach the overall patient population using faster means of communication, the time value saved would be enormous and the companies would (and should) be willing to pass it onto the governments in the form of lower cost per patient. Even if a new vaccine costs a billion dollars in research and development, if the governments various countries order tens of millions of doses in one go, the selling price

(spend per patient) can be just a few dollars. What is needed is a technology driven, universal FDA for a significant reduction in drug approval timelines for global launches. There is no doubt that safety and efficacy studies must be conducted before a new drug is launched but faster approval and launch timelines will help companies in pricing the products at very affordable levels. Some of the top global pharmaceutical companies have joined forces to form an entity called “TransCelerate Biopharma”. These include Abbvie, Allergan, Amgen, Astellas, Astrazeneca, Biogen, Bohringer Ingelheim, Bristol-Myers Squibb, EMD Serono, GlaxoSmithKline, Johnson & Johnson, Eli Lilly, Medgenics, Merck, Novo Nordisk, Pfizer, Roche, Sanofi, Shionogi and UCB. The intention is to collaborate their R&D efforts so as to simplify and accelerate their drug development efforts. The companies plan to combine resources, including funding and personnel so as to push new drug candidates quickly through the clinical trials phase. In the future we will see more of such collaborative efforts and the governments can encourage these by tax incentives or other suitable means. However, the governments should also realize the benefits in the form of faster drop in prices at the customer end. Currently a drug has a 20 year patent and it takes almost 12 years to launch the product so the innovator can earn money for just about 8 years after which other companies start selling the same product and competition pulls down the prices, sometimes by as much as 99%. So the innovator is focused on milking the drug during the 8 years of clear run (during which they need to educate doctors about the new drug and ask them to prescribe it). If the governments and universal FDA help the innovators in launching the drug in just (say) 7 years instead of 12, global launches help the innovators in reaching patients faster and better communication options help in reducing the time spent in educating doctors, then the innovators might earn much more money in five years than what they earned in earlier eight years of clear run. In such a new system, what the governments should get in return is that the drug should go off-patent after five years of clear run. This way, competition can come in not after 20^{th} year of the drug’s life but after (possibly) 12^{th} year and the drug prices will fall drastically by entry of the competitors. Details need to be worked out but the concept seems workable.

The third trend is the result of the zero interest rate regime we talked about. When the returns on traditional investment options like bonds, stocks, gold,

real estate are falling, savings will flow into newer avenues like hedge funds, private equity funds, venture capital funding, etc. and that money, in turn, will flow into new sectors including biotechnology, genetics, space travel, etc. Today we see the valuations of some unlisted, private equity funded companies at the stratospheric levels which prima facie don't make sense to us. But the reason is simply the money supply. And if it flows into funding innovation, it will be very good for mankind's future.

In conclusion, the pace of innovation is likely to increase, not come down, in future decades. That will make many of today's business models and companies obsolete and they will be replaced by new business models and new companies. Cars replacing horse-carts, computers replacing typewriters and smartphones replacing Blackberry were once-a-decade kind of events but the future will have many such coups every year.

Chapter 3.7: The New Social Structure

'I worked very hard to get to where I am in life… an unemployed university graduate!' – Anonymous

Education seems to be in a difficult phase today. Parents world over have understood that they need to educate their kids so as to get them decent jobs. Many of today's parents cut back on many important things so as to save more money and send their children to the best possible schools and colleges. So much demand and insufficient supply has impacted education sector just like Economics 101 predicts – the prices (meaning fees) have shot through the roof. A graduate degree in engineering costs about US$ 100,000 in the US which is almost four times the median wage. On the other hand, so much supply of educated labor is reducing its price (meaning salary levels) and moreover, so much workforce is unable to find jobs in the era of increasing automation. That's why nowadays we find many university graduates working in unskilled jobs like waiting tables in restaurants, sometimes just to service their education loans. So what is likely to be the future of education?

Just like Economics 101 tells us, if the price of a commodity shoots up beyond a certain level, substitutes at lower prices will come in to balance the scenario. With improving communication infrastructure, it is becoming easier to educate people sitting in opposite corners of the world; one good teacher can teach a thousand students simultaneously. Khan Academy and other non-profit organizations offer courses through internet that cost nothing. Online universities like Udacity offer degree programs like MS in Computer Science at a fraction of the cost charged by the physical (offline) programs. In coming decades, due to sheer scale, online education will become one of the biggest businesses and also one of the biggest charitable works. To me, it seems quite certain that education would be increasingly available at lower costs. But now comes the twist – with better social security there will not be any pressure on anybody to study anything. Today we see children in China excelling in academics because their parents force them from early childhood to excel at studies. Parents force them because they have seen the world which has been so competitive. If you read Amy Chua's 'Battle Hymn of the Tiger Mother', you will understand their exact sentiments. The thought process at work behind this is pure GeMax. Unless the children study and beat others in the

race for getting jobs they would not survive in this world (China hardly had any social security till very recently) and the parents' genes would wither away. Going forward, when the pressure to study diminishes due to better social security, it is quite possible that only the curious kids would get into the hardcore subjects such as math, science and technology. Others can study art, history, music and other things as per their inclinations but these may or may not be relevant from an employability perspective. So, again, what is likely to be the future of education?

For answering that, let's think about how the society would look like in a decade or two when the social trends we discussed actually materialize. In my opinion, the population would ultimately be split into three distinct groups. Majority of the population (maybe 70-80%) will be unemployable in the new era of rapidly evolving technology and automation. Some people would not want to be employed at all. The unemployed will form the bottom of the social pyramid. Because of the government giving all basic amenities for free, these people would not need to work. They may spend their time in pursuing their hobbies or in activities like hiking or fishing. Another 10-15% of the people might find employment in some old fashioned industry or in some last remnants of service industry. The remaining 10% of the population would be employed in fields of research, finance, law, advertising and other areas which require either a niche or very high level of education or a creative bend of mind (qualities that cannot be automated). I am also including self-employed creative people like fashion designers in this same set. The percentages can vary but our society is likely to end up with 'unemployed', 'just employed' and 'happily employed' categories.

In his book 'The Average is Over', economist Tyler Cowen forecasts societies splitting into two groups – a small group of the highly educated wealthy aristocracy and the majority earning nickels, living in ghettos and surviving on low priced goods. In my version, the majority will earn nothing but will still be able to live comfortably on government welfare programs. It would be inevitable for the lower classes to prosper due to technological innovations and government actions and catch up with middle classes. Middle class, which was typically distinguished from the lower classes by their better earnings and savings will find it difficult to maintain their high levels of earnings in the scenario of job losses. Middle class retirees planning to live off their savings will need a serious rethink as the savings may

produce zero yield in a zero growth, zero interest world regime of the future. Thus with continuing job losses and falling returns on assets, the middle class (which is today distinctly placed above the lower class) will erode and perish. From economic angle, I feel there will be only two classes left – the rich and the non-rich. The rich will have gradation amongst themselves with some being multi-billionaires and some being just millionaires but the rich as a whole might be much different from the lower class. At the same time, I think the rich & commons divide will not be unsurmountable. Even today it is increasingly becoming easy for a person coming up with a brilliant business idea to raise investor funding for his idea and become a millionaire within a few months; Mark Zuckerberg coming from a middle class background but making it big with Facebook is a story known to all and in the future there will be many such stories.

The movement of intellect will not be restricted within a nation. The leading countries will increasingly invite the crème-de-la-crème from developing nations. Due to advances in genomics, it will be much easier for host countries to screen immigration applicants and accept only those that are above the defined intellectual, mental and physical thresholds. The second line of people in the developing nations would then get to be the front line (filling in for those who migrated) and the third line would get a chance to become the second line, thus providing upward social mobility and this process will benefit the social pyramids across the whole world.

But the new social structure will bring in its own problems. First of all the population will be quite healthy due to healthcare innovations and healthcare support by the government. But if the population consists of mainly forty, fifty, sixty year old healthy people, what would they be doing with their ‘youth’, the time and energy they will have at their disposal? In Japan, many youngsters today are becoming recluse, spending all their time in playing games. Nobel laureate Angus Deaton and Anne Case recently published a research about the alarmingly rising death rates in US amongst white males. The killers are not lifestyle diseases like diabetes and heart attacks but suicides and over-use of alcohol and narcotics. It is possible that job losses, lower education, changing social fabric and resultant stress and anxiety are deteriorating the mental condition of this class and driving them to self-destruction. Governments all over the world are unable to continue the fight against drugs and hence they have started the process of decriminalizing

some drugs (like cannabis in some states of US) which become accessible to such people who have no idea about what to do with their lives. The answer is education; not the education leading to employment avenues but the education that teaches how to live life under new conditions. Educators will need to be more of motivators, counselors and buddies rather than the traditional professors in tweed coats teaching physics and math. The educators will need to teach people how to gainfully spend the extra decades added to their lives through healthcare innovations. They need to tell people that they are free to pursue their interests – be it fifteenth century French poetry or be it exploration of oceanic currents or anything else. The ideal message for the people would be this: the government is taking care of your deficit needs, so you are free to focus on your Self-Actualization needs.

What makes me believe this is achievable? We already see a rising number of scientific discoveries and technological innovations in each and every possible stream of life. We see people indulging in research that is not just potential money-maker but also in fundamental research like quantum mechanics of subatomic particles that would address the intellectual thirst. Today we already see a strong growth in the number of novels, films, plays, art projects and other creative ventures. Even if the percentage of quality work amongst the total work remains the same, we are looking at strong growth in good quality works in the world, making it culturally richer in a real sense. To me, the rising number of intelligent people indulging into intellectually satisfying pursuits is a victory for the governments who could create such atmosphere for their citizens. It reminds me of the ancient Greek period when a great culture flourished. Land was owned by big land-owners who grew olives, wheat, barley using slaves; trading income was good as global trade passed through Greek ports; minerals like gold, silver, copper, iron were easily available. Wars were few due to lesser needs and better resource availability. Such atmosphere helped in flourishing of various facets of culture viz. philosophy, literature, theatre, music, dance, science & technology, art and architecture. It might become possible for us to recreate that culture on earth again.

Chapter 3.8: Redistribution of Wealth

'The art of government consists of taking as much money as possible from one class of citizens to give to another.' – Voltaire

Thomas Piketty, in his book 'Capital in the Twenty First Century' has explained how the rate of return on capital being higher than the growth rate of the economy leads to continued wealth transfer from the poor to the rich. To check this trend, he has proposed a progressive taxation structure where the income of the top 1% earners in the society, meaning the super-rich, will be taxed at a tax rate of 80%. In the western world, the tax rates for the topmost income brackets were upwards of 70% till the 1970s and thereafter, during the capitalist 1980s, the topmost tax rates kept on falling and today stand at around 30%. Capital gains and dividends are two key contributors to the income of the rich (return on capital as termed by Piketty) and these are taxed at very lenient rates in most of the countries. In this chapter, we will try to conjecture the future of government finances, how much deficits the governments will really need to fund, whether there will be need to set tax rates so high and what will be the problems in implementing such measures. We will also discuss some new forms that governments can adopt for redistribution of wealth.

The economic divide between the rich and the poor has continued for thousands of years and hundreds of novelists, poets and economists have penned their thoughts on this issue. The tendency to collect resources is genetic. If a person has amassed a great wealth, people typically say "he has so much wealth that his seven generations won't need to work!" This is nothing but GeMax at work again; the person is trying his best to ensure survival of his genes in the form of his descendants who will not have to spend their time and energy earning bread but can focus on flourishing the family tree. But just like a single cancerous cell leads to a large malignant tumor, this tendency to amass wealth has led to an extremely disproportionate wealth distribution in the world today. I recently came across a study by Credit Suisse on Zerohedge which is quite disturbing. In North America, the Mecca of capitalism, the wealth distribution chart shows that people are either in one of the top 3 deciles or directly in the bottom decile. The six deciles in-between (which are supposed to represent the middle class) are almost empty. It gives credence to Piketty's statement that the emergence of

middle class was a historic anomaly caused by World Wars and would be corrected in due time. He also mentions the divide between the 1% and 99% and it is not far from truth. More worrisome, the divide is not stagnant or falling; it is increasing. Credit Suisse research shows that in 2010, people with wealth greater than US$ 1 million were about 24 million i.e. about 0.5% of world population at that time. They collectively owned about US$ 69 trillion i.e. 35.6% of the total wealth in the world. In 2015, people with wealth greater than US$ 1 million were about 34 million i.e. about 0.7% of world population. They collectively owned about US$ 113 trillion i.e. 45.2% of the total wealth in the world. If we add people owning wealth more than US$ 100,000 each, we will find that about 8% of the world population owns about 85% of global wealth. In contrast, more than half the world population (3.4 billion people) has wealth lower than US$10,000 and put together, their wealth is just 3% of global wealth.

Even amongst the rich, there is a great wealth divide. There are rich, super rich and uber-rich at vastly different levels. If you take the list of topmost billionaires and add up the estimated wealth of the top few, you will be surprised at the wealth concentration; just the top 80 individuals (meaning 0.000001% of world population) own about US$ 2 trillion of wealth and next 120 put together own another trillion dollars. This inequality is nicely depicted in a concept called Pen's Parade, described by Dutch economist Jan Pen in 1971. The parade is defined as a succession of every person in the economy, with their height proportional to their income, and ordered from lowest to greatest. People with average income are assumed to be of average height, as is the observer. The duration of the parade is one hour. At the beginning of the parade, the marchers cannot be seen at all because they represent businesses or individuals with losses. Very soon, upright marchers with positive income begin to pass by, but they are very tiny. Ten minutes in, the full-time labor force arrives and it lasts several minutes. If the observer expects to see average income people coming in around 30th minute, he is mistaken (the deception is due to average and median being different). Only about forty-five minutes into the parade, the marchers become as tall as the observer. In the final six minutes, however, when people with earnings in the top 10 percent begin to arrive, with heights start increasing quickly. Doctors, lawyers, and senior civil servants are about 20 feet tall and then come successful corporate executives, bankers, stockbrokers who are fifty feet,

hundred feet and five hundred feet tall. In the last few seconds the observer will see pop stars, movie stars and the most successful entrepreneurs, and they are so tall that the observer can see only up to their knees. At the very end of the parade (in the original book) is Jean Paul Getty; the soles of his shoes being hundreds of feet thick.

If this depiction of socio-economic inequality is shocking then imagine how it has grown during the last forty five years and how you would need to modify Pen's Parade to describe today's wealth spectrum. With so much evidence of inequality, there is no doubt that the socialist inside you (if there is one) is itching to take some drastic action. But let's first conjecture how much action is really necessary. We currently have three classes in our society based on wealth measures – the rich class, the middle class and the poor. The poor hardly own any assets, the middle class has some assets whereas the rich class owns majority of the assets. As we have discussed, due to increasing government welfare, vanishing jobs and zero interest rate regime, middle and poor classes will merge into one non-rich class. The wealth redistribution that we will discuss will be from rich to the poor.

As of now most of the governments carry a budget deficit even though they would actually want to have a balanced budget. In fact every Treasury Secretary (or Finance Minister, as may be the case) dreams of arriving at a surplus budget and then announcing major tax cuts, making him the darling of everyone. To fund the budget deficit, the treasury secretary will need to raise taxes or borrow money through bond issuance, print more currency notes or just cut the spending plan. Each of these actions has got its own positive and negative consequences. Good leaders also want to do something for the future generations. When the budgets are balanced and basic needs of people are met, the governments can take policy actions focused on the long term goals and strategic decisions that need big upfront commitment. When Indian space agency sent a satellite to Mars, the dissenters asked why the government was wasting so much money on science when thousands of poor don't have bread yet. On the other hand, the Apollo missions in the US were very well received because it was the time after the prosperous 50's and 60's and socio-economic prosperity was relatively high. A balanced budget remains just a dream today because the government must spend on various items: creating infrastructure, paying for pensions and healthcare, maintaining law and order in the country, maintaining armed forces for

external conflicts and maintaining a large bureaucracy to run the country. But things will soon change; governments will bring in technology to cut costs in each of these elements. For example, healthcare spend is one of the biggest component of government budget everywhere. With increased use of analytics reducing workload of doctors, increased use of medical and nurse robots, faster approval and dissemination timelines for drugs that will lead to lower prices of medicines for the common man without shortchanging the innovators. Many paper-pushing jobs at government offices will also vanish with time, leading to a lower wage bill for the government budget. Spend on defense can go down as probability of a physical, large scale war is going down (countries today fight at economic forums or in the cyberspace). This will mean further job losses but more savings for the government budget. But after all this, the government will still be left with some expenses and they will need to be funded from taxing somebody and that will have to be the rich. This has a poetic justice in it: companies owned by the rich lay off workers to increase profits and the government provides welfare to these workers through taxing the company profits.

As we discussed earlier, almost two third of the people in the society will be jobless within a decade or two and will be earning very less and living on government support. There is no point in taxing these people and it is not impossible that the governments will abolish income tax, at least till a certain income threshold (that will cover this population). The governments will need to target the R2R segment – the rich producing for and selling to the rich. Taxes on consumption, income and assets of the rich will provide the income to the government (A finer point here is that human mobility has increased greatly which compel the taxation policies to be consistent otherwise there will be an exodus to low tax destinations as we are seeing in some countries today). The governments can also borrow from the markets through raising of bonds but that might not be required if the plan to curtail spending through use of technology is successful.

Chinese culture has a metaphor called ‘The Cake Theory’. It is about economic development and redistribution of wealth. One side of the debate says that development should focus on dividing the cake more fairly and the other side says that development should focus on baking a bigger cake. The most potent approach would be to develop technology to bake a bigger cake and at the same time, educate everyone to share equitably. Governments have

been working with a scarcity mindset whereas in the future they will need to work with an abundance mindset. Abundance mindset is not “everything is hunky dory, we don’t need to do anything” but “everything will be hunky dory if we act in time and take steps X, Y, Z”.

In the new world, once resources are abundantly available, there will not be a real need for wealth accumulation (it goes against our inherent genetic make-up but it can be ‘learned’) and that thought would give government a moral platform for redistribution; just like ‘helping the handicapped’ has become a part of our social psyche today, ‘redistribution of wealth for the deprived’ will become a part of our social psyche in future. There is no doubt that government can redistribute wealth and till the time the last man in the country is not well fed, redistribution efforts will continue. Government is next only to Almighty when it comes to owning unlimited powers and the ability to use the power through different channels over and above taxation. Recently many pharma companies in US took large price hikes without sufficient reasons and there is a chance that the authorities may explore some kind of price control. Already, in many countries, governments decide a price cap for essential medicines. In Japan, the pharma companies have to compulsorily cut product prices every two years. A decade ago, some African countries ravaged by AIDS decided to ignore the patent rights of a large pharma company which was selling them anti-AIDS medicines at exorbitant prices and decided to procure the same from a low-cost manufacturer in India. Some countries have regulatory provisions which allow local pharma companies to manufacture a patented drug if the patent holder is not making the drug available to the local population at a fair price. Such measures are government’s means of transferring wealth from the rich who own the pharma companies to the poor who are the consumers. Technological breakthroughs have brought down profit margins in many industries but healthcare is one sector where profit margins have not yet come down meaningfully and that is one area where governments might be more active in the future.

I came across another interesting method of wealth transfer. Healthcare equipments like CT Scan, MRI, radiation therapy machines require a few hundred thousand dollars of upfront investments. Many healthcare facilities even in developed countries find it difficult to own such costly machines. But just like what Xerox did with photocopiers, medical equipments are now

being financed by the manufacturers or third party financiers and the users will need to pay as per pay-per-use policy. The key hurdle in buying a big machine was the worry that if the required number of transactions are not achieved, the capital blocked in such equipment creates a big burden on the finances. The pay-per-use model transfers the risk of achieving transactions target and the risk of profit shortfall from the healthcare providers to the manufacturers or financers. This is another method of redistribution of wealth, from the elite to the street. Write-offs of student loans, farmer loans, etc. where the government pays off the lenders and collects the shortfall through taxing the rich is another method of wealth transfer.

The tussle of power between the government (representing the poor) and the rich takes place at many levels. Traditionally it's observed that the rich can afford much better advice about investments, tax loopholes, etc. and have more lobbying power. These factors help them earn a much better return on their capital than the common man. The governments have encouraged platforms like mutual funds for small investors which can employ skilled people and have better bargaining powers to reduce trading costs and information asymmetry. The governments have put in better technology and strict compliance standards to curb violations like insider trading. In this particular tussle, the government seems to have scored a point. Another point of tussle is tax compliance. The rich have advisors to exploit loopholes in the tax law to such an extent that the millionaires end up with a lesser tax rate than the commoners. Nowadays, shifting assets and citizenship to tax havens is the new fashion for the rich. Swiss banks have traditionally helped millionaires in hiding assets they don't want to declare to tax authorities. Many film stars and sportspeople are citizens of Monaco, Luxembourg and Lichtenstein where tax rates are miniscule. Some hedge fund managers are shifting their personal assets to New Zealand, thinking it would be safer in case of a social unrest at home. Many large companies have been shifting their headquarters to Ireland or other countries where tax rates are low. If the governments raise taxes on the rich to 80%, this trickle will become a flood in no time. Governments world over have started waking up and are getting worried for this tax leakage. European Commission recently published a blacklist of thirty worst-offending tax havens. Stringent KYC (Know Your Customer) norms by banks, recent crackdown by US on Swiss banks and new acts like FATCA (which makes any and every investor in the world declare his details to the authorities) are some active measures being implemented as

a result of governments waking up. Renouncing citizenships and shifting business and assets to tax havens reminds me of a book I greatly admire – Atlas Shrugged. The protagonists in the novel shift their base to a secret place and the world they leave behind starts crumbling due to the dearth of skill and intellect caused by their absence. I am being subjective here but my sympathies lie with the rich who create wealth through their skills and intellect and not with the rich who amass wealth simply through return on inherited capital or through tax avoidance schemes. Coming back to the original point, will large economies crumble today if the rich shift to tax havens? What is the recourse left to the governments in such a scenario to bridge their budget gap? The complete answer to that question eludes me but there are some ways the governments are exploring to catch tax-evaders. The rich would be having their wealth in two forms – investments and hard assets. In extreme cases, governments can confiscate investments like bonds and stocks, which in today's world are nothing but electronic entries in the universal, interconnected banking system, maintained by specific depository institutions. Governments world over are promoting use of electronic money as against paper money so that all transactions can be tracked and this would curb the black economy and investments into assets like gold and diamonds which are sometimes used to hide black money. The evaders may warm up to the anonymity provided by crypto-currencies like Bitcoin but government agencies are on their way to regulate those before they become preferred routes for hiding assets from the governments. Hard assets such as land and buildings can also be confiscated by the governments if they happen to be in that country. The cooperation between governments on issues like catching tax evaders is increasing and hence governments will be increasingly able to reach evaders' hard assets anywhere in the world. Some governments have started charging an 'Exit Tax' to the people who want to renounce their citizenships which will partially compensate for the future tax they would have paid. And even if citizenship is renounced, the person would have to pay taxes on income and assets if the income generation and assets are still in the original country.

The last tussle between the rich and the governments takes place in the bond markets. Amongst all investments in the world, the size of governments bonds is much ahead of other assets by a long mile. Investors cannot find assets that are more liquid and less risky than government bonds and that gives an upper hand to governments when they come to the debt markets.

Latin American bond markets have showed us that governments can default on bonds or restructure them repeatedly but after a few years, all is forgiven; investors will flock in again at the bond auctions. During the recent trouble with Greek debt, the world saw a new formula. The government bondholders (meaning the French, German and other banks owning Greek debt) got their bonds restructured without any apparent loss whereas the private bondholders were made to take a haircut of 53.5%. The formula is baffling until you look at it from the viewpoint of the tussle between the governments & the rich and the governments exercising their higher bargaining power. I think the example of Greece will not remain an isolated example. Debt restructuring for highly indebted nations would become a norm as the pressure from global population on humanitarian grounds will force lender nations to go easy on the debtors. When faced with a prospect of default, the lenders have two choices – one is to insist on immediate payment (and get cash which they cannot anyway use productively in today's low interest rate regime) and the second choice is to agree to a restructuring (and own a new bond which provides some yield, at least on paper). There is another reason why lenders cannot be too harsh on the borrower nations – memories of the Treaty of Versailles and its subsequent effects on German economy leading to Second World War have not faded completely from the world memory. With genetic engineering and nanotechnology growing with leaps and bounds, it would be very easy for a rogue nation to destabilize the global economy if pushed into a corner.

Additional boost to this model will be provided by the dual engines of lower inflation and higher savings worldwide which are forcing the rich to invest in government bonds at very low yields and making the government's job much easier. If the interest rates are very low and the governments can restructure debt payments at will without any permanent damage to their borrowing capacity then the governments will not mind carrying a large debt burden. Governments borrowing at zero or negative interest rates means the rich investors will not earn anything on their capital and this will be the new, ingenious model for redistribution of wealth. With falling inflation, the rich investors may not be worse off from a real return viewpoint. If the investor was earning 4% return, the tax rate is 25% and the inflation is 2% then the real rate of return is 1% (4% x (1-25%) – 2%). If the rate of return is zero and inflation is negative 1% then the real rate of return is still 1% (0% x (1-25%) – (-1%)). But a government keeps its books in nominal terms and a nominal

rate of zero percent makes the government debt far more sustainable. You might have spotted that the government will be foregoing some tax on investment income in this scenario and it will need to make it up through higher taxes on income or assets or through higher borrowings.

In the upcoming era of low returns on capital, the rich will need to take extra risks for generating extra returns. However, due to faster communication, all investors flock to any and every promising investment idea. The crowding in trades is so intense that any reversal in stance causes a stampede for exit, like what happened recently when the ECB failed to meet investor expectations on rate cuts and quantitative easing. I think in the future this cycle of bubbles and bursts will be more frequent and heightened volatility will become a permanent quality of financial markets. Such volatility will in turn lead to wealth erosion or wealth transfer during bursting bubbles. But governments are unlikely to interfere and curb the volatility because, first of all, it would be mostly a wealth transfer amongst the rich and secondly, the supply of savings will flow in when a bubble bursts and pull the prices back to normal.

Being the optimist, I think our world will not really come to such a state. For one, prudent governments will cut costs using technology and thereby cut their debt burden. Lower cost and investment needs of the governments will also obviate the need to implement extreme tax rates on the rich (that might drive them away). Secondly if the masses are living comfortably on social welfare, they will not mind the riches of the rich. Revolutions start from empty stomachs and as long as our governments implement social welfare programs properly, there will be no need for the rich to fear a social unrest and move to New Zealand.

I will end this chapter with a word about the need for a new economics textbook. The old economics we learned in college cannot show us the way today because the economics we learned was based on many simplifications like single country policies, less number of asset classes to be modelled and the old-age tools in the hands of the central bankers that no longer work. In this book, we have discussed issues that are so multi-dimensional that the traditional, linear thinking may not show the right path. There is a dire need for new frameworks and new tools. One tool that may help is economic modeling using self-learning AI. It might sound like a flight of fancy but if the number of people on earth are finite and people are mapped for their

genes and resulting behavioral traits then with sufficiently advanced AI systems we might be able to predict the outcome of any proposed economic or social policy. That will help in designing optimum policies and drastically lighten the burden on the policymakers by altering their current model of trial and error. I am really looking forward to that day.

Chapter 3.9: Profligacy and Philanthropy

'If your name is on a building, you are rich. If your name is on a desk, you are middle class. If your name is on a name-tag on your shirt, you are poor.' – Anonymous

While reading human history, one can observe a very funny trend. The rich have always wanted to be distinct from the masses but the masses emulate the rich and then the rich invent a new fashion. About two or three centuries ago when the masses used to work in the farms, the rich used to put lots of face powder to distinguish them from the masses with tanned bodies. When the workers started working in the factories and had light skins due to lack of sunlight, getting a nice bronze or golden tan became the new fashion. When the poor were wearing torn and faded jeans, the rich were wearing spotless dresses. Now the poor can afford decent dresses but the rich are wearing torn and faded jeans. When food was scarce, the masses were emaciated due to malnutrition. The rich used to be well-fed and, most of the times, obese. Today when basic food has become abundantly available at low cost, there are growing obesity epidemics in middle and lower classes in countries like US and China whereas the rich are going thin and lean because 'Fit is the New Rich!'

A distinct and classic sign of richness is ownership of assets. Historically, the rich have owned large land parcels, buildings, stocks, bonds, bullion and jewels. With increasing wealth polarization, saving glut and low returns in government bonds, there is an unprecedented amount of wealth chasing these assets and making them overvalued. Gold and silver, which have been stores of value traditionally, seem to have lost investor interest in recent years due to two reasons – firstly these are traditionally used as inflation hedges and going forward, inflation is unlikely to be a pressing problem. Secondly, with improving methods of production, the supply has improved and with schemes like India's Gold Monetization Scheme which aims to bring hundreds of tons of dormant gold into circulation, the incremental demand might take a dip. This situation is forcing the rich investors to look for other investment avenues like art, wine and others. It wouldn't have escaped your attention that in recent auctions, various famous and not-so-famous paintings got sold for tens of millions of dollars. The global (reported) sales of art and antiques was about 28 billion euros in 2009 and increased to 47 billion euros in 2013,

as per a report by European Fine Art Foundation. A research report by Bain & Company estimates the overall luxury goods market to be about 850 billion euros in 2014 and growing at about 7% per year (when the world GDP growth is about 3.5%). Personal luxury goods market, a subset of overall luxury goods, is about 220 billion euros. Knight Frank's Luxury Investment Index tracks the performance of a theoretical basket of nine collectable assets – antique furniture, art, stamps, jewelry, Chinese ceramics, wine, watches, coins and vintage cars. In the last five and ten year periods, most of these asset classes have given decent returns when compared to bonds and stocks but the most impressive amongst all these have been the vintage cars segment. The Knight Frank Luxury Investment Index has outperformed broad equity indices like FTSE100 by a long mile over a ten year period. Why are the rich flocking to such investments? One reason is security – investors may prefer to have some part of their wealth in the form of tangible assets (say, a rare Chinese vase sitting in the living room) rather than have everything in the form of mere electronic entries (like stocks, bonds and cash in the bank) which are susceptible to hacking and pilferage by cyber crooks. But the main reason is the short supply of these assets. There can be only a finite number of bottles of Romanee-Conti of a certain vintage ever made. There can be only a finite number of 1957 Ferrari 250 Testa Rossa. There can be only a finite number of paintings by Ernst or Dali. A living artist may be painting equally absurd and unfathomable paintings but those painted by a dead artist will sell for millions, possibly because the supply has stopped and those paintings have become a rare commodity. The surety of limited supply makes such items a store of value. You would be absolutely right in pointing out that there is no income or a real utility value for many of these. Paintings at least improve the décor of one's living room but the expensive wine bottles hiding in the wine cellar don't have even that perceived utility. In fact many of these investments make the investor incur maintenance costs for the upkeep. Another asset that follows such baffling logic is natural diamond. Scientists have developed technology to make flawless diamonds in labs at low costs. These artificial diamonds have the same, or in fact, better mechanical and other properties. The only way to distinguish between a natural and lab-made diamond is to run special tests (UV-florescence microscopy and photoluminescence spectroscopy). But diamond investors give premium pricing to natural diamonds irrespective of them having flaws, precisely because they are in short supply, underlying the point I made about

collectible assets – great assets are not those which have great utility value but those which are in short supply. That is why an investor owning an apartment in Manhattan may keep it empty (if the high rent deters potential tenants) but even without generating any rental yield, the asset can be highly priced just because there is a limited supply of Manhattan apartments. Sustained high levels in real estate prices (especially in certain pockets like Manhattan and Central London) because of continued investor interest would mean that these pockets would be affordable only to the upper class and a present day concept of ‘gated community’ may one day take the form of a ‘gated city’. If robots for domestic help are sufficiently developed by that time (which seems likely) then these cities will have no need whatsoever for the masses and we may see these gated cities becoming islands exclusive to the rich people. This will further divide the classes and the masses. In fact, taken to its logical extreme, it would be like the rich living on different islands altogether, paying taxes to the masses (meaning the government) to just ‘let them be’.

Another area where the rising wealth is flowing and where the demand is more for consumption rather than investment purpose is private jets and fancy yachts. The global spend on private jets was about 19 billion euros and the global spend on yachts was about 7 billion euros in 2014. Canadian private jet manufacturer Bombardier expects the buyers from greater China region to order around 1000 private jets over next ten years. But the rich are already moving to bigger ambitions like space tourism. Some are taking luxury to the level of sheer profligacy, with their gold plated cars and yacht interiors.

But there is also a heartening trend increasingly seen today. Many rich are rising above the lure of collectibles and luxury goods and are thinking about the common man. In the original Pen’s Parade, the procession climaxes with Jean Paul Getty. Today, it might be Warren Buffet at the end of the parade and there is a sea change. Getty hardly gave any of his fortunes for helping the poor; instead he spent his money collecting art for his museum. Warren Buffet on the other hand has pledged most of his wealth to charity. And there are many who are joining him. Rather than waiting for the time when social inequality has worsened and the governments are forced to raise taxes on rich to 80% to redistribute wealth, the rich are acting now. Governments do not have a glowing record of efficiently managing social welfare schemes till

now. So many rich are proactively, smartly and efficiently using their money to directly address the social problems they want vanquished. The pragmatic ones are channelizing their money into various areas of research and into some focused social causes. Bill Gates, for example, has donated most of his wealth to Bill and Melinda Gates Foundation. The primary aims of the foundation are to enhance healthcare, reduce extreme poverty globally and in America and to expand educational opportunities and access to information technology. Through different divisions, this foundation works in various areas such as stopping sex trafficking & slavery, financial services for the poor, agricultural research, water supply and sanitation, aid to earthquake and epidemic victims, fight AIDS, tuberculosis and malaria, eradication of polio, vaccination for poor children, internet access, improving education standards, scholarship to the needy, etc. Richard Branson and George Soros have been giving billions to philanthropy. Starbucks CEO Howard Schultz recently donated US$ 30 million for research on brain trauma. Sheryl Sandberg, the COO of Facebook has recently announced US$31 million for charities working in the areas of women empowerment, education and anti-poverty efforts. Naguib Sawiris, an Egyptian billionaire has offered to buy a whole island for Syrian refugees displaced by the civil war. Many philanthropists are choosing microfinance institutions which directly reach the needy in third world countries and help them through small livelihood loans at rates much cheaper than the local moneylenders. Google.org and Google Foundation (arms of the commercial enterprise Alphabet, Inc.) have committed upwards of 100 million dollars for charitable purposes. The latest in the line has been Mark Zuckerberg who has pledged to give 99% of his Facebook stock (worth about 45 billion dollars) for Chan Zuckerberg Initiative whose mission is to advance human potential and promote equality in areas such as health, education, scientific research and energy. About five years ago, Zuckerberg had pledged 100 million dollars for reforming Newark school system but it didn’t succeed. Misplaced efforts like this should not deter philanthropists from further experiments; as Thomas Edison said, ‘I have not failed, I have just found another way that won’t work’. Some investors are investing in socially responsible ways meaning not investing in companies that manufacture harmful goods or that have unfriendly policies towards any of the stakeholders.

The biggest initiative for philanthropy has been ‘The Giving Pledge’ which was formed in 2009 by Warren Buffet and Bill Gates to encourage wealthiest

people to make a commitment to give most of their wealth to philanthropic causes. As of now 137 billionaires spread across the world have joined this initiative and the total contribution promised till now is upwards of 125 billion dollars.

It is certainly commendable that the rich are focusing on improving the living conditions of the extremely poor people in the world. Better resource availability would be the next logical requirement of these people and it can be met through better food production techniques and easily affordable solar energy, computing, transportation, education, essential appliances and healthcare devices. If the rich can target their donations towards developing such technologies, it will be the best help to the poor and the best help for mankind.

Chapter 3.10: Risks to the Future and Possible Solutions

'Prediction is very difficult, especially if it is about the future'.
- Niels Bohr

Reality is notorious for straying from plans. Like a last minute goal in a soccer match, unseen and unwanted surprises jump out at us at the most unfortunate times. The trends we tried putting together and the predictions we tried to make based on them look quite reasonable and achievable given the pace of progress. However, we live in such a complex world that many predictions can turn out to be wrong, like Mr. Bohr said.

It is expected based on the trends we discussed that mankind would progress towards a peaceful future, with science and technology contributing to bring down government's costs and the rich stepping ahead to lend a hand to the underprivileged. But there can be various factors that may derail the train to future. If two countries or groups of countries keep fighting over geopolitical superiority and that leads to skirmishes or even a cold-war mentality that prognosticates a potential war in future then governments will spend all their resources for preparing for war and not for developing technologies that will benefit the common man. Crude oil seemed like a resource that could have led to a global conflict. Water is sometimes predicted as the potential reason for Third World War. Luckily technology has provided solutions for energy and water both. I feel that as the resource availability improves countries will have less reasons for not cooperating with each other. Also, governments will need to align policies on issues like taxation, new drug approvals, interest rates and law & order. Global collaboration in these matters will benefit everyone.

The biggest risk I see to the future is the chance of technology not delivering the expected cost reductions and ubiquitous resource availability on time. Disparate pace of technological advances in different fields might cause this to happen. A good example of this will be solar energy and robotics. Think of a hypothetical scenario where robotics advances so fast as to cause faster than expected job losses and governments start running out of tax revenues. If solar energy dependent food, water and transportation technologies haven't advanced enough by that time, the governments will find themselves in a

really precarious position of having to support the people without having the means to do so. That can very well be the perfect recipe for anarchy and eventual disaster. The solution, of course, is not to restrict the advance of robotics but to ensure faster advance of solar energy based applications.

Social welfare is another part that can go really awry. Many countries are already halfway on the path we predicted for the social welfare schemes and due to pressure from the population, the social benefits can only increase, not come down. But as a result of social welfare and lost jobs, if people become lazy and while away all their time playing video games then it will be an outcome that is intellectually, spiritually and mentally dissatisfying. But I think majority of the people will use the opportunity to pursue their self-actualization needs and the governments will prudently provide educators and motivators who will teach people how to best use their time.

The risk of bioterror and nanoterror is something that needs to be taken seriously. With ongoing technological advances it might become increasingly easy for a person of talent to create a virus or a nanobot carrying the most alarming properties with respect to propagation and power against human immune system and against known antidotes. What may forestall such risk is better social care and social security for the desolate, educating everyone about unselfishness and the need to grow together and lastly, better systems and processes to identify and treat people with anti-social mindset. From the nanotechnology angle, researchers can develop ‘police nanobots’ that may reside inside each person’s body and can counteract any attacks by new viruses or nanobots.

We have also not considered external risks like the risk of extreme weather shocks in our predictions, though that possibility cannot be denied. US and Europe have faced severe winters for last two years. India has faced a big monsoon shortfall for two consecutive years. These have supposedly resulted out of the El Nino effect (pattern of oceanic currents) going haywire due to earth’s rising temperature. We don’t know if we have already destabilized earth’s weather pattern so much that such undesirable events have already become the norm. Further research can provide more clarity. Fortunately, most of the nations have now agreed on the need to reduce carbon emissions. If the move to solar energy and other technologies is quick, there is good chance that we can save our atmosphere and avoid such climate mishaps in

the future.

But the biggest risk to mankind's future will be the emergence of SuperIntelligence at a time when mankind is not ready. Forget countering, we don't have the ability to even assess the impact of that event! How can we counter such a threat? It is possible that today's children will grow up to write the AI software that may bring in SuperIntelligence and Singularity one day. If we can teach the children about the nature of selfishness and conflicts over resources, and how all this is futile given the potentially unlimited resources lying ahead of us, then there is some chance that the SuperIntelligence they will build 'may' be benign towards everyone including humans. As I said earlier, none of us can really predict how the SuperIntelligence will behave but if there is any way we humans can influence the outcome, it is through spreading this knowledge.

At the beginning of this book I had mentioned a hypothesis that life on earth might have been seeded by extraterrestrials. Mankind has been trying to contact the extraterrestrials for almost four decades now and we don't even know whether there are extraterrestrial life forms out there in the universe. Even the scientists who believe in their existence cannot predict the date of contact. However, as mankind's technological prowess grows exponentially, the chances of contact will start increasing. If scientists figure out a way to travel through wormholes or travel at speeds faster than light then the chances will grow much more. Keeping aside the prediction about timing of contact, we do not have any information to even predict a possible outcome of contact. So, contact with extraterrestrials is a risk that may or may not materialize during our prediction horizon and mankind is currently unable to take any action regarding this perceived risk. However, it is a topic that needs to be kept at the back of the mind and not forgotten.

Lastly, there are things we don't know that we don't know and many times they pose the maximum risk. Donald Rumsfeld, ex-Secretary of Defense (US), calls them Unknown Unknowns. We cannot even discuss about these risks because we don't even know what these risks are. The only strategy for tackling these risks is to focus more on analysis and research and spread the horizon of human knowledge to such an extent that today's 'unknown' will come under the ambit of 'known' tomorrow.

If the future is going to be so different from the present and so unpredictable,

it would be imperative to discuss what a common man like you and me should do to face the future. First and foremost, we must look after our health. If we can manage good health for the next thirty years, we will possibly live for a million years. Keeping a steady job will become increasingly difficult as we discussed earlier. But rather than waiting for the government's social welfare schemes, we can be the change – some of us can work for companies spreading useful technology and ideas to the underprivileged and some of us can work on cracking the Brain-Machine Interface puzzle. But most importantly, we – through our elected representatives – have to induce our governments to be 'future ready'. Governments should use their increasingly benign fiscal status to encourage development of technology for the masses. Nations should collaborate on issues such as forming a Universal FDA so as to bring down the drug launch timelines and overall healthcare costs. Lastly, we have to urge the billionaires to take a lesson from the likes of Bill Gates and Warren Buffett and use some part of their money towards development of socially useful technology.

Epilogue

We have come a long way on this journey. We have traversed continents and we have travelled across time. Our discussion has covered many topics: evolution of organisms millions of years ago, psychology of human behavior, history of civilizations and wars, foundation of religions and other social systems. We discussed how science and technology are changing our lives today and how they might change our lives a few decades from now. We also discussed how our society and its various constituents are going to change as a result of these technological changes.

In the first part we discussed how mankind has been at the mercy of diseases, ailments, suffering and death. In subsequent parts we saw how advances in molecular manufacturing, genetics and artificial intelligence can make us immortal.

This journey reminds me of some beautiful lines from Brihdaranyaka Upanishad:

	Asato Ma Sadgamaya	
	Tamaso Ma Jyotirgamaya	
	Mrityorma Amritam Gamaya	

This is a prayer in Sanskrit and the English meaning is as follows:

	Lead me from the Lies to the Truth	
	Lead me from the Dark to the Light	
	Lead me from the Death to the Immortality	

Mankind has an eternal drive to improve itself and keep progressing. The prayer above is embodiment of the same spirit. While reading this book you may have felt that the picture that I have painted for the future is tilted towards being too rosy. But my research makes me believe that the progressive spirit of mankind will definitely lead us to a better future. Mankind has been fighting with cancer for about a hundred years and it is now about to emerge victorious. Mankind has been fighting with poverty and malnutrition for centuries and is now about to emerge victorious. More than 99% of human efforts are towards solving present and future problems and such humongous and unceasing flow of efforts is bound to reach its goal. That is the simple reason behind why the world moves ahead and not

backward. *Technology, when used correctly, takes us forward, not backward.* "Where we come from and where we are going" is the same journey that started with Homo Sapiens and that might culminate into an immortal man-machine combination ruling the universe peacefully.

We can summarize the key takeaways from the whole book in just five points:

- Humans subconsciously use GeMax processing to every decision. This is why selfishness is inborn amongst us. The extent of selfishness in the decision depends on availability of resources. Lower availability leads to increasingly selfish decisions and to conflicts.

- Use of technologies like healthcare innovation, solar energy, molecular manufacturing, genetic engineering and fusion with Artificial Intelligence will possibly give humans the option to live forever. Educating this population will be a necessary task because most of the population will at best be partially employed.

- Ability to harness solar energy and use of innovative technologies would be equivalent to having infinite resource availability as cheap energy can be converted into almost any other form of resource – food, water, shelter, etc. This will greatly boost the living standards of even the most destitute people.

- Governments need to give up fighting the losing battle of creating jobs for all and instead focus on encouraging research and innovations that will save governments' spend in areas like infrastructure and healthcare. Seamless collaboration amongst key agencies such as drug approval authorities and law & order authorities is very important.

- Because of these factors at work, we might really see a peaceful and prosperous human society in a few decades' time. But the necessary condition is that, to achieve such a future, all the people and their governments have to act together. A very important part is that the rich need to channelize their wealth towards encouraging development of the key technologies that benefit mankind and to directly help the needy where the government is unable.

This knowledge has the ability to end conflicts and develop peaceful behavior amongst existing nations, societies, races and religions. We should see nations collaborating and not competing in the areas of science and technology, space exploration, exploration of oceans and rainforests (not with the intention to grab resources which was hitherto the case but out of actual academic curiosity).

But of course, there is a big difference between what SHOULD happen and what WILL happen. The optimism about the future will be in vain if mankind does not develop the maturity to collaborate on technological and social issues. Benjamin Franklin – polymath, one of the founding fathers of the United States and famous for his lightening experiment – had once said, “We must, indeed, all hang together or, most assuredly, we shall all hang separately.” We, the people of the Earth, are today in the same boat – we have to help each other, make our governments collaborate with each other and collectively urge the billionaires to direct their wealth towards development of socially benevolent technology so that we can all progress towards a great future. *Great future is not assured but possible!*

Lastly, on a lighter note, the same Benjamin Franklin had once said, “In this world, nothing can said to be certain, except death and taxes”. The new era of technology will be such that within a few decades, we might see many people (including you and me) escaping death and taxes both! ☺

~ The End ~

P.S.: Dear reader, if you enjoyed reading ‘Relax! The World Makes Sense!’ would you mind taking a minute to write a review on Amazon or Flipkart?

Even a short review helps and it would mean a lot to me! Thanks!