

## **ONLINE INTERACTIVE SESSION WITH PROFESSOR J. SRINIVASAN**

22<sup>nd</sup> October, 2020

On the 22<sup>nd</sup> of October, 2020, the regular batch of Class XI students at Mushtifund Aryaans Higher Secondary School had the amazing opportunity to interact with Professor J. Srinivasan, B.Tech, M.Sc., PhD.

Prof J. Srinivasan has done B. Tech from IIT Madras in Mechanical Engineering. He did his M.Sc. from New York State University, USA. He then went on to acquire his Ph.D. from the prestigious Stanford University, USA.

Professor returned to India from the USA in 1975. From 1975 to 1982, Professor was a member of the faculty at the Mechanical Department at IIT Kanpur. From 1982 to 1992, Professor also worked as faculty at the Mechanical Department at IISc, Bangalore. From 1993 to 1995, Professor was an NRC Senior Resident Research Associate at the NASA Langley Research Center, Virginia, USA. From 1996 to 2005, Professor was the Chairman of the Centre of Atmospheric and Ocean Sciences at IISc, Bangalore. From 2005 to 2009 i.e. after he became the Chairman of Atmospheric and Ocean Sciences, he became Chairman of Mechanical Engineering Department and the Mechanical Sciences Division at IISc, Bangalore. From 2009-present, Professor is the Chairman of the Divecha Centre for Climate Change.

Professor J. Srinivasan is a member of several prestigious societies. He is an amazing researcher and has more than 150 international publications to his name, those being related to climate change and weather changes in India. He is also the recipient of several prestigious awards. He received the Banco Foundation Gold Medal at IIT Madras. He was also presented with the "Lifetime Excellence Award" by the Ministry of Earth Sciences in recognition of his outstanding research contributions in the fields of climate change and the study of weather patterns.

Professor began his session by answering a question which we had in our minds, why would professor who has studied mechanical engineering work in the field of climate change. Professor said that we are at such a phase in our life where we shall find it difficult to find the career and the branch that will suit us due to the wide variety of choices available. Understanding what really excites us and ignites that spark of interest in us will take another 5-10 years. But in the meantime, we should choose a course which we feel is good because in today's world there is always the option to change your field or course. Professor then gave us the example of Arjun Divecha to prove his point. Arjun Divecha did his B. Tech in Aeronautical Engineering, then decided to pursue finance and finally invested money to start the Divecha Centre for Climate Change. It could be seen that a person's career is not predictable.

Professor Srinivasan said that climate change is one of the biggest threats that the future generation faces. He then spoke about Greta Thunberg, an environmental activist who urged the world's leaders and businessmen to treat climate change as an existential crisis. Professor then put forward three points to ponder upon. Firstly, is climate change actually occurring?

Secondly, are humans responsible for such a change? And thirdly, can we control it? Professor then explained to us the various challenges that present itself when we try to answer these questions. The various aspects of such challenges were:-

- Scientific challenges because we need to understand why climate change is occurring. Unless this is understood, it cannot be understood how much humans are contributing to it or is it occurring due to natural causes.
- Technical challenges for engineers as they need to mitigate climate change. The engineers need to find a way to reduce the amount of carbon dioxide emissions.
- Political challenges as we need to convince politicians to take steps to control Earth's climate.
- Social challenges to convince people to change their ways and lifestyle. Professor gave an example of the current situation of COVID-19. People are unable or find it difficult to change the way they behave, like covering the face with a mask or not holding any gatherings.

We were then shown a graph of the increase in the mean temperature of the globe. The 10 hottest years ever recorded have been the last 10 years. Global temperatures today are 1-1.25 °C above normal. From the next graph, it was evident that the decadal average temperature in the 19th century had ups and downs but from 1960 onwards it has been increasing steadily. Professor then answered an important question from Sir i.e. why is a 1 °C change in temperature as significant as there is a usual temperature variation of 10-15 °C between summers and winters. Professor answered that due to the 1 °C change there is a change in the season cycle all over the world in a short period whereas living organisms have adapted themselves to certain temperatures over millions of years. Therefore they can't adapt to a sudden increase in temperature.

The concentration of carbon dioxide has increased manifold in the last century. It was below 300 ppm but from the year 1900, it has catapulted to 410 ppm in a span of 100 years. An increase of 110 ppm concentration of carbon dioxide in such a short span is unheard of. Professor then explained how an increase by a few hundred parts per million of carbon dioxide could affect the climate. Nitrogen, oxygen and argon make up 99.9% of the earth's atmosphere. However, they do not have any significant effect on temperature. The temperature is controlled by four minor gases- water vapour, carbon dioxide, methane and ozone. Upon examining the spectra, nitrogen and oxygen being diatomic gases have very few or no absorption bands. Hence they don't have any effect. But gases like carbon dioxide, methane and water vapour have absorption bands at the same wavelength at which the earth is radiating heat approximately at 10 microns.

Professor then told us about an error in a textbook that said-"a part of reflected solar radiation is trapped by the atmosphere and this warms the earth". This was wrong because the atmosphere absorbs Earth's radiation not the sun's radiation. Sun emits radiation in the range

of 0.4-4  $\mu\text{m}$  whereas Earth emits radiation from 4-100  $\mu\text{m}$ . Hence the atmosphere is nearly transparent to Sun's radiation.

Professor said that Earth's climate is not stable. There were times when the Earth was ice-free and there were times when the Earth was completely snow-covered. Such an earth was called the "Snow-borne Earth". Recent data shows that the ice even reached up to the Equator at one point of time. Professor then explained the reason behind such fluctuations of the Earth's mean temperature in a range of  $-10$  to  $14$   $^{\circ}\text{C}$ . Earth contains water in all the three forms, ice, liquid water and water vapour. Water vapour is responsible for absorbing the earth's radiation, liquid water absorbs solar radiation and ice reflects solar radiation. Thus there are fluctuations in temperature depending on the amount of ice and liquid water present. If there are large quantities of ice, most of the solar radiations are reflected and the temperature falls. However if there is more liquid water, the temperature rises as water absorbs 10 times more heat than ice.

In the past 50 years, the mean Arctic temperature has increased by  $4$   $^{\circ}\text{C}$  whereas the global mean has increased by only about  $1$   $^{\circ}\text{C}$ . This means the Arctic ice is melting rapidly causing the temperature to rise.

Professor then answered a question asked by a student i.e. were the dinosaurs really killed by the meteorite striking and did the meteorite strike trigger the Ice Age? Professor said that there is sufficient indirect evidence to suggest that the dinosaurs were extinct due to the meteorite strike as a large amount of dust was sent up in the atmosphere due to which the temperature dropped rapidly and dinosaurs being large animals can't survive in cold climate.

Professor explained to us the difference between weather and climate. Quoting the famous Mark Twain "Climate is what you expect, but weather is what you get". Weather cannot be predicted accurately for more than a few days in advance as Earth's weather is a complex non-linear phenomenon. Weather is a regional phenomenon and occurs over hours-days whereas climate is regional and global phenomena which occurs over years and beyond.

Professor said climate requires statistics of weather, the whole distribution of data. He then gave an example of the cities of Bangalore and Chennai. On a given day, Bangalore may be hotter than Chennai, but on an average it is  $6$   $^{\circ}\text{C}$  colder than Chennai as it is at a higher altitude. Sir Vyankatesh then desired to know if Bangalore's higher air pollution is contributing to higher temperatures on certain days. Professor then informed us that air pollution is responsible for bringing down Earth's temperature as it blocks Sun's radiation. If not for air pollution, Earth's temperature would have been much higher today. It is carbon dioxide which is responsible for increasing the temperature as it traps about 100 times more heat than that emitted by cars and other sources. Unless carbon dioxide concentration is reduced, climate change is inevitable.

Professor Srinivasan then showed a graph in which the temperature increased by 1 °C in the last 1000 years. However there has been an increase of more than 1 °C in the last 100 years. The temperature has risen 10 times faster than the natural rate. The increase in temperature is not a problem, the relative rate at which it is increasing is a problem. Plants and animal beings are not able to adapt themselves to such a rapid change in temperature. We were then explained the reason behind the global climate change over the past thousands of years. It is because of the change in the inclination of earth's axis and change in the Earth's orbit around the Sun which changes the amount of radiation received by the Earth. Local climate change is due to change in CO<sub>2</sub>, land use and due to air pollution. To illustrate this, professor gave us example of maximum temperature in winter, in India. South India has warmed by about 2 °C whereas North India has cooled down due to air pollution. From Punjab to Haryana, there is a layer of air pollution which reduces the temperature illustrating local climate change.

Professor told us about the frequency of heat waves. Since 1950, the number and duration of heat waves has increased. The global area hit by heat waves has increased about 50 times. The areas most affected are the tropics and countries such as South East Asia, India, Northern Africa, Northern Australia and regions such as the Amazon in Brazil. Professor then recounted his experience in Bangalore when he went there in 1959, the minimum temperature was around 11-12 °C but for the past 5-10 years he hasn't experienced any temperature below 15 °C. Professor showed us a graph which showed the mortality rate in Ahmedabad. During a heat wave, the number of deaths per day tripled from 100 to 300.

Another big aspect of heat waves is forest fires. Professor explained that as the temperature increases, the air becomes drier especially in places like California. Forests become drier and wildfires occur. The number of wildfires in California has increased 4 times. Millions of acres of land are destroyed due to this.

Professor said that climate change has a favourable impact on insects. Due to increasing temperatures, the winter mortality of insects is reduced. Rising temperatures accelerate life cycles as they breathe faster, their lifespan is increased and more insects are produced. They allow expansion of range of insects. One of the major effects will be that crop yield will go down, causing shortage of food grains, especially in developing countries most of which face already hot climate. Developed countries on the other hand will have more crop yield due to most of them being in colder climates and already having well irrigated land. The number of catastrophic events in Asia have increased by 4 times in the last 40 years. Professor then gave an example of the unreal Mumbai flooding on July 26, 2005 when it rained more than 900 mm in 24 hours.

Professor explained that extreme rainfall has three major causes, Global warming, Aerosols, and Urban heat islands. Urban heat islands are major cities which experience much warmer temperatures than the surrounding areas. Professor elucidated that another major problem that faces us is the subsidence of land and simultaneous increase in sea level. Coastal areas

especially Eastern coast of India are at risk. Land is subsiding at a rate of 6-100 mm/year whereas sea level is rising by 3-10 mm/year.

Professor threw light on an interesting fact. He explained that Earth was present in the 'glacial' stage a few thousand years ago and that due to change in its orbit, it had arrived in the 'interglacial' stage. The concern is that due to human intervention Earth may go to an even warmer stage. The Earth may have gone back to an Ice Age in another 20,000 years but due to human intrusion, we may shift to a much warmer climate. This will happen if the Earth crosses a 'tipping point'. A tipping point is one beyond which the climate of the earth will change. The 'tipping point' is expected to be somewhere around 2 °C above the mean temperature. A big shock was the ozone hole over Antarctica since there are no human activities over there. Professor informed us that following this, the Montreal Protocol was signed following which chemicals which depleted the ozone layer were not to be used and new chemicals were developed to be used in air conditioners and other devices. And over the last 30 years, the chemicals have been stopped using and the ozone hole will come back to normal in the next 30-40 years. A student then asked an intellectual question i.e. if the Earth were to pass the tipping point would the survival of humans be possible and would there be any safe zones on the earth for this? This was very well answered by professor that the tropic regions would be unlivable and that large animals such as elephants wouldn't survive. This is the reason environmentalists are warning world leaders of global warming. Drawing an accurate analogy, professor said that this is not like the COVID-19 situation which will be solved with the arrival of a vaccine, instead the only way to solve this is reducing the carbon dioxide emissions and there is no other 'magical' way to solve this.

Professor said that the major problem now was that since the developed countries already have the required infrastructure, their CO<sub>2</sub> emissions have remained constant over the years whereas developing countries like India, China etc. are increasing their industrial output and infrastructure due to which their CO<sub>2</sub> emissions are increasing. Professor says that the developed countries are responsible for the past generation whereas developing countries are responsible for the future generation. The only way out is co-operation. India's predicament is that it produces less than 6% of the global CO<sub>2</sub> emissions but it will face the greatest impact of global warming. Professor then showed us a cartoon depicting India as an 'elephant' sitting before the 'train' of the Paris Climate Summit and disproved that cartoon. Professor said that India is trying its best to reduce CO<sub>2</sub> emissions, it's due to development and increasing population that its emissions are increasing.

India, in fact has the lowest per capita carbon emission, lowest per capita meat consumption, lowest per capita energy consumption and per capita car ownership. Professor then reminded us of the great personality, Mahatma Gandhi who warned us of these events more than 90 years ago. Professor then enlightened us by telling that when Mahatma Gandhi went to England and saw the way of life over there, he said that "If all Indians were to live in this way, then the world would be destroyed". Developing countries need to avoid the mistakes made by

the developed countries in the past. They need to adopt new technologies to break the nexus between development and CO<sub>2</sub> emissions. Professor then told us about the study conducted by IISER Chandigarh. The crop yield in North India has gone down by about 50% due to ozone pollution (and this ozone is present at ground level not in the stratosphere). Professor said that though India's per capita usage of plastic was 11 kg whereas the global average is 28 kg. But even though India's usage is much lower than USA which uses 109 kg plastic per capita, it uses the same amount of plastic as the USA due to its population density being about 10 times higher. Professor ended his presentation by saying that since engineers have increased the concentration of CO<sub>2</sub> by discovering ways to generate power from natural gas, run factories and produce plastics, now engineers must discover ways to 'decarbonize' the economy.

Sir Vyankatesh thanked professor for the presentation which everyone truly enjoyed and it made us realize that work in environment and climate can be so interesting. The session was now open for questions. Professor answered brilliantly a very smart question i.e. how can ice melting cause rise in sea level as isn't its volume already accounted for in the ocean on which it floats? Professor explained that the ice that is floating isn't causing a rise in the sea level as it has already displaced that amount of water when it floats. It is caused when the land ice melts and the liquid water formed that flows to the ocean increases the sea level.

Professor answered a question asked by Sir Vyankatesh i.e. how does professor compare research at Stanford University and research at IISc. Professor said that some of best Ph.Ds. in IISc are as good as anywhere else in the world, the main difference is the amount of money available. Stanford has a corpus of 35 billion dollars. Because of such resources, they are able to do much more expensive experimental work. One who wishes to do high-end experimental research must travel abroad. However, Professor said that we are as intelligent as them, only our resources differ. The data gathered from such research is shared today. A person in India could obtain the necessary data from the internet and interact with any scientist anywhere in the world.

Prof. Srinivasan said that anyone who has come from abroad has told him that the faculty at IISc is as good as the faculty at institutes like MIT and Stanford. Modern research demands large group of people. A group of 100 bright people will conduct one breakthrough research. India is losing out in terms of scale as compared to other countries. This is changing and the scale of IITs are increasing. Indian students do find experimental research abroad more beneficial but they should come back to their country and contribute to the society.

Atharva Lotlikar, a student of Aryaan Study Circle, then proposed the vote of thanks.

Overall, the session gave us an insight into the topics of climate change and study of weather patterns. Prof. Srinivasan's experience, research, and his views on education shall be of immense help to all students. On behalf of the students of Aryaan Study Circle, I would like to thank Prof. Srinivasan for spending his valuable time with us and for enlightening us with such knowledge.

I would also like to thank Sir Vyankatesh Prabhudesai for organizing such sessions and giving us the opportunity to meet such eminent personalities from time to time and giving us the chance to imbibe the experiences of champions of their fields.

Written by,

Kushal Jain

Student, XI (regular) MAHSS