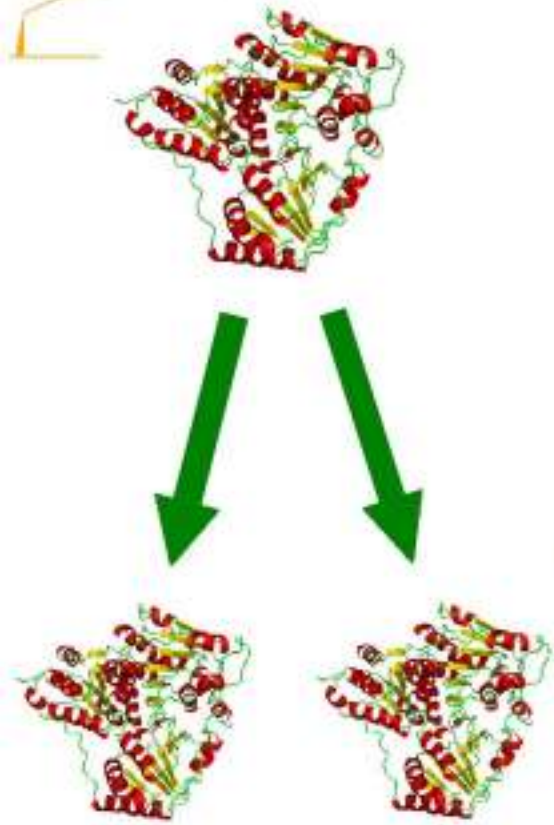
NERD

IITK

NOTES ON ENGINEERING RESEARCH AND DEVELOPMENT ★ AN IIT KANPUR STUDENTS' PUBLICATION



PROTEIN HOMOLOGY

THE PERIODIC SCIENCE

GLUCOBAND
A sigh of relief for Diabetic patients

Interview with Prof K. A. Padmanabhan

VOLUME 3 NUMBER 2
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MUSINGS from EDITOR'S DESK

Ever tried to figure out human faces in clouds, moon, or carve one out using sauce on a toast? You might have also seen dolls, but something is missing which makes you realize that the face, though seems similar to a human face, is not real and alive. Do you wonder what is that which creates this difference in perception of a living face and an artificial face? To give you a hint, try recalling the speciality in Bumble bee in famous Hollywood movie Transformers that gave it a look close to reality. Another hint, what was the concept which the director of movie, Tarzan, the wonder car incorporated to show the emotions of the car? If you still don't get it, let me give you the answer. According to a recent study jointly done by Thalia Wheatley of Dartmouth College and another graduate student Christine Looser, they found the following. When they morphed the images of various dolls after surveying various shops of New Hampshire through blending software, and then generating a continuum of intermediate faces that were part human part doll, they took views of various volunteers regarding the same. To their surprise, an average person considered a face to be alive when it had threshold of two-third portion of human and one-third of a doll. Another fact emerged concluding that eyes were also an important feature in determining life. All the transformers had emotions depicted through eyes and similar was the case with headlights of the wonder car which represented eyes.

The study may or may not be accurate, but this is what Wheatley says in the end, "I think we all seek connections with others. When we recognize life in a face, we think, this is a mind I can connect with". Now the question is up to you to ponder what the true fact behind the story is.

With this thought, we present you the new issue of NERD. We hope that you cherish the message of Dr. M.K. Harbola, ex project investigator, NERD has to the students. Also read what the author, C.P. Snow, had to say about the relevance of Humanities and Social Sciences back in 1993 and what the reviewer of the book has comments on the topic regarding the same. Apart from these, there are other articles of varied tastes.

Signing off,

In anticipation of your feedback,

Editors, NERD

Create, Communicate, Contribute!!!

Interview With Dr. Harbola

▪ Gaurav Krishna and Pranjal Nayak

Dr. M.K. Harbola has been in this institute as student and also as a faculty for almost one decade. Many students respect you for the way you have been teaching the Physics courses. You have been well known for pedagogical techniques adopted by you to become so effective in teaching. You did your postdoctoral research from the University of North Carolina, Chapel Hill, USA. You have worked at the Raja Ramanna Centre for Advanced Technology, Indore as a Scientist in the Laser Physics division. Many students respect you for the way you teach. You have written many research papers and articles on Electronic Structure Theories. You penned a book titled 'Engineering Mechanics'. You are currently developing electronic structure theories for excited states and you got a new way of doing this problem, which will really widen the horizon of theory of electronic structure . Here is a talk of NERD with Professor M.K. HARBOLA.

NERD: What is the most striking feature of IIT Kanpur you have ever noticed?

Dr. Harbola: Going back to the time when I came here as a student, the most striking feature of the institute was that it gave me a lot of opportunity to learn what I had not seen until I came here. Teachers were willing to discuss and argue on a concept rather than saying that we tell you so therefore this is so, and I believe this is still continuing.

NERD: You have received the Distinguished Teacher Award at IIT Kanpur and many students respect you for the way you have been teaching physics courses and taking tutorials. What pedagogical techniques did you adopt to be such a teacher?

Dr. Harbola:I expect students to 'think' rather than doing things perfunctorily. My emphasis is Think, Think and Think! It does not matter even if you take time of two days rather than one hour. Even if you make a mistake while thinking, it would be a classy mistake rather than a routine mistake. As a teacher I think like a merchant who looks around and finds as well as produces good and useful stuff, and tries to pass them to students. I try to give my students things which are interesting. Some students get interested in real classic problems that open up a subject, while others like to do current ones, such as trying to explain few phenomenon using whatever knowledge they have in a subject.

NERD: Sir, you have authored a book 'Engineering Mechanics'. What is your take on science education and what are your plans to promote the same?

Dr. Harbola: Lot of us do science because we are charmed by it. Having said that I do not believe in getting a medal for everything that you do; same for Science education. Learning science does not mean it should immediately give you something to develop a project. Doing science is a process via which we enrich ourselves and our society and as a consequence lots of good things keep coming out of it. If I keep looking for a useful result all the time, I think then the basic purpose is lost. We human beings are curious and want to learn new things and when we understand something, we may or may not develop something out of it.

NERD: Please elaborate our audience on your area of research and major contributions in the same.

Dr. Harbola: My research work is related to electronic structure theories that calculate how electrons are distributed in atoms, molecules, solids, materials and clusters, and how is this distribution affects their properties. A theory that has been popular for the past thirty years for such calculations is density functional theory. I have mainly worked on the fundamentals of this theory, trying to develop new ways of calculating the electronic structure especially for the ground state. I have been trying to develop it further for excited states for the past 7 years. Right now we have a very good lead in the theory for excited states and I would continue work on the same in near future.

NERD: You have worked at the Raja Ramanna Centre for Advanced Technology, Indore as a Scientist. How are High Energy Physics centers in India, such as Institute of Physics (IOP), Physics Research Laboratory (PRL) etc. involved in international scientific research?

Dr. Harbola: Raja Ramanna Center for Advanced Technology works on development of lasers and accelerators for research on materials and medicines. It supplied superconducting magnets to the Large Hadron Collider at CERN. I believe such centers are doing well on international scientific research front, but they are not involved in teaching. That is a loss. As someone wrote long ago that you are not a good scientist until unless you produce a one thousand like you – that part is still missing with such centers.

NERD: You are also a part of the Academic Review Committee 2009 which has suggested ways to promote undergraduate research. What is your take on the promotion of research among students?

Dr. Harbola: The concept of undergraduate research is a new one and the involvement of students is certainly increasing, but I really do not understand so far how seriously is it taken by students- do the majority of undergraduates do it to build up their CV or they really are interested in it?

I believe that undergraduate research should build on what

students have been learning in the class and the questions they have been asking to clarify the concepts. At undergraduate level, I would emphasize on a project that makes their fundamentals clear and see how these fundamentals can be applied to generate new ideas. It should be more like widening you horizon and exploring things further. You need to see how someone thought of such an idea, and if you are reasonably smart, it should hit you how come I did not think along these lines and how come this guy thought about it. For example, if you are doing a course on thermodynamics, you can take entropy and can explore how it changed the perspective and

I believe that undergraduate research should build on what students have been learning in the class

thinking of people. I will not call it research, I will rather call it exploration and that is what I would encourage undergraduate students to do. When you do exploration, it's not always necessary that you will get an idea that will lead to new thinking. For example, some time ago, I asked students to find out how to observe that Coulomb's law (i.e. force between charges varying as 1/r2) and what would have happened if the force depended on r as 1/r 3/2 or 1/r 5/2 .This is a interesting problem related to what they are studying and should be fun. At undergraduate level I do not expect students to work on my current research projects; for that I should first train them a couple of years.

So, Undergraduate research is a different ball game; we are taking it as a Ph. D. research diluted a bit and that is not good. For undergraduate research we need a different paradigm. Of course if a student is interested and willing to spend time, they can always do the research at higher level but that requires a much longer commitment in terms of time and cannot be done over a semester or a summer term.

NERD: You have been quite particular in case of attendance dropping in the lectures and the tutorials. This is also one of the major issues discussed in the Academic Review Committee 2009. What do you feel is/are the possible reason(s) for the same? And don't you think that making attendance compulsory is a philosophy like 'You can lead a horse to water, but you can't make it drink'?

Dr. Harbola: That's what I feel if you do not have motivated students why force them to come. I have experimented with taking regular attendance and also with not taking attendance. But let me show you a different prospective on attendance. When I come to IITK as a faculty member and you come as a student, we have a deal with each other. The deal is, I will give you my best and you give me your best and that way both of us grow intellectually. For that we have to interact regularly in a class. I look forward for a good question from students. Question that I may not have thought of; after all one person can't think of everything. Teaching is that way satisfying because you are thinking with other seventy people. However, if students are not attending the classes and not making a teacher think hard, I think then they are not fulfilling their part of the deal. That is one thing. The other side of the story is if students are not motivated, what do I do? I mean a class of students with low level of motivation is more of a disturbance than anything else. One thing I strongly feel about is: suppose you are a young faculty member, 29 or 30 years of age, who has just finished Ph.D. or post doctorate. In preparing for your class, you think of really good students, you work really hard for each lecture, putting in five to six hours to prepare a good lecture. Then you come to the class of 150 and you find ten people, slowly the number increases to 20 -30. Would you not feel really discouraged? By not attending the class, are the students not doing a disservice to that teacher? Five years down the line, he may not care; if he does not care, such students have managed to spoil a system. Our teaching system is dynamic system in which students should be contributing. Students' duty is not just to attend the classes and learn but also to create an environment. I think that is where students are failing, i.e. in creating an environment which is conducive to intellectual growth of the place. Thus I would expect that if a teacher is not giving his/her best to the class, push them to work harder; as students of this place you have full right to do so and in the process you also help in maintaining the standards that IITK is known for. This is something students cannot do unless they come to the class.

NERD: Sir what changes on personal note you will recommend in present curriculum and system?

Dr. Harbola: I think, what happens is, things evolve with time, and you can't suddenly change them. In the class, I keep evolving the material that we cove as the course progresses. We evolve continuously. I would like to say what my post-doc advisor told me when I asked him how you do things; he said you feel your way through. In academics, we have certain guidelines, for example we have a semester of 14 weeks, we have certain course structure, and then you evolve with time within this structure if you are observant. I cannot tell you five or six changes all of a sudden but what I think is, the students should concentrate on fundamentals in which they are lacking.

I think that students are failing in creating an environment which is conducive to intellectual growth of the place

I used discussion hours for giving reading assignments because reading and communication skills are really going down. As a student you can solve a problem in five steps but when you are thinking you don't use mathematical terms, you use language. When you are not good in communication and at language, you can't think properly and your thinking power will go down until unless you are very strong. You should be able to couple words together and play around with them. So the meaning will change and you will come up with new theories and ideas. That's how it works. So I will make changes to make students more communicative rather than just getting the answer, more thinking and somehow we should work towards that.

NERD: You did your postdoctoral research from the University of North Carolina, Chapel Hill, USA. What difference do you see in the quality of education as well as the techniques employed in imparting it to the students in USA and in India?

Dr. Harbola: At undergraduate level, talking of IITs, there is not a big difference. I think we are doing well and we should not give it up .There is a lot of talk that we have been very stressful and we drive students to work very hard. I don't know whether it is true or not because in the past, the studies were much harder and if you look at good universities they believe in making students work very hard. This is an age where one can work really hard because one has a lot of energy. I think that the stress has come because of students now having a lot of diversions in terms of doing many activities, so that point should not be taken to that we are teaching too much. For other universities, I can't comment upon because I don't know how teaching is done there.

NERD: You just said that the stresses come because of students now having lot of diversions in terms of doing many activities. Could you elaborate on it further? Are you talking of doing other activities at the cost of academics?

Dr. Harbola: I think that for a balanced life you do one main activity and around it you do many other activities. If I talk about some good university even in India, doing things like music and fine arts would come as an extra course or you take it as a course of some department. Then it becomes part of the curriculum and so there is no extra load. However, here it becomes an *add-on*, you are doing your studies and on top of this you do all these things. So you are stressed. Activities are for you to grow fully as a person and to have a well balanced life. Again it becomes a matter of majority and minority, majority of students are getting involved in too many activities with studies becoming secondary. Another thing that I feel bad about is that when I asked a couple of students about the hostel environment, for example if there is a student who is really falling behind in academics, is the environment such that others will pull him out, for this their answer was negative.

NERD: There have been activities like galaxy since you were a student these are again back what the difference you see in that time and this time and how would you like to reform your just made statements on extracurricular activities?

Dr. Harbola: Extra-curricular have to be taken in one's stride; you should do them just as going along. For example, it is like when you eat in the evening you don't make a big feast out of it every time. Similarly these activities should not be on big scale, these things should not be done with the sole aim of writing it on CVs. It is like if I am playing something, I need not be very good player, I do it because I feel good about it. I am doing plays; I am doing music because I get joy in doing so. Once a year somebody may appreciate it. There should not be competition every day; I need not to win battles for everything. If you have intelligence, capabilities and others, it implies that you will enjoy life, it will not overburden you doing things, and everything need not win you a medal. I think students should not be in such race. It is said that if you win a rat race, you will still be a rat. So, why be in it!

NERD: Sir, you have been warden of an undergraduate hostel. What are your views on sudden decline of interaction among students in the last decade?

Dr. Harbola: I was warden of Hall-2 for three years, the problem is, that younger people today think that who are you to tell me something, without realizing that the person, who is telling, you is actually thinking about you. You may not like his techniques, you may feel he is old fashioned but at least listen to him, at least think about what he is saying. One is not saying do precisely what he said, but think. So, constantly, what is happening, is, one does not feel like telling do this, do that. Youngsters feel that the advice is from an elder. The younger people think that they (elders) are unnecessarily interfering with us. So, they keep away, therefore the distance between the faculty and students increases. I think if you are just willing to listen to others, things will be all right. If somebody talks, may be out of ten sentences only one makes a difference in the way you think. Even then he is done his job and you have really benefitted from him. Every sentence does not have to count.

Extracurricular should not be done with the sole aim of writing it on CVs

Related to this, I would like to say one more point related to attendance. One says the class is boring, he hardly does anything. One thing similar to what I've just said is, in the entire class if fifteen minutes worth of have you gathered and you learnt something new, that is what I think worth. It is not always that whatever you do, hundred per cent of it is useful to you, it just adds.

NERD: Please tell us about some of your most interesting experiences in class. Which course did you enjoy the most while teaching at IIT Kanpur and why?

Dr. Harbola: I enjoy teaching, so any course is fine, because I again look at it as a way of interacting with students and thinking together. So, the process of thinking and exploring is really enjoyable. In that way, any course is fine.

What I have learned over the years, it's my personal experience, that teaching is really a very noble profession and if I give my best, sometimes there can be hick ups, but most of the times you get a reward seeing the faces of students lit up due to the work one puts in.

One particular experience I share with people is of a class of repeat physics 101 and first two lectures had gone really bad, I felt really down, I was not able to convey anything; and I thought where have I been caught and what I was going to do with this class. I went home and thought, "This is the class that I have got. If they are not getting interested then probably it's my fault. If they are not seeing things the way they should, because of whatever reason, I should make them interesting. And after that I worked really hard and suddenly the communication with the students went up. We showed many demonstrations, explaining things

many times. In the end, the survey and the comments, I found, were really gratifying. I said this is a noble profession and it gives you such rewards.
Another incident is related to Ph.D. scholars, I had been taking the class for la few weeks but I had not seen any good progress. I talked to Head of my department that how had the admission committee selected these students. He told me that the committee had seen some spark in them. So I thought "these students have some spark but they are not making progress because of lack of exposure" and talked to the co-instructor about it. So, we decided to double the number of classes to give them more exposure. We were supposed to be doing 4 sessions per week, I asked to 8 per week and somehow we settled to 6 per week. After some days the results were really good. So, as I said this is a noble profession, If you are doing your best, you will get the reward now or sometimes 10 years after when any student will come and tell you, "Sir, I have been in your that class and it was really worth taking and really goes very well." That's what a person is looking for. In this profession it is more about giving.

NERD: No platform exists in IIT-K where people working on various research areas can write for the general audience other than NERD. Being the project investigator of the magazine for the past two years, what suggestions would you propose to improve it?
Dr. Harbola: As I said earlier if a student is doing undergraduate research, it becomes a good general audience topic. Suppose if I am doing a research on quantum chromo dynamics and someone asks me to write that for general audience sometimes it is not possible. When you are doing exploration as an undergraduate student, you are capable to convert it for general audience. So I think it is more to do with what people can understand than what I do, communicating at that level, raising questions at that level. So, it's the matter of choice of question or problem for which I want to write about than the level at which I want to talk about it. For example, it is better write on environment then writing about a project just being done on moon exploration. So, it's the case of choosing the general topic. NERD has been popular because it addresses the topics of general nature.

NERD: Describe Dr. Manoj Kumar Harbola in one line.
Dr. Harbola: I am trying to be as honest as good as human being is possible.

NERD: What is your final message for the students?
Dr. Harbola: You have a lot going way for you, don't let it go waste. If you are good, most of you are good intellectually, being an endowed with gift that God gives to very few people, use it properly to lead to a good life and to make society better.

About the Interviewers

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The Periodic Science

• R. Loganayagam

When Primo Levi had to find a title for his book of short stories, he chose the title as Il Sistema Periodico - 'the Periodic Table'. It is a grand metaphor that captures in one stroke the diverse hues of life and a strange pattern running through it all. The periodic table, as we know, historically emerged out of human temptation to classify in order to comprehend - and that human intuition is often quite valuable in Science especially when there are deep patterns which lie undiscovered.

Periodic table, if you remember, has a curious structure - the elements of the chemical arena fall into distinct 'periods' sprawling across 'groups' that broadly describe their respective chemistry. The periods, as our school textbooks loved narrating, were initially thought to be determined by atomic weights - and only later did we realise that what matters is the number of electrons. To put such a picture of chemistry together, we had to take a long road hitting upon a lot of blind alleys before we saw light - a familiar story in the pursuit of any kind of knowledge. Now, what I am going to describe in this article is a curious structure of similar beauty and elegance which describes the realm of particle physics

and has an unimaginative name "the standard model".

What is the standard model? It is the best answer to the question - "How do things look like at smallest lengths that we have probed?" If you see the whole world that we see around us as chemistry, then in one sense, the standard model is its next periodic table. To be more precise, it is more like the periodic table at the times of Mendeleev - there are strong reasons to think that its structure is incomplete and even if we limit ourselves to the known structure, we do not know where that structure comes from. Further, to complete the analogy, some "elements" that it predicts still remain undiscovered. But, before stepping into the mysteries of the unknown forest, let us admire first the rivers and the grasslands of the known.

Standard model is a set of principles that describe the exotic chemistry of matter at very small length scales and at very high temperatures. As all of us probably know, any matter including you and me sufficiently heated will eventually vaporise into atoms and molecules. If the temperature is further increased to gigantic proportions, they ionise and all we are left with is electron and nuclei made of protons and neutrons. If you go on further increasing the temperature, at some point the protons and neutrons themselves melt into things called as quarks and gluons[1]. And standard model confidently predicts that there is yet another \melting" waiting for us to discover at higher temperatures – melting of something called the Higgs field.

The aim of this article is to talk about the different particles that make up the standard model. But, before that, I will first tell you about the different ways that these elementary particles "react" with each other. I put the word "react" within quotes, because in the particle physics, particles do not just react in the chemical sense, they get created and destroyed too. So, people prefer to call these as processes rather than reactions. Almost all processes can be classified into two broad classes - the ones that are of electroweak kind and others are of strong kind. Though the analogy is not quite perfect, you can think of them as somewhat analogous to the division of chemistry into the organic and the inorganic.

In this classification, all known reactions of the conventional chemistry will fall under the class of electroweak processes. The usual chemical reactions happen basically because of the electric force between the various ions and electrons. Every electric force has of course a corresponding magnetic force associated with it. To explain the world that we see around us, the Standard model has some twelve different kinds of 'electric' and 'magnetic' fields analogous to the fields we know - four of them are responsible for electroweak processes and the other eight for the strong processes. As you can imagine, twelve is really quite a large number of fields and one of the outstanding problems in particle physics is to explain why there are so many different kind of fields in nature causing these processes.

As if that were not enough, the standard model predicts a third class of processes - those that are associated with the name "Higgs". Standard model predicts that there is a kind of matter which has in one sense condensed every- where around us (and inside us) somewhere in the first few picoseconds after the Big Bang. This phase transition is one of the central themes of the standard model. For example, any answer to a question like why electrons have a mass of 9.1×10^{-31} Kg should begin with an understanding of this condensed phase. And it is absolutely crucial in order to understand why among the four electroweak fields; only one of them can be felt at the ordinary human scales.

Unfortunately, all our knowledge about this third kind of processes come from the study of their indirect effects - mainly because any direct study would involve at least melting this condensate locally and we have not yet been able to create the high temperatures required to do that. In what is arguably one of the greatest experiments that mankind has ever devised, there is a new machine called the LHC (the Large Hadron Collider) where people think we would be able to break that barrier and study these processes directly. Since I do not have a lot of space here, I will do to LHC what I did to RHIC, and just refer to the many videos already available on-line [?, ?]. Now, we are ready to go into the details of the different elementary particles that make up the standard model. First of all, every single one of these elementary particles comes with an 'antiparticle' which has exactly the opposite charge. Now, there is something like ninety-six elementary particles and anti-particles and obviously, I am not going to list their names.

But, what I will do is to describe for you the general structure of the standard model. As I had already said, the standard model looks and feels very much like the periodic table. First, the 'elements' (called as 'elementary particles' in this case) fall into three 'periods' (called as 'generations'). Like the periodic table, the particles in the second generation are generally heavier than the particles in the first generation and so on - but there are many glaring exceptions to this rule. In fact, in case of particles called neutrinos, we are not even sure which way the trend goes. This structure which mimics the basic 'row structure' of the periodic table is one of the deep puzzles in the standard model. Nobody knows where it comes from or why there are three generations - it is a mystery not very much unlike the mysterious structure of the periodic table a century and a half ago.

Then there is the 'vertical' structure which is analogous to the 'column structure' of the periodic table. The columns of the periodic table, if you remember, are the different groups - from alkali metals, alkaline earth metals to halogens and noble gases. This classification is a crucial theme in the

[1]This "melting" itself is a process that we do not understand well enough. One of the most important physics experiment that study this form of matter(called the Quark Gluon Plasma) is the so called Relativistic Heavy Ion Collider (RHIC in short). I did not have much space to talk about it here - but, fortunately, there are already many good articles and videos on RHIC catering to a general audience[?, ?, ?, ?].

[2] In case you are interested, I have put a short note at the end of this article explaining how this classication is done.

explanatory beauty of the periodic table - it tells you which elements react violently and which are mostly inert, which elements form metals and which ones do not. The standard model has a similar explanatory splendour that comes out of classifying the elementary particles into what are called as different 'representations'.

The 'representation' a particle lies on tells us how it reacts in the strong and the electroweak processes - it tells us for example, which particle would decay flamboyantly in the ash of the moment and which particle would, like the noble gases, remain silent and pass by without much ceremony. About three-fourths of particles (called 'Quarks'), for example, take part both in strong and the electroweak processes whereas the rest of the one-fourth (called 'Leptons') just take part in the electroweak processes.

All known particles of the standard model fall into five different representations[2]. Again, nobody knows where these representations come from either -it is just a simple classification which captures the essence of countless observations. But that is all it, these five representations repeated three times one below the other along with the various processes that they undergo summarizes the complete structure of the standard model. The standard model is the ultimate essence of our current state of knowledge about the extremely microscopic realm. However, it is time to remind you that the standard model is not everything! It is indeed the periodic table for the chemistry of everything that we see around us but there are two glaring exceptions to that statement. One is gravity - one great trouble in the standard model is that it is unclear how gravity fits into the rest of the picture. Next, the standard model has nothing to say about a lot of other stuff which seem to be completely transparent to all known probes - stuff which we know exist only because we can measure the gravitational fields produced by them. Even forgetting these shortcomings for a moment, there is a great structure to standard model with its vast array of elementary particles and weird kind of reactions - a structure that humanity has only discovered quite recently. And we do not know where that structure comes from - as I said, we are standing again at the times of Mendeleev - we stare at an elegant structure that experiments have led us to and we do not yet know the explanation for that structure. As we stand at the twilight of new discoveries, one cannot help but wonder how the pursuit of knowledge is itself like a periodic table - every new period comes with new elements and new chemistry but every new period also comes with poetic analogies to the old.

Ponder Yonder

[1. The Scientific American article on RHIC, "The First Few Microseconds"
http://www.sciam.com/article.cfm?id=0009A312-037F-1448-837F83414B7F014D

2. RHIC videos at
http://www.phenix.bnl.gov/WWW/software/luxor/ani/

3. RHIC Website - http://www.bnl.gov/rhic/

4. Physics Today article on RHIC
http://www.physicstoday.org/vol-56/iss-10/p48.html

5. Large Hadron Collider - The Search For The Higgs

Part 1
http://www.youtube.com/watch?v= fJ6PMfnz2E

Part 2
http://www.youtube.com/watch?v=MQNPpeVvZ9w

Part 3
http://www.youtube.com/watch?v= XbKZwXK-3c

6. LHC videos at
http://lhc-machine-outreach.web.cern.ch/lhc-machine-outreach/lhc-video-links.htm

Endnotes: Various Representations in the Standard Model

As mentioned in the text, all known particles of the standard model fall into five different representations arranged in three generations. In this end note, I will tell you what these five representations are and what are the basic rules which tell you how they react.

In fact, there is a neat way of representing the particles in each generation which makes this classification an extremely easy thing to learn. That way goes like this - every particle is represented by a string of five plus-minus signs, which is basically a binary code for each particle in a generation. If the product of all the signs comes out to be +, then call it a particle, the corresponding antiparticle can be got by changing all the +'s into -'s and all -'s into +'s. For example, (- + - - -) is a particle called the left neutrino and (+ - + + +) is its antiparticle.

The last three slots for any particle represent how it reacts in strong processes. The basic rule is simple to state - calculate how many different permutations are possible with the last three plus-minuses. Sometimes there is just one permutation - this happens, for example, if the last three slots are either +++ or - - - . In that case, the corresponding particle simply does not take part in strong processes - such particles are called `Leptons'. The left neutrino that I mentioned above, for example, is a lepton.

In other cases where three distinct permutations are possible, you get particles which do take part in strong processes and such particles are called 'Quarks'. It is now a simple problem in counting to determine that one fourth of particles in each generation are leptons and the rest are quarks.

The behaviour of particles under the electroweak processes is slightly more complicated. To understand it, it is better to divide the electroweak processes into two types - the 'weak processes' and 'the hypercharge processes'. The rule for weak processes is exactly like the rule for strong processes. The first two slots on the 'particle code' tell you how a particle reacts with the weak processes - if the number of distinct permutations is two, then the particle reacts else, it does not. It is easy to determine again that this criterion divides each period into two equal halves.

The rule for hypercharge processes is slightly different - first you find out a number called as 'hypercharge' - it is defined as the average of the first two slots added with the average of the last three slots. For example, the particle

(- + + - +) has a hypercharge (- 1 + 1)/2 + (1 - 1 + 1)/3 = 1/3. The particle takes part in hypercharge processes only if its hypercharge is not zero.

Now, we are ready to classify elementary particles into different 'representations'- the analogue of different groups in the periodic table. I will just classify the particles (the ones where the signs in different slots multiply to a +) and leave it to you to extend it to the anti-particles. There are in principle, six different representations

1. A sextet with six particles having hypercharge 1/3 - the particles are (- + - + +); (- + + - +); (- + + + -); (+ - - + +); (+ - + - +) and (+ - + + -).
2. There are two triplets - one triplet with particles (+ + + - -); (+ + - + -); (+ + - - +) each having a hypercharge of 2/3. The other triplet (- - + - -); (- - - + -); (- - - - +) has a hypercharge -4/3.
3. There is one doublet with particles (+ - - - -) and (- + - - -) having a hypercharge -1.
4. There are two singlets with one particle each - the particle (+ + + + +) with hypercharge 2 and the particle (- - + + +) with hypercharge 0.

But, the experimental evidence for the particle (- - + + +) called the right neutrino is quite indirect and so most people leave it out and say that there are five representations in the standard model - one sextet, two triplets, one doublet and one singlet with hypercharges 1/3 ; 2/3 ; -4/3 ; -1 and 2 respectively.

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Wide Area Monitoring Systems

A Stitch in Time

▪ Ranjana Sodhi

With the continuous development and increasing complexity of power system networks (the meshed network for transferring the electrical energy from generating plants to the substations, located near the end users), monitoring of its dynamic behavior is becoming increasingly important. This requires accurate power system measurements, provided at a faster rate than what is currently provided by the traditional Supervisory Control and Data Acquisition (SCADA) systems. In a highly interconnected and geographically dispersed grid, not only high accuracy of the measurements but their time synchronization also becomes one of the requirements to have a wide area picture of the network. With the advent of Phasor Measurement Units (PMUs), effective wide area monitoring of the power system has become technically viable. This article throws some light on the emerging synchrophasor technology based Wide Area Monitoring Systems (WAMS), and recognizes the advantages it opens for the present day power systems.

1. Introduction

The modern power system is one of the most essential infrastructures today, required for the economic growth of a country, which has been continuous for quite some time. While the traditional Supervisory Control and Data Acquisition (SCADA) architecture has been utilized for several decades to provide steady state health of the power system, it's utility in detecting dynamic changes in the network and preventing severe blackouts is limited. This limitation of SCADA system has laid the foundation to the development of Wide Area Monitoring Systems (WAMS).

Wide Area Monitoring System (WAMS) is essentially based on the new synchrophasors' based data acquisition technology. Conventional Remote Terminal Units (RTUs), forming part of SCADA system, are capable of acquiring Root Mean Square (RMS) values of currents and voltages but does not record the corresponding phase angles. The phase angle contains valuable information about the state of the grid, and time synchronized synchrophasor based WAMS can collect this additional information along with the magnitude of voltages and currents. A WAMS consists of geographically dispersed Phasor Measurement Units (PMUs), which provide the phasor measurements in the power system networks. The measurements include both magnitude and phase angles of voltage and current signals, and are time-synchronized via Global Positioning System (GPS) with an accuracy of 1 microsecond. The phasors, measured at the same time instant, provide snapshot of the power system network and by comparing the snapshots of two consecutive time instants with each other, not only the steady state but also the dynamic state of the critical nodes (substations) in the system can be monitored. Thereby, a dynamic picture of the critical nodes in the network can be achieved.

2. Synchrophasor Technology

PMU is the foundation stone of synchrophasor technology, and is defined as *a device that provides as a minimum synchrophasor measurement for one or more phases of an AC voltage and/or current waveform.* The synchrophasors can be single phase or symmetrical component values.

Figure 1 shows the block diagram of a typical PMU. The GPS receiver provides 1 pulse-per-second (pps) and a time-tag (time stamp), which is synchronized to Universal Coordinated Time (UTC). The analog signal is derived from the voltage or current transformers' secondary side and this input signal)(*tx*is sampled at a variable or constant frequency depending upon nominal power system frequency. An analog anti-aliasing filter is used to limit the bandwidth of the input signal to be compatible with the sampling frequency chosen. Further, a digital filter may also be used to provide a band-pass filtering and removing frequency components that may create problem for specific applications. Finally, the sampled data is used to estimate the synchrophasors, and the most commonly used method for estimating the phasors is 1-cycle Discrete Fourier Transform (DFT).

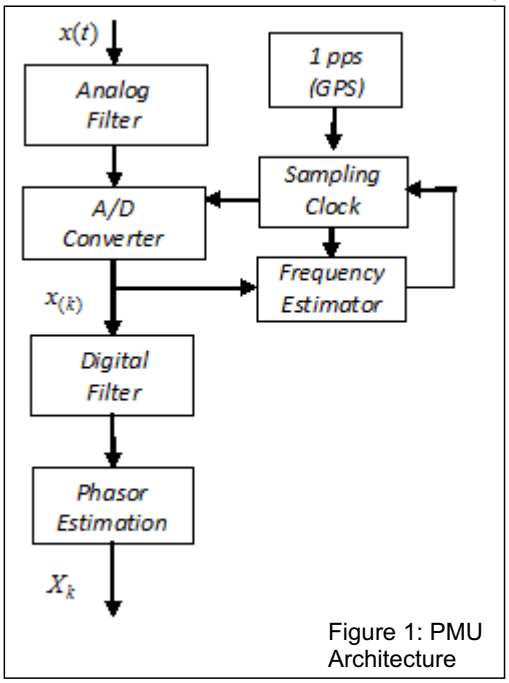

Figure 1: PMU Architecture

3. PMU based WAMS Implementation

Enhancements of power system security can be achieved by developing an on-line environment, where the control center operators might be able to monitor the dynamic behavior of the system in real-time, recognize threats to the integrity of the system, evaluate and implement suitable control actions. These goals can be achieved by PMU based WAMS implementation. The following sections highlight the requirements of WAMS, followed by its design architecture.

3.1 Requirements for Wide Area Monitoring System

The existing SCADA/EMS (Energy Management Systems) system focuses on the steady state operational requirements, and is

not able to effectively catch the dynamics of the system. Evolving cascaded outages, which might lead to the frequency, short-term or long-term voltage instabilities or transient angle instabilities are not satisfactorily covered by the conventional solutions as these instabilities build up along with a dynamic unfold of the system status. Therefore, it becomes increasingly essential to integrate synchrophasor based WAMS with the existing SCADA systems so as to provide,

- Dynamic measurements and representations of events
- Wide area system view
- Coordinated and optimized stabilizing actions
- Handling of cascaded outages, etc.

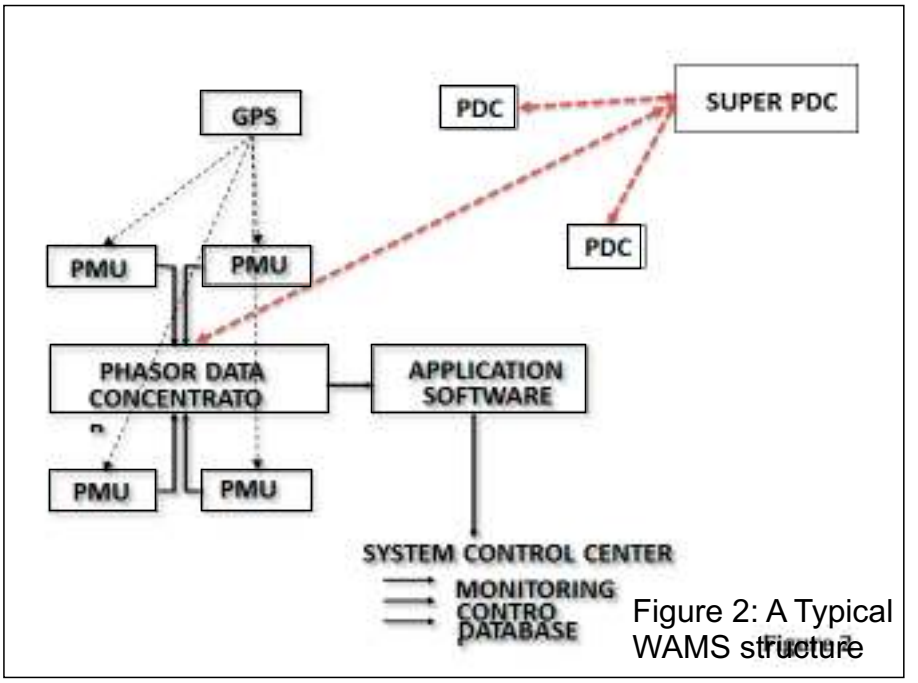

Figure 2: A Typical WAMS structure

3.2 Design of Wide Area Monitoring System

Figure 2 depicts the concept of WAMS. The PMUs, installed at various locations in the power system, measure voltage, current phasors (having both magnitude and phase angle) and frequency using the Discrete Fourier Transform (DFT), and can detect transients within milliseconds of their occurrence. PMUs then communication with a central monitoring station which is called the Phasor Data Concentrator (PDC). The typical functions of the PDC are to collect data from several PMUs, reject bad data, align the time stamps and create a coherent record of simultaneously measured data from wider part of the power system and provide it further for the applications.

The communication links, used by WAMS, include both wired (telephone lines, fiber optics, power lines) and wireless (satellite) options. The decision of using a particular communication link is mainly influenced by the communication delay that the link adds to the overall measuring system and the infrastructure costs involved in setting up the communication link. The total link delay is summation of fixed delay, associated with transducers used, DFT processing, data concentration, multiplexing, etc. and variable delay, which depends upon the amount of data transmitted, medium of communication and physical distance between transmitting and receiving end. Assuming an average propagation delay of 25 millisecond for fiber optics, power cables and telephone lines, total link delay associated with different communication channels is listed in Table 1.

3.3 Applications of WAMS

The applications of the data, obtained in PDCs from various PMUs in WAMS, can be broadly categorized into two types. First type of applications is the one which can be implemented based on phasor measurements, available from few key nodes. Some of such applications include:

1. Enhanced state estimation
2. Voltage stability monitoring
3. Oscillatory stability monitoring
4. Line temperature monitoring
5. FACTS set-point optimization using feedback control

The other category involves the case when PMUs are optimally placed in the power system network and result in full observability of the power system network with only phasor measurements. Applications resulted from full observability include:

1. Enhanced state estimation
2. Real-time congestion management
3. Real-time monitoring and control

Table 1:Synchronised Phasor Estimation Errors

Error Cause	*Error in degree*	*Error in microsecond*
Time synchronization	*0.0216*	*1*
Instrument Transformer	*0.3*	*14*
Phasor Estimation Device	*0.1*	*5*

The present power systems are still far from having such a rich phasor measurements configuration. However, looking at the wide popularity of WAMS, it is likely to have optimally placed PMUs in the networks, which will completely observe the power systems with only phasor measurements.

4. WAMS Initiatives In India

The Indian power system, with installed capacity of about 162 GW (as on 30th June 2010), is growing at an accelerated pace. In India, large generation addition is taking place. Continuous expansion of the grid, through increasing grid connectivity, has made the power flow in multiple directions, coupled with wide variation in generation as well as demand on a daily or seasonal basis. With the above features in view, it is important to know the dynamic state of the grid in terms of voltage stability and angular stability, how much increase in transfer capacity can take place at different instances on various transmission corridors, control and regulation of power flow. It is also important to identify what corrective actions can be taken in the event of a severe contingency and how various corrective actions can be implemented in real-time. These issues call for the development of an intelligent grid in India, comprising of WAMS.

For achieving the above stated objectives, POWERGRID, the central transmission utility, has already initiated the work for the development of an intelligent grid comprising WAMS, for dynamic state estimation and control purposes. The following staged approach is adopted.

1. In the first stage, a few PMUs are to be installed at critical buses (substations) in all the five regional grids. Output of these PMUs can be used to validate the offline simulation models, especially exciter and governor characteristics of large generators. PMU output rate can be one phasor measurements every two to five cycles. PMUs to be installed shall comply with the IEEE standard C37.118. Based on PMUs' output, a common state estimator is to be developed by combining regional state estimators.
2. Based on the success of stage-1, more PMUs will be installed by optimally placing the PMUs at various locations in India. All the PMU data will be stored in different PDCs through an optical-fiber communication link. Further, data from various PDCs will be collected in a central location and used for further applications.

Apart from Power Grid Corporation of India Ltd. (PGCIL), some of the state transmission utilities have also shown interests in adopting the WAMS technology and installing the system, initially at pilot test level, in their grid.

5. Related R&D at IIT Kanpur

The Synchrophasor technology related research at IITK started in 2007. The R&D involved covers the following topics:

1. Optimal PMU Placement
2. Phasor Assisted State Estimation
3. Transient Phasor Estimation
4. Machine Rotor Angle Estimation using phasor measurements
5. WAMS based Transient and Small Signal Stability Assessment
6. Synchrophaser based voltage stability assessment
7. Wide Area Measurement based Adaptive Distance Protection
8. Optimal Frequency and Voltage stability based load shedding

The extensive work of developing the Synchrophasor Lab is also underway, where the aforementioned algorithms, developed by the research scholars, will be tested and validated in real-time.

6. Conclusion

With the advancements in communication and information technology and the ever increasingly need of wide-area visibility for power transmission networks, synchrophasor based Wide Area Monitoring System (WAMS) is getting deployed around the globe at an accelerated pace. This article has revisited the concept of synchrophasor technology based Wide Area Monitoring System. It described how WAMS can be used to solve some of the existing problems and can give a better understanding of the power system's dynamic behavior.

Due to increased size of Indian power transmission network, it is necessary to deploy the synchrophasor assisted WAMS in order to monitor the power system dynamics and take fast control actions under emergency conditions. A few initiatives have already been taken in India in this regard. The experience of many countries, which have successfully deployed WAMS, shows a promising future of WAMS in improving the power system operation, protection and control. The technology has certainly proven to be a stitch in time in order to save the power systems from severe blackouts.

Ponder Yonder

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Structural Engineering: A Key to Development of Nation

▪ Aditya Dutt and Shashank Pathak

Structural engineering is a vast field and has its application in almost all the important engineering structures, that's why a structural engineer has to be very competent, decisive, efficient and quick decision maker. He has to make all the decisions keeping in mind the fact that how his working is going to affect the economy and safety of the resulting structure. The duties of structural engineer become more critical in nature as he always has to fulfill the obligation of related codes, standards, specifications and to follow all the stipulations of the same in a short and predefined frame of time with reasonable accuracy. Structural engineers should always contribute towards the growing economy of the country using their skills, knowledge and capabilities .This is one profession where an advanced level degree is more a necessity than an option.

The visible signs of shortfalls in capacity and inefficiencies include increasingly congested roads, power failures, and long-waiting lists for installation of telephones and shortage of drinking water which illustrate the widening gap between demand and supply of infrastructure and also raise questions concerning the sustainability of economic growth in future. Civil and structural engineers do all sorts of work with roads, harbors, airports, hospitals, power stations and they need to reduce the environmental impact of all projects. Sustainability is not just a buzzword it's essential for survival.

How can we as structural engineers contribute to sustainable design in the future?
First, we cannot be passive about sustainability. We are uniquely positioned to take a seat at the table and have a strong, compelling voice. In other words, we must explain the impact on the community-at-large, to the community-at-large.

Second, we need to be strong advocates for education. We must be moving toward collaborative and interdisciplinary project work. The best structural engineers of the future will need to see the interrelationships and their value among the entire project team.

Third, we can't fear conversation about the legal side of building codes. We need to support performance-based ordinances. We need to push for sustainable solutions that are serious, safe, and non-traditional.

The future of sustainability will not be about leadership in Energy and Environmental Design. The future will be about the whole building envelope and its inherent design that reduces our carbon footprint.

Environmental issues are coming to the fore. Buildings are big polluters so engineers are looking for ways to make them better. There are two lines of attack: during construction, by using sustainable materials, minimizing waste and disposing of waste responsibly; and during the life of the building, by making the mechanical services more efficient. A sustainable building, or green building is an outcome of a design philosophy which focuses on increasing the efficiency of resource use energy, water, and materials while reducing building impacts on human health and the environment during the building's lifecycle, through better sitting, design, construction , operation, maintenance, and removal. Green buildings should be designed and operated to reduce the overall impact of the built environment on human health and the natural environment by:

1) Efficient use of energy, water, and other resources

2) Protecting occupant health and improving employee productivity

Building materials typically considered to be 'green' include rapidly renewable plant materials like bamboo as it grows quickly and straw, lumber from forests certified to be sustainably managed, ecology blocks, dimension stone, recycled stone, recycled metal, and other products that are non-toxic, reusable, renewable or recyclable .The EPA (Environmental Protection Agency) also suggests using recycled industrial goods, such as coal combustion products, foundry sand, and demolition debris in construction projects. Polyurethane heavily reduces carbon emissions as well. Polyurethane blocks provide more speed, less cost, and they are environmentally friendly. Building

materials should be extracted and manufactured locally to the building site to minimize the energy embedded in their transportation.

If we consume fewer resources for a building of similar strength then we are doing well for the environment. This is a particular strategy of sustainable design called dematerialization. For ex: Voided Slabs.

In current scenario there is a great need for development of structures which are safe towards natural disasters like earthquakes. There have occurred several disastrous earthquakes in India in recent past. The earthquake prediction is still at experimental stage. An earthquake mitigation project has been drawn up cost of Rs. 1132 crore. This includes detailed evaluation and retrofitting of life line buildings such as hospitals, schools, water and power supply units, telecommunication buildings, airports, railway stations, bus stands and important administrative buildings in seismic zone IV and V. This also includes training of mass on earthquake resistant constructions. Earthquake resistant design and construction is very important for country like India.

There is a need to holistic approach to look in to infrastructure from the industrial perspective. The new economic policies aimed at stepping up economic growth, improving market efficiency and competitiveness, and integrating the Indian economy with global markets have already placed a heavy demand on all types of urban infrastructure services. Infrastructure development is a major constraint on the industrial growth in India. Adequacy and reliability of transport infrastructure and services are important factors that contribute towards the ability of the country to compete in the field of international trade and attract foreign direct investment.

Indian Railways is often referred to as the lifeline of the Indian economy. Indian Railways has also stepped up developmental efforts and is preparing itself for an even bigger role in the future. The longer term development of the Railways in India depends crucially upon its ability to move freight, in keeping with the needs of the growing economy, and at speeds and reliability determined by the need to be competitive.

A good road network is a critical infrastructure requirement for rapid growth. It provides connectivity to remote areas; provides accessibility to markets, schools, and hospitals; and opens up backward regions to trade and investment. Roads also play an important role in inter-modal transport development, establishing links with airports, railway stations, and ports.

Protecting the coast is increasingly important to society due to sea level rises and coastal erosion. Accessing the marine environment involves ports and harbors being built and maintained along the coast so that it can be used to transport people and goods, and catch food. The recent accelerated growth in Indian economy and trade underscores the increasing criticality of the shipping sector for India, as almost 95% by volume and 70% by value of India's global merchandise trade is carried through the sea route.

As structural engineers, our role in sustainable design has expanded largely due to increased demand by building owners and the public for greater efficiencies, which makes it both an exciting and challenging time to be in this profession. Sustainable issues are much more global in nature. As a result, our charge as structural engineers is to ensure that the sustainable goals and the building design strive for higher levels of achievement. If we simply relegate ourselves to discussions of recycled steel or fly ash in concrete, we commit ourselves to a pedestrian and rather environmentally insignificant future. The future of sustainable design mandates changes today that will affect our traditional building processes and codification. And in order to define and actualize these new conventions, we can no longer think conventionally. The preservation of an existing structure is the ultimate in sustainability. With today's advances in material choices, such as fiber-reinforced polymers, it is possible to save an existing structure and reduce the carbon footprint produced from demolition. Although cost is always a consideration, many of these structures can be converted into sustainable, cost-effective structures by using alternative materials. In order to equitably compare the development approach when dealing with an existing structure, we need to reconcile the environmental impact of the demolition and replacement of the structure with the impact of a new structure. From a sustainable viewpoint, building information modeling (BIM) represents the future. BIM enables every component of the building to be modeled for efficiency. When the structure becomes part of the architecture, the structure has to be modeled to see how the systems interrelate. For structural engineers, greater the ability to collaborate using BIM, the more efficient we become and the smaller our carbon footprint. The good news is that in many cases structural engineers are leading this transition. Thus it is clear that design of structures should be such that it is environment friendly and proper disaster management (For earthquakes, landslides and flood) has been taken into account. By leveraging our structural expertise to engineer efficiently designed that benefit the community; we will become champions of a sustainable future.

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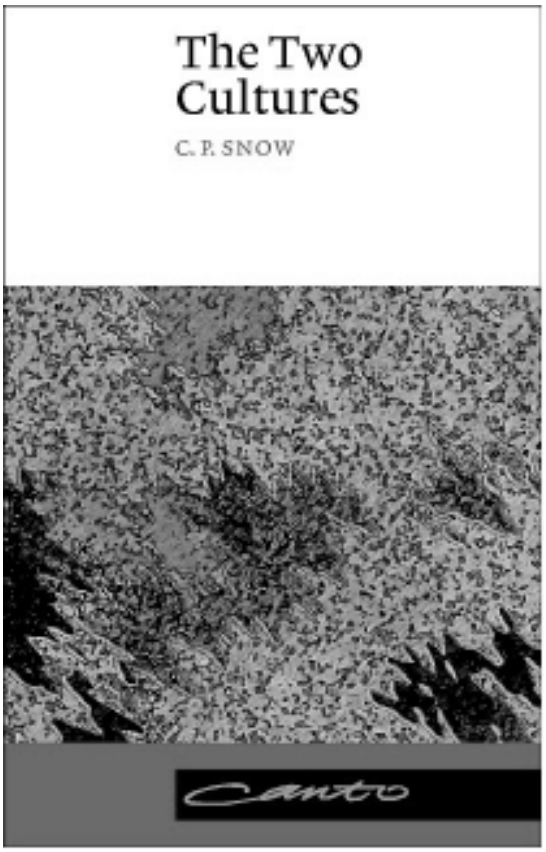
Shashank Pathak is an alumnus of Class of 2009 from IIT Kanpur. He has done his thesis work in analysis of earthquakes in relation to distrotion of the existing structures. Right now he is working as a structural analyst in Larsen and Toubro.

The Two Cultures: Book Review

▪ Sarvendra Yadav



The Two Cultures

Author: C. P. Snow
Publisher: Cambridge University Press (July 30, 1993)
ISBN-10: 0521457300
ISBN-13: 978-0521457309
Pages: 181 pages

Much has been talked about the differences in methodology and ways of investigation in the social sciences and sciences. Early thinker like Weber has talked about the value relevance in social sciences and sciences. Whereas Immanuel Wallerstein in his book "Open the Social Sciences: Report of the Gulbenkian Commission on the Restructuring of the Social Sciences (1996)" points out the historical development and restructuring of Social Sciences as discipline with respect to Natural Sciences. Contemporary political philosopher like Martha Nussbaum also shows her concern about the decreasing importance of humanities and social sciences and why it is important for propagating democratic citizenship? But Snow's book presents a totally different perspective to view this gap and this contributes to its fascinating appeal to the readers.

Arresting in its style and coherent in its structure, The Two Cultures (1964)* engages readers' attention immediately and provokes to contemplate deeply about the interrelation between science and humanities. Based on the thesis proposed by British novelist and scientist Charles Percy Snow's Rede Lecture in mid 1959, this book, therefore addresses one of the age old as well intriguing debates regarding the academic cultures. Exploring the breach between sciences and humanities, this book becomes a telling comment on educational and intellectual endeavors. Appreciated for its relevance even in this decade, Snow's book encapsulates his critical evaluation of the practicing sciences and practicing literary discourses as two separate 'cultures.' Discussing the different attributes, he examines meticulously the rigidity of boundaries between the two cultures and the subsequent problems entailing from this demarcation.

Mainly divided in two parts, the first part centralizes the main argument in four chapters. These chapters engage in elaborate and meticulous discussion about the two cultures, intellectuals as Natural Luddites, Scientific Revolution and finally about the economic discrepancy between rich and the poor. Defending the original argument, the second part becomes an earnest effort on his part to engage with all the criticism and comments after its publication in 1959.

Close observation of both the academic streams and intimacy with scientists and writers inform Snow's vision in this book. In his own words: "By training I was a scientist: by vocation I was a writer". From his personal involvement with friends who were both scientists and writers he could figure out the difference inherent in 'two cultures.' Though they are comparable in intelligence, identical in race, with similar income level and not grossly different in social origin yet he felt that they inhabit 'two cultures'. Quite significantly he also enunciates how members of each culture conceptualize about the other, often indulging in constructing distorted images in arbitrary manner.

Possessing deep rooted conviction that scientists lack humanitarian sympathies, the literary intellectuals develop apathetic attitude towards the scientists. The governing assumption is scientists, though pragmatic and optimistic, yet are shallow in matters of general human and social concerns. On the other hand, scientists believe that literary intellectuals totally lack foresight and are reluctant towards fellow men in terms of social commitments. Denigrating the intellectual endeavors of the non scientists, the scientists emphatically devalue their talent as well deny socially efficacious role to them. Moreover solitariness being one of the attendant crises in the lives of all intellectuals, the general belief claims the scientists to be more optimistic and vivacious even in midst of this. Temperamentally inclined to pursue something productive, the scientists aspire to indulge themselves in some positive action. Literature, lacking the same automatic corrective often fails to situate itself according to pragmatic demands. As enunciated by Snow, these constitute the major misunderstandings

between two cultures.

Interestingly, entitling the community of scientists as a 'culture', Snow elucidates common attitudes, standards, pattern of behavior, approaches and assumptions that goes on to construct the community monolithic in nature. The homogeneity also pervades also in their emotional life, as Snow observes. Thus drawing attention to the incompatibility between the two cultures, Snow foregrounds the problems of negotiation between these two cultures. Lamenting about the polarization which is sheer loss to humanity, Snow also contemplates how the integration of these cultures can be very really beneficial for human society. Prominently pervading in England, this cultural demarcation is broadly due to two reasons: fanatical belief in educational specialization and profound crystallization of social norms. Comparing the education system of America, USSR and Britain, Snow found in USSR favorable environment of science education and research. He however credits the Russian novelists who attempt to bridge the gap between the two cultures.

Acknowledging the scientific culture as essentially instrumental in materializing the industrial revolution, Snow goes on to express his opinion about the intellectuals. For him literary intellectuals are Natural Luddites. During that time literary and traditional culture focused in training young men for administrative purposes in Indian empire, thereby consolidating colonial concerns. Mourning this, Snow urges that if his ancestors (British) had invested talent in the industrial revolution rather than strengthening colonial empires, his culture might be more soundly based at present. However, Industrial revolution which was neglected in traditional culture had directly benefitted the poor by providing better facilities of health, education and food. Out of these changes emerged another transformation and that is the application of real science to industry like in electronics, atomic energy and automation which had decisively effected the world and gave impetus to the 'scientific revolution'.

Although Snow has discussed about only two cultures but while defining the pure scientists and engineers he portrays them as of different cultural groups. Several other writers have criticized him for being restricted to only two cultures. Manifestly, he has asserted about the possibility of a third culture which is in process but he has not eloquently articulated anything about it. Significantly, following this postulation in 1995 John Brockman published “The Third Culture: Beyond the Scientific Revolution” as testifying to third culture speculations.

Envisaging social progress, Snow observes that the widening gap between rich and poor countries can be eradicated only by providing capital from outside to the poor countries. Besides this, trained scientists and engineers adaptable enough to a foreign country must devote themselves for at least ten years for improving the conditions. For this he expects the developed countries especially USSR and America to assume pioneering role and send assistance in the form of developing scientific culture in the poor countries.

But what makes Snow's book more fascinating is his explicit concern in preservation of culture. Undue accentuation of one culture can prove detrimental to any society. Literary intellectuals do not make the decisions but often their assertions are implanted in human minds, thereby indirectly influencing their thoughts. In a similar fashion, scientists can also be bad advisors to the policy makers. Informed mainly by two motives, that of understanding the natural world and consequently controlling it, Snow mentions the possibility of predominance of any of these motives in individual scientist.

So, after a sweeping glance of the book, I am really inspired to consider this book as one of the first initiatives about making sciences more humanitarian. Snow's critical observations and his visionary stance become more relevant when reviewed in the present globalized context. In a pluralistic world, marked by liberal economy and driven by the incessant urge to better the social scenario, Snow's book foregrounds a fitting example of reciprocal relations between humanities and science. Mutually reinforcing each other, science and humanities can offer best models for societal development. Whereas science can provide rationalized way for attending and solving practical problems, study of humanities is expected to rejuvenate comprehensive way of judging into everyday matters. Suggestively, various institutes have been following this model, which underlines the equal gravity of science and culture. **The Indian Institute of Technology exemplifies this most manifestly. It is common assumption that IIT's are meant only for technical education. But this is a wrong conception. IIT's also have humanities and social science departments which are really flourishing and aim to develop the humanitarian values. Nonetheless the recent plans of introducing medical courses in the IIT's and humanities departments in medical institutes can be seen as inspiring instances validating Snow's theoretic investigations. Not only for inculcating the values of tolerance and empathy but also for implanting a strong historic sense of humanity in general, these steps are vital in today's world.** Most importantly, the unification and mutual respect of one culture towards other, which Snow envisions, thus have become inevitable to adopt and actualize for a holistic development of society. This is where the intellectual appeal of the book resides even after five decades. Though dealing mainly about 'two cultures', yet by dint of its powerful arguments and humanistic outlook, the book is a must read for people from every culture in present day.

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The Wireless World

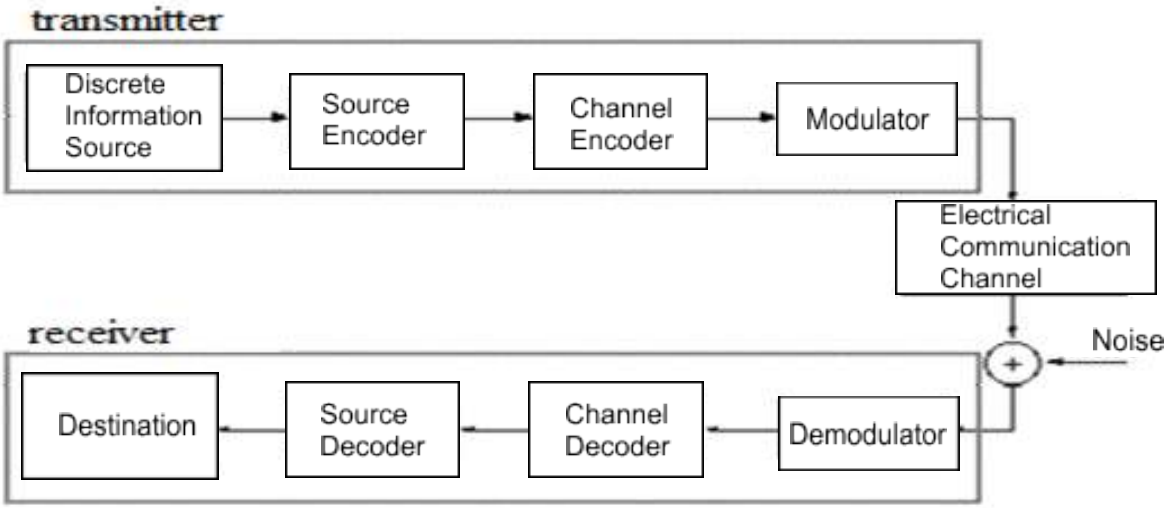
▪ Abhishek Arora

Thousands of years ago, who could have imagined that talking or sending signals to any person at any location on earth could be done in a fraction of seconds (or it was possible at all!). Truly, the way science and technology is revolutionizing our world is amazing. The age of information technology has shrunken the world into a mere tennis ball. Communication is one of the most fundamental requirements of any species. Human species developed sophisticated languages and symbol structures to communicate in early days. The need to transfer and process the information at a faster rate has led to many revolutionary advances which we see in the form of wirelined phones (earlier developments), computers, mobile phones, satellite systems and numerous wireless gadgets, all performing mostly the same task of transferring and processing the information with inbuilt decision making.

Wireless communication has been a hot area of research since 1960s but the past decade has been a great boost for the wireless industry. Now the world is becoming wireless. Number of cellular users has far surpassed the wireline users. This is mainly due to the progress in the VLSI (Very Large Scale Integration) technology which has enabled small area, low power and low cost implementation of sophisticated signal processing and coding algorithms. Moore's law, which asserts the doubling of processors capability every 18 months has been quite accurate in the past two decades and promises to be so in the future. The success of 2G (second-generation wireless telephone technology), in particular Interim Standard 95 (based on CDMA-Code Division Multiple Access) has provided a good example as to how the wireless technology can have significant impact in practice. The data traffic, mainly internet access and intensive multimedia applications like HDTV on mobile, is growing exponentially. Thus, growing users, huge data traffic and security considerations call for innovative ways to optimally utilize the limited bandwidth and power resources and make intelligent choices among various trade-offs.

It is also important to understand the way the different wireless systems work in the same spirit. Let us briefly look at the different types of propagation methods first. The voice traffic primarily utilizes the radio spectrum (30Khz-500Mhz) because of low data rate requirement (~20Kbps). The radio transmission has been in wide use for a long time as it can travel long distances, is easily generated and can easily penetrate buildings. Radio transmission is good for voice but not good for high data rate applications like multimedia. Transmission over higher frequencies like microwave (300Mhz to 300 Ghz) is required to cater to high data rates. But higher frequency waves are attenuated greatly due to band pass nature of air, which reduces the range of transmission. Millimetre wave (upper microwave spectrum, 110Ghz-300Ghz) and infrared (approx. 1 - 430 THz) have been used for very short range communication (~10m) like indoor personal LANs and TV remote control. They do not pass through solid objects. In small scale applications, laser beams have been employed for unguided unidirectional communication purposes, for example, connecting LANs between two buildings using laser mounted on the roof.

Now, let us look at the basic digital communication system structure which is the integral part of all communication systems. The information to be transmitted is first converted into digital format (may be already digital or else analog to digital conversion required). The source encoder mainly provides compression by employing various coding schemes. These encoded bits are further encoded by channel encoder to facilitate correction for



channel errors due to noise at the receiver end. The coded bit stream then modulates a carrier wave. This process changes the amplitude, phase or frequency of the wave according to the information (coded bit stream). Analog or digital modulation can be employed. Power amplification may be required before the modulated carrier wave is finally transmitted through the wirelined or wireless channel. At the receiver end, the blocks perform the opposite task to that of the blocks at the transmitter end and the decoded bits are sent to the destination with conversion to analog form (if required).

Depending on the application, there are numerous types of wireless systems in use today. Some of the most important of them are briefly described below:

Cellular Systems

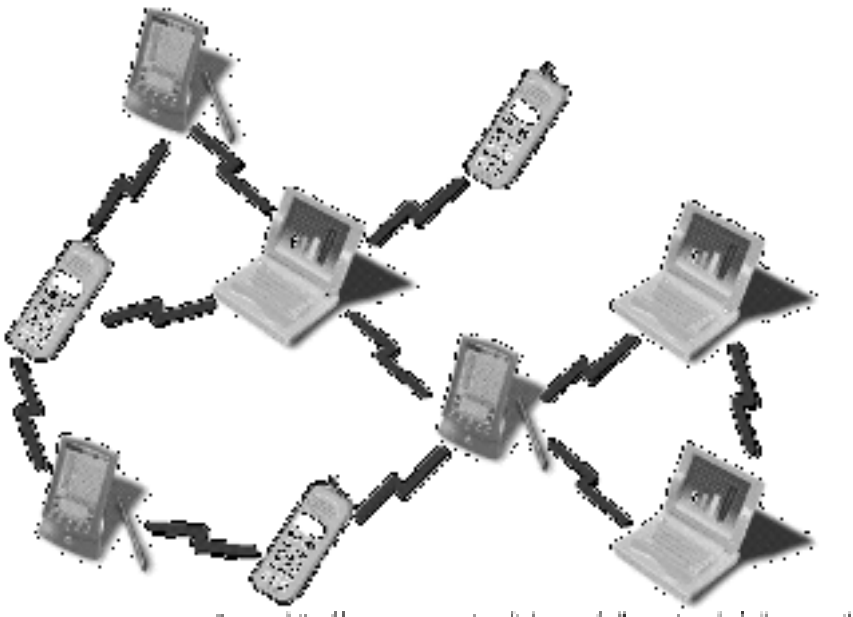
The cellular systems provide two way voice and data communication. The cellular system design uses the concept of frequency reuse, which exploits the fact that the signal power falls off with distance to reuse the same frequency band at spatially separated locations. The coverage area is divided into hexagonal shaped non-overlapping or partially overlapping cells where some set of channels is assigned to each cell. Hence, the name cellular systems and these are the ones responsible for igniting wireless revolution because of huge market potential. The frequency reuse increases the overall network capacity but this capacity is limited by the trade-off with inter cell interference.

The 1G (first-generation of wireless telephone technology) cellular systems used analog communications while the 2G cellular systems moved to digital communications due to its many advantages which include low cost, faster processing, smaller area implementation, low power requirement, higher capacity, error correction and encryption capability, and greater flexibility in developing applications with the help of software. In order to provide access to multiple users over the same channel, multiple access technique is employed which divides the signalling dimensions along time, frequency and code space axis. In OFDMA (Orthogonal Frequency Division Multiple Access) systems, the system bandwidth is divided into orthogonal frequency bands. In TDMA (Time Division Multiple Access) systems, each user occupies the whole frequency spectrum but is assigned orthogonal time slots for communication. The CDMA systems employ spread spectrum technology (that spreads the signal energy over larger bandwidth) and a special coding scheme (where each transmitter is assigned a unique code) to allow multiple users to be multiplexed over the same physical channel.

The 1G used FDMA (Frequency-division Multiple Access) with 30Khz FM-modulated channels and could only support voice traffic. The 2G-GSM (Global System for Mobile communication), the most popular cellular standard uses a combination of TDMA and slow frequency hopping with frequency-shift keying for the voice modulation. The GSM standard was widely used in Europe while the 2G standard IS-95 based on CDMA was adapted by US. There have been enhancements in GSM to support high rate packet data. These include GPRS (General Packet Radio Service) and EDGE (Enhanced Data Rates for GSM Evolution). A packet is a small chunk of digital data that can be transferred intermittently depending on the availability of the channel resources. The internet works on packet data. The 3G standard is based on the wideband CDMA and offers voice telephone, mobile internet access, video calls and mobile TV. The 3G system allows a peak data rate of atleast 200Kbps. The UMTS (Universal Mobile Telecommunications System) and its enhancements and CDMA2000 and its enhancements are branded as 3G and provide data rate of tens of Mbps. The 3G LTE (Long term evolution) is also known as 3.9G and LTE-advanced as 4G. These are based on OFDMA and will offer peak data rates of atleast 50Mbps (uplink – communication link from the user terminal or cell phone to base station) and 100Mbps (downlink – link from base station to cell phone).

Wireless LANs

Wireless local area networks provide high data rate communication in a small region. Wi-Fi belongs to this family. The user can connect to internet through the access points. These wireless LANs operate at the unlicensed ISM bands namely 900Mhz, 2.4 Ghz and 5.8 Ghz. The ISM (Industrial, Scientific and Medical) bands are reserved for industrial, scientific and medical purposes, and communications equipment are designed to except any interference generated by any ISM equipment. Different family of standards IEEE802.11 (US) and HiperLAN (Europe) have been developed which provide data rates of 20-70 Mbps and range of 50-100m.



Source: http://www.acorn.net.au/telecoms/adhocnetworks/adhocnet.gif

Satellite Systems

Satellite systems provide large coverage areas and hence easy access to sparsely populated, rural and difficult terrain regions. These require expensive base stations and great deal of power to reach Geosynchronous satellites (39000 km from Earth's surface) In addition there is a large round trip delay. For these reasons, LEO (low earth orbit) satellites (2000 km from Earth's surface) were thought as a good fit for voice and data communications. The major applications of satellite systems include weather study, military uses, Global Positioning system and radio/TV broadcasting.

Personal Area Networks (PANs)

•*Bluetooth*

This is basically a cable replacement technology and works on the 2.4 GHz unlicensed band. The name "bluetooth" is inspired from a Denmark King named Harald I Bluetooth who united Denmark and Norway. Bluetooth also aims at integrating devices wirelessly. It provides one asynchronous data channel (700Kbps) and three voice channels with a range of about 10m (at 1mW transmit power). Different modes of operation provide 1 Mbps aggregate rate which can be shared between a maximum of 7 devices.

UWB handset centric usage models.

http://www.mastergasservice.com/wp711me/wp-content/uploads/2009/07/handset-centric-uwb-applications.png

•*Zigbee*

This is designed for lower cost and power consumption than Bluetooth. It is based on IEE802.15.4 standard which supports data rate of 256Kbps and 30m range. It provides connectivity to upto 255 devices per network. The goal is to avoid recharging of sensors and inventory tags for several months.

Above, we have briefly discussed some systems which are in wide use in our daily life. A very interesting technology RFID (Radio Frequency Identification) uses RF tags with inbuilt memory. These tags can be put on products in supermarkets, animals in wildlife and on patients. These tags can have sensors, can be used for tracking purposes and can store information like product's present state, manufacturer's information, patient's medical history and so on. The Delhi Metro extensively uses programmable RFID ticket tokens. Although, the wireless systems are constantly evolving and are providing innovative solutions to applications including weather warnings, vehicular security, health care services and user specific needs. Let us briefly discuss them as emerging wireless systems.

Ad-hoc wireless networks

These self-configuring networks provide peer to peer communication and have dynamic (not pre-defined rather adaptive) topologies. Each wireless device can have the potential to act as a routing node. The ad-hoc software detects active nodes to establish a multi-hop communication link between different devices to form a network.

Sensor Networks

The nodes are powered by non rechargeable batteries with life time usually upto 5 years. The challenge is to enhance the battery life so that sensors need not be replaced frequently. The sensor nodes sense some kind of information and pass on the data to a central unit. The data is highly correlated in time and space. The sensor nodes can cooperate for compression and signal processing. Sensor networks are very helpful for applications like earthquake and tsunami warnings, monitoring forest fire alarms, stress-strain in buildings and spread of poisonous gases at a disaster site. Military applications include identification and tracking of enemy targets, detection of chemical and biological attacks, support of unmanned robotic vehicles, and counter-terrorism.

Wireless Distributed Control Networks (WDCN)

A distributed control system is a system of control system in which the control elements are not central in location but are distributed among many system components. The entire system is connected by network for communication and monitoring. The aim is to distribute the computing burden among different wireless devices. In WDCNs, remote devices, sensors and actuators are linked via wireless channels. Such networks enable automated highways, mobile robots and easily-reconfigurable industrial automation. The major problem is the delay impacts and packet loss that deteriorate the controller performance.

Ultra Wideband Systems

These systems employ nanosecond scale ultra-short pulses

to provide high data rate communication (100-1000Mbps). These systems operate either at baseband or at carrier frequency in the range 3.6-10.1 GHz with severe transmit power constraint to avoid interference with the primary users in this band. Its many advantages include multipath immunity, low power consumption, secure communication, low interference and no need for licence. The challenges faced are generation of ultra short pulses and reduction of signal processing burden on the device processor to enhance battery life. Nonetheless, UWB systems are future generation wireless systems that will provide wireless home entertainment, precise object tracking, hand-centric usage models in which user can connect to any device with in 10 m bubble and wearable computing that will also facilitate Health Care.

The wireless industry has grown enormously in last few decades. Many companies have enjoyed spectacular success but failures like first generation wireless LANs, the iridium satellite system and wide area data services like Metricom indicate that not all wireless applications and developers will flourish. Nonetheless, spectacular success of cellular and wireless internet technology promises significant potential in the wireless industry in general in the coming years. As a result, there is intense competition in the sector with great optimism among the investors. The future vision is to provide smartest computing devices with the almost the whole world in your hand.

Ponder Yonder

Wireless communications by Andrea Goldsmith

About the Author

Abhishek Arora (abhishenator@gmail.com) graduated as B. Tech. from the Department of Electrical Engineering with Dr. AK Chaturvedi as his guide. His research interests include Signal Processing and its applications to wireless communication systems. He can be reached at.

Time to Shoot

We are looking for some really mouth-watering photographs that might help us design the first cover pages of upcoming issues of NERD.

The photograph maybe a very beautiful image of a bird or a tree or anything picturesque in the campus. So come forwards and contribute by sending in the photographs latest by 30th January, 2011 to nerd@iitk.ac.in. If the photograph is selected for the cover page, you get certificate of appreciation. We require at least two photographs per issue. Please keep in mind that the photographs should be original and may be modified using any image editing software.

Picture taken from Flickr User Xavez
http://www.flickr.com/photos/xavez/4101398348/sizes/m/

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- The designers get to take care of the layout and cover page design of the issue.
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Let's Decode that Structure!

PROTEIN HOMOLOGY MODELING USING BIOINFORMATICS TOOLS

▪ Jyoti Gupta

Ever since Francis Crick, in 1957 laid out the groundbreaking "Central Dogma" of molecular biology which states that the flow of information in our body is in the direction of DNA to RNA to proteins, it has become known that DNA, which carries genetic information from parents to offspring, has as one of its primary biological functions, the production of one class of molecules which form the basis for carrying out virtually all the functions in our body, and making us function the way we do- right from determining the colour of our eyes to fighting off diseases. And these wondrous molecules are something we've been hearing about since we were little kids, with our mothers asking us to eat eggs so we don't fall short of them. Ladies and gentlemen, I present to you - proteins! Since it has been shown that the three dimensional structure of a protein, which is a long chain of aminoacids, is intrinsically related to its function, in order to understand these molecules and their functions better, it is necessary to know about their structure. The main techniques used to experimentally determine protein structures include X-ray crystallography and nuclear magnetic resonance (NMR). However, due to a large number of experimental constraints, the rate at which 3D structures of proteins with known amino acid sequences are being experimentally determined is quite low, even as the amino acid sequence of new proteins are being discovered at a relatively much faster pace. And as there is so far no direct correlation known between a protein's amino acid sequence and its final structure, and hence function of a protein cannot be determined by simply knowing its amino acid sequence. In this situation, it is the boon of bioinformatics that allows us to predict the 3D structure of a protein, by comparing it to the known structures of proteins which are sequentially or evolutionarily related to our protein of interest, by using databases and computational tools available freely online. So, all you really need is the curiosity, a protein sequence to work with, and an internet connection, to come very close to precisely answering some of the most pressing questions in biology today - a protein's structure, and thus, function, which can further be used in genetic therapy and in better understanding of the functioning of the greatest machine of them all- the human body.

During the summer of 2010, I worked for two months under Dr. Debasisa Mohanty at the National Institute of Immunology, Delhi, in the Bioinformatics department, on a project titled "TO PREDICT THE STRUCTURE OF THE ZP-N DOMAINS OF HUMAN ZP PROTEINS", aimed at making computer generated models of certain segments, or 'domains' of a particular class of human proteins, using a bioinformatics based approach. This article starts with a brief description about the formation,

importance and role of proteins in the human body, followed by a brief description of my project.

Protein basics - What they are and how they're formed

Proteins are organic compounds made of amino acids arranged in a linear chain and folded into a globular form. The amino acids in a protein are joined together by the peptide bonds between the carboxyl and amino groups of adjacent amino acid residues.

DNA molecules have a double helical structure, with molecules called nucleotides on the two strands which are opposite to each other, being paired with one another by hydrogen bonds. This is called complementary pairing, as, of the four nucleotides there are two specific pairs that can bind with each other. Groups of three consecutive nucleotides, called codons code for a specific amino acid, and this codon-amino acid relation is called the genetic code. Thus, the segment of a DNA molecule which codes for a particular protein, and is called a gene, has its nucleotides arranged in the sequence corresponding to the amino acid sequence for that particular protein. So, when a cell needs to produce a protein, the gene segment coding for that particular protein, is 'transcripted' into what is known as pre-messenger RNA, thanks to the complementary pairing property of nucleotides, and this m-RNA then leaves the nucleus, travels to the cytoplasm, and is read by a cell organelle called ribosome to get 'translated' to form the corresponding protein. The protein now travels wherever the cell needs it to be, and performs its functions.

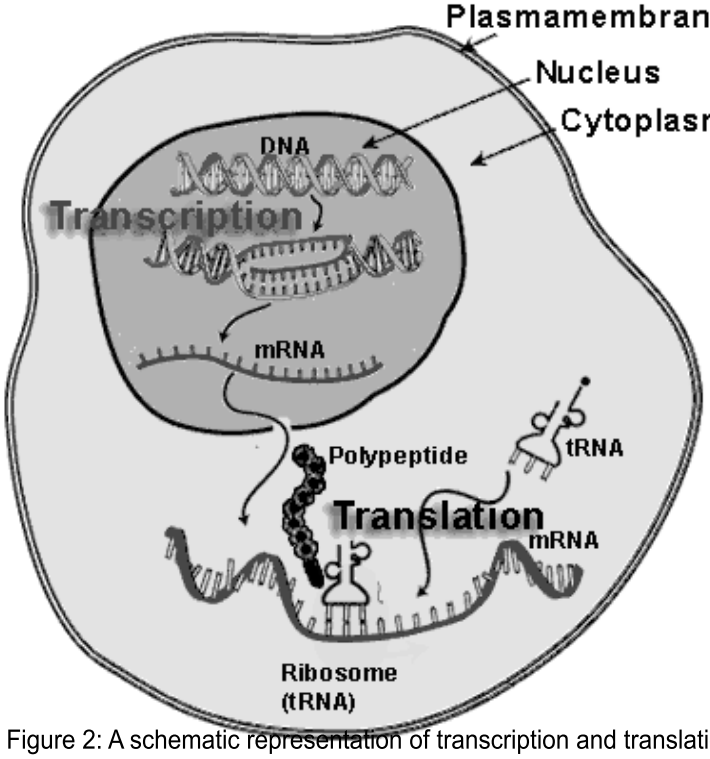

Figure 2: A schematic representation of transcription and translation in eukaryotes

Source: http://www.mysciencebox.org/node/366

Once a protein is synthesized, it collapses into a specific three dimensional structure by a process called protein folding, and this unique shape into which a protein folds is known as its native conformation. Different types of proteins perform a wide range of diverse functions: antibodies defend the body from foreign substances called antigens, contractile proteins are involved in cellular movement, enzymes catalyze biochemical reactions, hormonal proteins perform various bodily activities, and structural proteins provide support, to mention a few! Now you know why they're considered one of the most important molecules in the human body!

Protein structure

As mentioned earlier, proteins, upon synthesis, collapse into their native conformations. Biochemists often refer to four distinct aspects of a protein's structure:

Primary structure: It simply refers to the amino acid sequence.

Secondary structures: These are regularly repeating local structures stabilized by hydrogen bonds. The most common examples are the alpha helix, beta sheet and turns. Because secondary structures are local, many regions of different secondary structure can be present in the same protein molecule.

Tertiary structure: It refers to the overall shape of a single protein molecule; the spatial relationship of the secondary structures to one another. Tertiary structure is generally stabilized by nonlocal interactions, mostly the formation of a hydrophobic core, but also through salt bridges, hydrogen bonds, disulfide bonds, and even post-translational modifications. The term "tertiary structure" is often used as synonymous with the term fold. The tertiary structure is what controls the basic function of the protein.

Quaternary structure: It the structure formed by several protein molecules (polypeptide chains), usually called protein subunits in this context, which function as a single protein complex.

Methods of protein structural prediction

Due to the importance of protein structure in determining its function, various bioinformatics tools have been developed to help predict structures of proteins of known amino acid sequence.

The determination of protein amino acid sequences is a lot easier than determination of protein 3D structures. Protein sequencing was earlier done by using many chemical methods, by cleaving off the 'last' amino acid from the protein and carrying out various chemical reactions to test which of the 21 possible amino acids it was. This process was then repeated for the remaining protein and so on, till the protein sequence was fully determined. Today, however, another approach is used to determine protein

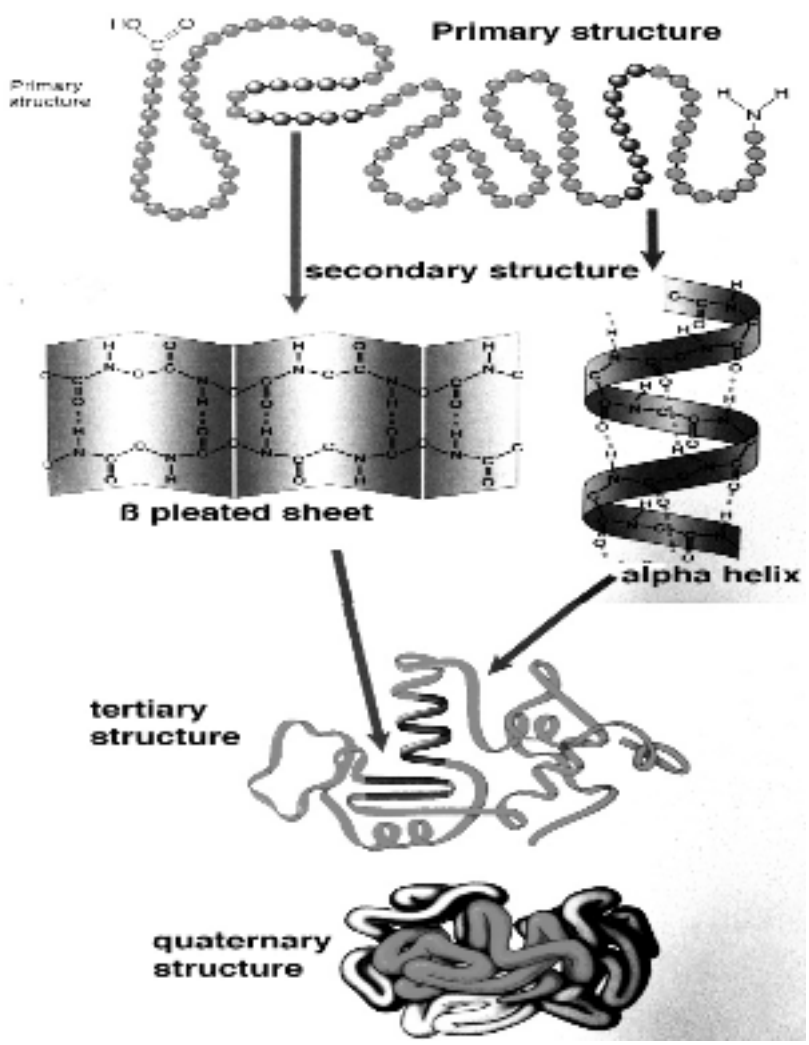

Figure 3: Schematic diagram of the four aspects of protein structure Source: http://academic.brooklyn.cuny.edu/biology/bio4fv/page/3d_prot.htm

amino acid sequences- it is done by sequencing the DNA that encodes the protein. This is actually the easier way, using DNA cloning technology. The gene is cloned, and the order of the bases is determined by a series of reactions that is sort of similar in concept to the way proteins are sequenced. (For more information, visit http://www.newton.dep.anl.gov/askasci/mole00/mole00255.htm).

Determination of protein 3D structures, on the other hand, is done by techniques like X-ray crystallography or NMR, which require extremely pure protein in larger amounts, and have several technical difficulties. So, all in all, it is much easier to obtain a protein's amino acid sequence than its 3D structure.

Once a protein's amino acid sequence is known, several tools may be used to predict its structure, using bioinformatics tools. In this effort, some very important resources are the various repositories of protein structures and sequences, which are available online freely. The Protein Data Bank (PDB) (http://www.pdb.org/pdb/home/home.do) is a repository for the 3-D structural data of large biological molecules, such as proteins and nucleic acid. The data is typically obtained by X-ray crystallography or NMR spectroscopy and submitted by biologists and biochemists from around the world.

An important repository of protein sequences is Swiss-Prot (http://www.expasy.ch/sprot/), which has the amino acid sequences of all the proteins observed so far.

The modeling of proteins can be done using two basic approaches. The first is the ab initio approach, which attempts to model proteins from scratch, knowing only the amino acid sequences, on the basis of physical principles rather than on previously solved structures. There are many possible procedures that either attempt to mimic protein folding or apply some stochastic method to search possible solutions by global optimization of a suitable energy function. However, these procedures tend to require vast computational resources, and have thus only been carried out for tiny proteins. The other approach is of comparative protein modeling which uses previously solved structures as starting points, or templates. This is effective because it appears that although the number of actual proteins is vast, there is a limited set of tertiary structural motifs to which most proteins belong. It has been suggested that there are only around 2000 distinct protein folds in nature, though there are many millions of different proteins.

Here, we will discuss comparative modeling in more detail, as that was the approach used in the project. The

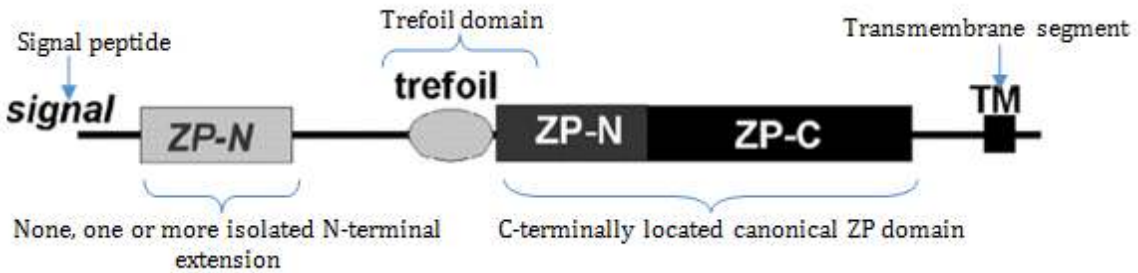

Fig 4: Schematic diagram of a human ZP protein. (Monget et.al. Bioinformatics, 2007)

methods for protein structure prediction by comparative modeling rely on some basic observations and conclusions made from the protein sequences and structures that have already been determined.

The first is the reasonable assumption that proteins having a high amount of sequence similarity will adopt very similar structures. The modeling of a protein structure on the basis of sequence similarity with a protein having known structure is called homology modeling. Evolutionarily, the protein fold is more conserved than the protein amino acid sequence, and so, when a protein is compared with a database of all proteins with known structures, and sequence similarity is observed of our query protein with any of the proteins in the database, that's great news, because now, various online tools can be used for homology modeling of our protein of interest using the other protein as a structural template.

Another approach, that of protein threading scans the amino acid sequence of an unknown structure against a database of solved structures. In each case, a scoring function is used to assess the compatibility of the sequence to the structure, thus yielding possible three-dimensional models.

Aim of the project

In our project, our aim was to predict the structure of the ZP-N domains of human ZP (zona pellucida) proteins. A protein domain is a part of protein sequence and structure that can evolve, function, and exist independently of the rest of the protein chain. Each domain forms a compact three-dimensional structure and often can be independently stable and folded, and many proteins consist of several structural domains.

The zona pellucida is a glycoprotein membrane surrounding the plasma membrane of an oocyte (a female germ cell involved in reproduction), and, though external, it is of essential importance to it. The zona pellucida first appears in primary oocytes. It binds spermatozoa, and is required to initiate the acrosome reaction, a reaction in which the sperm penetrates the egg's hard shell, eventually allowing fertilization to occur. The zona pellucida is made up of four major glycoproteins, ZP1, ZP2, ZP3 and Zp4.

Domain organization of ZP Proteins:

1 Proteins of the ZP family are characterized by various overall architectures, containing various domains. They are listed below[1].

1. All the zona pellucida subunits polymerize using a 'zona pellucida (ZP) domain' module, which is involved in the polymerization of the ZP proteins to form the zona pellucida.
   The conserved amino terminal part (ZP-N) of this domain was suggested to constitute a domain of its own.
   The ZP domain has a C-terminal location (which means, it is located on that side of the polypeptide chain which ends with a free carboxylic acid group).
2. In addition, ZP proteins may contain other domains, such as trefoil, CUB and EGF/EGF-like domains.
3. Except for ZP3, the ZP proteins possess, in addition to their C-terminal ZP domains, N-terminal extensions, which are thought to play an important role in the species-specific gamete recognition. These N-terminal extensions are made of single or multiple copies of a small globular domain, which can be significantly related to the N-terminal region of ZP domains (ZP-N domains).

In our project, we attempted to model all the ZP-N terminal domains, i.e., the N terminal extensions, as well as the ZP-N domain of the C terminally located ZP domain, using homology modeling.

Methods

We first needed to identify a template on which to model out ZP-N domains. No structural information had been available for ZP domain proteins till very recently, when, in 2008, the crystal structure of the ZP-N domain (from amino acid numbers 42 to 144) of ZP3 of Mus musculus (mouse, a species of rodents) was determined by X-ray spectroscopy at 2.3 Å resolution2 (Jovine et al).

Carrying out a sequence comparison between the mouse ZP3 N terminal domain and the human ZP3 protein using a server called the lalign server, we saw extremely high sequence homology (71%) between the mouse ZP3 N terminal sequence and part of the human ZP3 sequence, again, from residues 42 to 144.

If we could establish sequence homology between the mouse ZP3 N terminal sequence and the other human ZP-N sequences, then all our domains could be modeled using homology modeling.

As mentioned previously, it has been found out that the human ZP proteins, apart from ZP3 have, in addition to the canonical ZP-N domain, which is a part of the C-terminally located ZP domain, isolated ZP-N domains present as N terminal extensions. They are one, three and one in number in human ZP1, ZP2 and ZP4, respectively, and the domain organization of human ZP proteins has been determined to be as shown below:

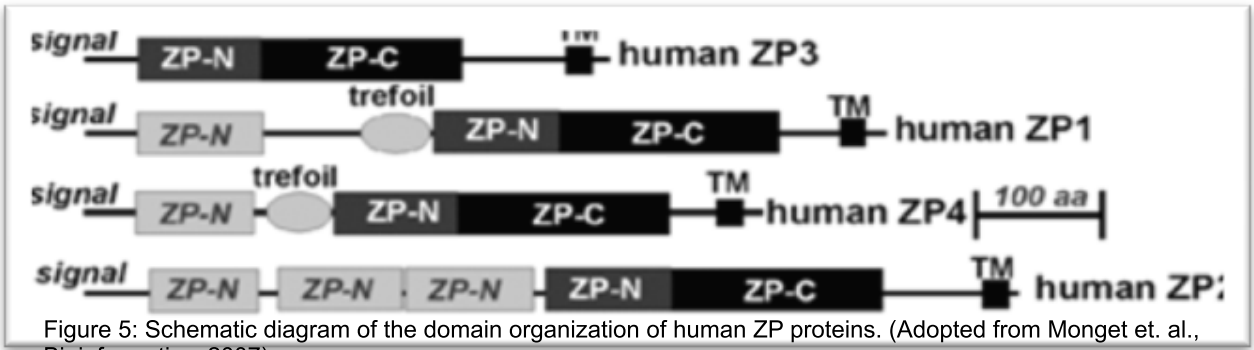

Figure 5: Schematic diagram of the domain organization of human ZP proteins. (Adopted from Monget et. al., Bioinformatics, 2007)

We also verified the above domain organization of the human ZP proteins by using the tools CD scan3 (http://www.ncbi.nlm.nih.gov/Structure/cdd/cdd.shtml), lalign5 (http://www.ch.embnet.org/software/LALIGN_form.html), and Tcoffee4 (http://www.ch.embnet.org/software/TCoffee.html). As we had identified the ZP-N domain of human ZP3 directly by a tcoffee alignment with the mouse ZP3 N terminal sequence, this sequence was now used to locate the other ZP-N domains of human ZP proteins, as it is a very reasonable assumption that the human ZP-N domains would have more in common with another human ZP-N domain, as compared to a mouse ZP-N domain. By our exercise, we were able to verify that the domain organization predicted by us using bioinformatics tools corresponded well with the known domain organization of human ZP proteins.

Next, we attempted to establish clear sequence homology of the ZP-N domains of human ZP1, ZP2 and ZP4 with the mouse ZP3 N terminal domain sequence, as had been done for the human ZP3 sequence, i.e., getting a direct alignment between the mouse ZP3 N terminal sequence and the human ZP-N sequences, which would enable homology modeling for the ZP-N domains directly using the mouse ZP3 N terminal domain structure as a template. This time, however, we were less successful, as no clear sequence homology was detected by the lalign or the Blast25 servers, showing that the ZP-N domain sequences had diverged more, as they were now coming not from the corresponding proteins of two different species, but rather, from more different proteins of two different species.

Since establishment of direct sequence homology failed, we decided to create a multiple sequence alignment, (which is an alignment involving a greater number of protein sequences, which is capable of recognizing more distantly related species as compared to direct sequence homology) using the Tcoffee server, which aligns more than two protein sequences with each other, and can detect more distant sequence homology between various proteins. Using the domain boundaries as had been determined in an earlier study (Monget et al), we created a multiple sequence alignment of all the human ZP-N domains and the mouse ZP3 N terminal domain.

The conserved Cysteine residues, which are a characteristic of ZP domain proteins, are highlighted in the below alignment. They are seen to be present in all the isolated, as well as canonical ZP-N domains of the human ZP proteins, except for the 2nd and 3rd isolated ZP-N domains of human ZP2. The four conserved Cysteine residues in the rest of the ZP-N domains form disulphide bonds linking the Cysteine residues in the 1-4, 2-3 positions, which give stability to the ZP-N domain structure.

The multiple sequence alignment is shown in the diagram below.

Homology modeling using the Swiss-Model server

Once we had created the multiple sequence alignment, we used an online server called Swiss-Model6 to do the actual homology modeling. To the server, we provided the multiple sequence alignment, each time giving one of the human ZP-N domain sequences as the target sequence, and each time choosing the mouse ZP3 N terminal domain sequence as the template, along with the PDB (Protein Data Bank) code of its crystal structure. Swiss-Model then retrieved the relevant structure from the PDB and carried out homology modeling of the ZP-N domains, using the mouse ZP3 N terminal domain as a template, and using important information obtained from the multiple sequence alignment provided to it, such as the presence of conserved cysteine residues.

Results and Conclusions

Swiss-Model was able to return the structures of all the ZP-N domains in human ZP proteins except for the second isolated ZP-N domain of ZP2, which, as can be seen through the multiple sequence alignment, is the most widely different from the others. Once the models were obtained, they were validated and evaluated using Ramachandran plot parameters provided by the Procheck7 server. The models were all found to be good models.

Thus, we had started with the knowledge of the domain organization of the human ZP proteins, and verified the same using various bioinformatics tools.

We also created a multiple sequence alignment of the ZP-N domains, highlighting the characteristics of ZP domain proteins, like the conserved cysteine residues.

We next modeled the ZP-N domains of the human ZP proteins using homology modeling, using the crystal structure of the mouse ZP3 N terminal domain as a template. We saw that the human ZP3 N domain showed high homology with the structural template, while models for other isolated and canonical ZP-N domains had homology lower than 25%.

Though this project was essentially an attempt to

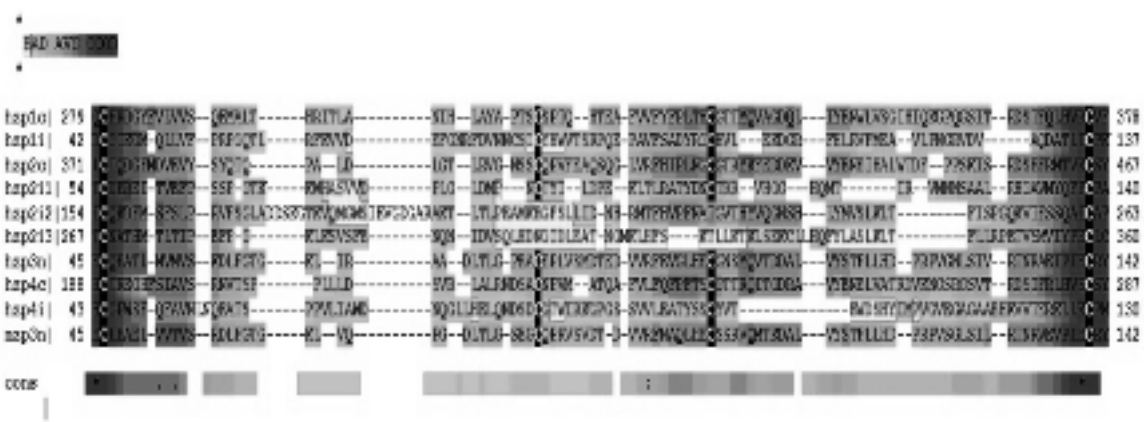

Figure 7: Model generated for human ZP3 N terminal segment by Automated Modeling Mode of the Swissmodel server

understand the basics of Bioinformatics in protein structure prediction, it shows how the huge problem of determining protein structures can be solved to some extent with the use of Bioinformatics tools, using the known structures of proteins as a basis. A formulation of how a protein will fold after formation remains a huge unsolved question in biology, with thousands of laboratories all around the world working to solve it, but till the time this can be predicted with certainty, such bioinformatics based results give scientists a great base to work on, in determining protein structure and function.

Ponder Yonder

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About the Author

Jyoti Gupta is a second year undergraduate student of the department of Biological Sciences and Bioengineering at Indian Institute of Technology, Kanpur. Her areas of interests are developmental biology and bioinformatics. In her spare time, she enjoys painting, reading fiction and debating.

An Ore of Medals!

An Interview with Prof. K. A. Padmanabhan

▪ Mohit Kumar Jolly

Prof. K. A. Padmanabhan requires no introduction. Besides being the first Indian to receive the 'FORSCHUNGSPREIS' of the Alexander von Humboldt Foundation, a career award of the highest category of the above organization, and the first Indian engineer to be conferred the Sc. D. degree (Doctor of Science) by University of Cambridge, UK for his research contributions, he has been a very active and efficient academic administrator. He has been the Director of IIT Kanpur and Dean of Academic Research at IIT Madras to name a few. He is presently the Mercator Professor of DFG (German Research Foundation) at the Institute of Materials Physics, University of Muenster, in north Germany. He is an expert on super-plasticity and can be truly termed as 'an ore of medals' for the abundance of eminent awards, medals, patents and distinctions he has achieved. Here are some excerpts when a NERD team member interviewed him over a conference call

NERD: You have been deeply into teaching and research in India for around past four decades. Kindly share your experience of growth of R & D sector and technical education in India, and some changes which you would like to see.

Prof. Padmanabhan: The way technical education is imparted in India in IIT system is very professional. We choose the best students from India and when the input is better, the output is also likely to be better. IITs have not allowed the quality of their technical education and students to fall.

The growth of R&D sector, especially in engineering, has not been so great. Indian industries lack confidence badly. They always prefer shortcuts and buy foreign technology for which they pay through the nose, but do not allow a young man to try some new technology which has not been used anywhere else. They do not realize that it takes time to absorb the imported technology as well. Collective capacity for hard work is missing. When it comes to developing elements of a system, we are ahead, but in terms of planning and coordination to put those elements together to form a system, we are way behind.

Individually, in my opinion, around 100 Indian companies are competent internationally. They have a well-defined path and good growth rate, but the first and second level leadership is often not of a very high quality in India. There

is another problem with Indian philosophy which is holding our R&D back- the strong condemnation and outcast force one receives when one fails- if India gets out of race for T20, you burn the effigies of team players.

NERD: You also have been involved with academic administration- Director at IIT Kanpur, Dean of Academic Research, Founding Chairman- GATE and Chairman, Center for Continuing Education at IIT Madras. Recently, we are witnessing the dying curiosity of students in classrooms. What, in your opinion, are the reasons for these winds of change?

Prof. Padmanabhan: Karl Marx once said "Ruling ideas of any society are the ideas of its ruling classes." Does Indian society respect Ph.D. fellows? Girls would marry MBA students, IT professionals, bankers but not engineers. Parents would force their kids to take a career with an easier life- a 10am-5pm job, good income and a steady growth rate. We succumb to the society.

> The growth of R&D sector, especially in engineering, has not been so great

Once Margaret Thatcher asked the Chairman of Mitsubishi Corporation of Japan, "What should I do to improve the quality of engineers in UK?" The answer she received was, "Start giving 10% of the respect you give to your bankers and chartered accountants to your engineers."

NERD: You are an expert on superplasticity and hold the distinction to be the author of first-ever comprehensive expert level book in this area. Kindly elaborate on some basic fundamentals of superplasticity, and your related research.

Prof. Padmanabhan: Superplasticity is something more than plasticity. It arises under special microstructure conditions- when grain size gets very small (close to a few micrometers down to a few nanometers), they slide past each other without any distortion. Normally the best available materials are 40%-50% ductile, but under superplastic conditions, tensile deformation of the order of a few thousand percent can be obtained in metals and you can draw them to a point. You can make a metal behave like a chewing gum.

NERD: You have also outlined a new field of research 'Mechanics of Superplasticity'. Can you please brief us about this interesting field and its opportunities?

Prof. Padmanabhan: We (I, Russian Professor R. A. Vasin and his student F.U. Enikeev) have just outlined this new field. It is a very tricky field where you are simultaneously solving 10-12 equations in a self-consistent way. Mechanics of superplasticity comes under Mechanics of solids, where you have boundary value problems, flow, and force and conservation equations which are to be simultaneously solved. Since superplasticity is achieved at high temperatures, thermal balances also have to be kept into mind. Effects of

grain size can't be introduced in a very hard and fast way in mechanics. Finite strain is also very difficult to handle under conditions of superplasticity. This is a very complex field, where some set of equations have to be invariant (same in all frames of reference), and so it becomes a formidable problem.

NERD: You have also been the Coordinator (on the Indian side) of Indo-German, Indo-US, Indo-UK, and Indo-Russian Collaborative Research Programs on different aspects of superplasticity and high temperature creep. What are some state-of-art applications of the same?

Prof. Padmanabhan: 108 parts of the B1 bomber were replaced by a single part through superplasticity, and there was a cost reduction of 50% and weight reduction of 30%. Using superplasticity, turbine discs of nickel alloys can be made very easily. Material utilization gets close to 100%. There has been a breakthrough in aluminum superplastic alloys, which are being mainly used in automobiles and rails. All plastics are getting replaced by superplastics, and transportation sector remains the main push.

NERD: Your research has directly benefited high technology areas in ISRO, Department of Atomic Energy, HAL, DRDO Laboratory and many others. You also hold several patents for the same. Kindly explain some of your major contributions to these organizations, and how are they being used in today's context.

Prof. Padmanabhan: Steel industry in 1980's developed EDD Steels (Extra Deep Drawing Steel), which was indigenized in Bokaro Steel Plant, and I and Dr. Sanak Mishra (CEO, Arcelor Mittal Steel) were the two counselors to Steel Authority of India Limited.

There was a technology pull in 1990's in Indian stainless steel industry and a marvelous piece of work was done by 2nd level still mills. India has no nickel deposit and there were no international standards for stainless steel. US, after the World War II, had developed stainless steel with 4.5% nickel instead of 8% nickel. Our fellows developed stainless steel with 1% nickel, and today we export thousands of tons of it.

In Vikram Sarabhai Space Center in Thiruvananthapuram, we set up the facility to superplastically form hemispheres of 415 mm diameter, for which I was awarded the Consultancy Development Centre - Department of Scientific and Industrial Research (CDC-DSIR) Certificate of Merit. Water tankages were made using Al 7020 alloy, which was made in IIT Madras and met French specifications. This work was of relevance to the Liquid Propulsion System Center of ISRO.

We transferred superplastic forming technology to HAL and I worked for some defense- related work for DRDL. I also worked for IGCAR, Kalpakkam, Department of Atomic Energy to characterize the properties of Fast Breeding Reactor construction materials, on which today an excellent R&D group continues to work at IGCAR.

NERD: You were the founder Professor-in-Charge of the Center for Nanotechnology at University of Hyderabad and helped in establishing Anna University-Centre for Nanosciences and Technology. Please tell about your related research in nanosciences and nanotechnology.

Prof. Padmanabhan: I have been studying the mechanics of nanostructured materials since 1994. Study of the deformation of many types of nanomaterials has been my main area. We also introduced the concept of 'mesoscopic grain boundary sliding' (how grains deform collectively), which was recently talked about in an editorial of Nature Materials. Presently, I am trying to extend this idea to understanding the deformation of bulk metallic glasses, which under certain conditions respond similar to nanomaterials or superplastics.

> 108 parts of the B1 bomber were replaced by a single part through superplasticity, and there was a cost reduction of 50%!

NERD: You have been a consultant to Indian Stainless Steel Development Association (ISSDA), and assisted TISCO as well. Technologies developed by you are used in Indian steel industries. How do you envision the technical and economic growth of Indian steel industry in next decade?

Prof. Padmanabhan: In the 1970s, Hindalco in Renukut was penalized because their production was 130% of the sanctioned capacity, i.e. they were penalized for their efficiency. Now that sounds funny! Our industrial policies and rules and inefficiency in technology have kept us back, when Japan, in spite of importing oil, coal and iron ore, yet produced the cheapest steel. Things are different today. It is a pity that we do not have good steel makers in abundance, and the manpower situation in our industry is critical, but Indian steel industry has a very bright future. Steel and cement are backbone for India. China, India and Brazil shall soon be the three steel leaders of the world.

NERD: You hold a rich experience of working at academic-industry interface in India as well. How can we improve this collaboration in our country?

Prof. Padmanabhan: Indian industries pay through the nose for foreign technology but are very selective in paying Indians. Their approach towards Indian academicians and scientists needs a drastic change. There are weaknesses with Indian scientists too. Everyone wants to be a manager, and they lack the capacity to judge the industry-level scalability of a process, and their time consciousness is not exemplary! These gaps can't be closed overnight, but awareness about them can be increased. The situation is better today than in the past, but there is a great scope of improvement.

NERD: You participated in the Indo-US Science and Technology Round Table meeting in 2000 as a member of the Indian Prime Minister's Scientific Delegation. What do you consider the major differences in research and academia set up in India and that in US?

Prof. Padmanabhan: In one word, I would say 'Professionalism'. We were members of the PM's Scientific Delegation, so we went prepared to the meeting, but in US, you can see the level of preparedness in all the present members in any meeting. That's missing in India.

I asked the scientific assistant to the US President what was the motivation for such a professional behavior. He told me that the members who were selected to PCAST (President Committee of Advisors on Science and Technology) or any other committee were made to realize that they were selected to represent a particular field because they were pioneers in it, but once they are members of the committee, their individual scientific/technical background or the exemplary work they had done did not matter, even if they were Nobel Laureates. They had to come prepared to each meeting with better ideas. I would say that this capacity to view people professionally has yet to arrive in India.

> Without a good foundation, you can't build a skyscraper. Undergraduate studies are that foundation, in which research should not only be introduced, but also be taken seriously

NERD: You were the first Indian to receive the 'FORSCHUNGSPREIS', the career research award of the highest category of the Alexander von Humboldt Foundation for your outstanding research contributions. What, in your opinion, is your most significant contribution to materials and metallurgy science?

Prof. Padmanabhan: The concept of 'mesoscopic grain boundary sliding' which I introduced gave a new approach to the study of deformation of materials. This new concept explains collective deformation of grains based on metal physics, and is useful in understanding superplasticity.

NERD: What is your stand on undergraduate research, especially in Indian context?

Prof. Padmanabhan: Without a good foundation, you can't build a skyscraper. Undergraduate studies are that foundation, in which research should not only be introduced, but also be taken seriously. Opportunities should be developed and challenges should be posed to students at the earliest stage, what earlier stage can there be

than the UG level?

Age need not necessarily improve your ideas. Our school students win medals in Olympiads, because their innovation is emphasized and challenged. If you emphasize on creativity in UG studies, I am sure UG students will do good. They are actually not driven hard enough and real challenges are not posed to them, and they, by themselves, are not aware of the problems. Bring industry closer to students because industry can suggest a lot of problems.

NERD: Tell us something about your student life.
Prof. Padmanabhan: I studied in Banaras Hindu University metallurgy department. It was a much more peaceful campus than today. There were no student upheavals or activities of political parties. Food was also great. I was a good debater and represented BHU in many competitions. Great Hindi poets like Hari Audh and Hazari Prasad Dwivedi were the Heads of Hindi Department at BHU. I found BHU better than IITs because in BHU, apart from engineering, we had departments ranging from agriculture to Vedic medicine to astrology to what not.

NERD: How would you describe Dr. K. A. Padmanabhan in one line?
Prof. Padmanabhan: One who tries to live according to his beliefs and tries to learn to the best of his abilities.

NERD: What final message would you like to give to students?
Prof. Padmanabhan: If you are not happy with a situation, try to change it. If you want to change it, be a revolutionary or a missionary but not a cynic. All great civilizations have perished because of apathy.

About the Interviewer

Mohit Kumar Jolly (mkjolly@iitk.ac.in) is a first year M.Tech. student in the Department of Biological Sciences and Bio- Engineering at IIT Kanpur. He is interested in science journalism and communication, and is one of the founders of NERD.

Errata

A few mistakes had unknowingly crept into the previous issue:

- Article: Learning with Supportive Vectors, Page 5, Figure 6: The caption is *Making XOR Linearly Separable* instead of *Macking XOR Linearly Separable.*

- The picture in the Editorial is taken from Raintree, Issue 6, March-April 2010, IITB.

- Article: Monolithic Reactor: A Novel Reactor for Chemical, Page 25: The first picture 'A Novel Idea' is taken from Flickr user Zen Sutherland

(Link: http://www.flickr.com/photos/zen/4922289596/)

- Name of Our Team Member Anjaney Kothari got misspelled on the last inner cover page

NERD Team apologizes for the mistakes and requests our readers to bring to our notice any discrepancies that might have crept into any of the issues of NERD. We shall be grateful to you.

Attributions

Page 2: The photo of Dr. Harbola is taken from his homepage:
http://home.iitk.ac.in/~mkh

Page5: The Universe Building Kit photo is taken from:
http://plus.maths.org/issue29/features/kalmus/UniverseKit.jpg

Page 8, 12: The NERD Boy was designed by Prabha Malya

Page 14: The cover photo of the book 'The Two Cultures' is taken from:
http://www.cambridge.org/gb/knowledge/isbn/item1145060/?site_locale=en_GB

The Scientoon on the last cover page is contributed by Puneet Singh.

NEBULLA - WHAT HAVE WE DISCUSSED RECENTLY

We are a group that meets regularly and have pleasure in 'cerebral' discussion. A few recent discussions include:

1. Why there is a very strong reason to believe that genetics is taking us to a male-less society
2. Everyday science like the stability of a bicycle and the mirage phenomenon, where we found that the textbook explanations had gaping holes in them
3. Development of New Painkillers using Electrodes in Brain
4. The reason why we are awed by the Apple Touchpads in comparison to others
5. Understanding the brain and neural networks
6. A better Algorithm for Stable Match Making

If you want to know more about the group or if you are the type who finds the world around us more interesting than our courses allow us to believe, drop in a mail to
nerd.iitk@gmail.com
or visit
http://thenerd.in/nebulla

CALL FOR ARTICLES

NERD is the scientific and technical research and development magazine run by the students of IITK. We publish news on scientific breakthroughs happening in various technical education institutes, research labs et cetera across India and the world with an emphasis on the workdone by students. So NERD is a magazine of the students, by the students , for everyone. The NERD magazine is first of its kind and we need everyone who is interested in science and technology to be in our team. Join "the NERD Herd!" Yes, you can be the one writing for the magazine.

SCIENTOON -by Puneet Singh

Organic Solar cell performance depends on absorbing as much light as possible, converting the photon energy into free electrons, removing the electrons, and minimizing resistance.
They can be manufactured easily and cheaply, they have low environmental impact, and since they are compatible with flexible substrates, they could be used in many applications such as packaging, clothing, flexible screens, or for recharging cell phones and laptops.
Presently silicon solar cells are being used which have achieved efficiencies of more than 24% but have high cost and complicated technology.
IIT Kanpur is initiating new and augmenting the existing programs for long term research and development in solar power generation, storage, distribution, management and policy making.

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