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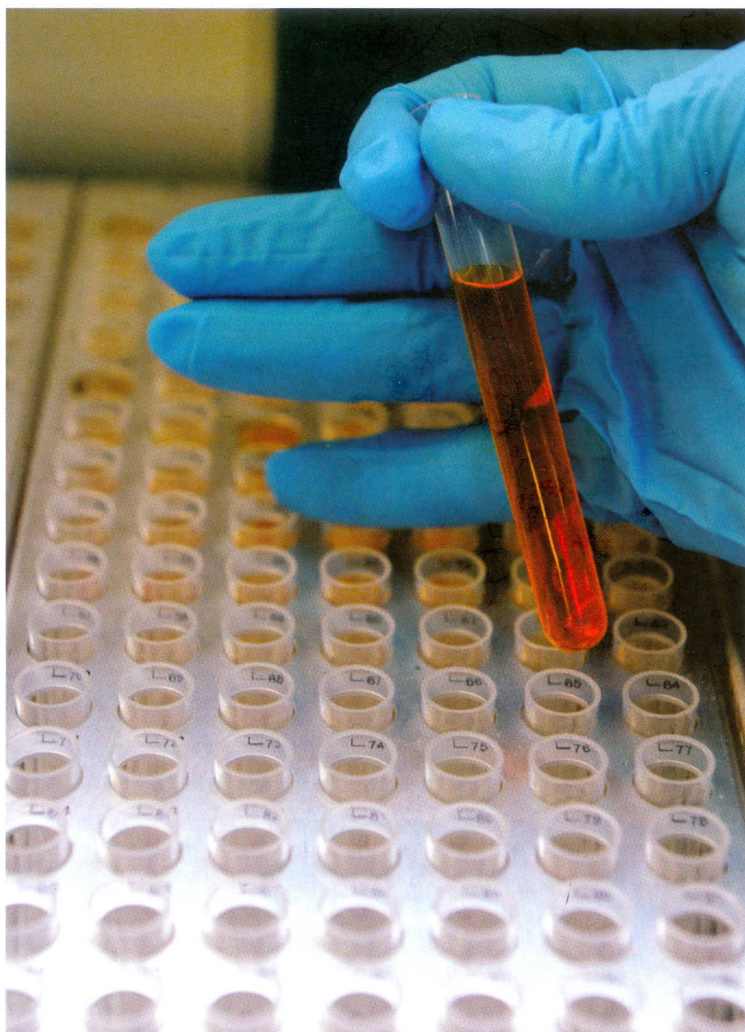
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The right Chemistry

2011 is celebrated as the International Year of Chemistry. From potent smells to medicines, pesticides and weapons, our lives are punctuated, even enabled, by the study of Chemistry. Professor T. PRADEEP, in his own formulaic fashion, explains why this is a compelling and challenging subject, with plenty of opportunities for research.



Chemistry brings to mind smells and colours. Education in the senior high school level gives a feeling that chemistry as a subject makes hands unpleasant, stains fingers and makes the world outside dirty.

While it contributed to a world free of hunger by making ammonia fixation from atmospheric nitrogen possible, it has also made the very same world unsafe and impure by making mustard gas, agent orange and plastics. It has helped prolong life through medicines but has also contributed to the creation of endosulfan, a pesticide present in surface waters in many places and accused of birth defects in affected populations.

While this is true of science and technology in a general sense -- nuclear fusion, genetically modified foods, internal combustion engine, hydroelectric dams, etc. are examples impact of chemistry on the environment is much more evident in everyday events. Obviously, a student of science is naturally concerned about the path one should take -- should chemistry figure in the basket of options?

It is important to know what chemistry means to the world. Chemistry contributes nearly \$3 trillion (Rs. 1.35 crore crores) in global production. Chemistry employs about 50 lakh people globally. Manifestation of chemistry is apparent in every aspect of life --

food, clothing, housing, water, medicine, the list is endless. Chemical industry contributes 7 per cent of India's gross domestic product (GDP), it is 14 per cent of our exports and is 12th in terms of volume. It employs 18 per cent of the organised work force. The conclusion: Chemistry does produce jobs.

Chemistry is traditionally one of the oldest disciplines, but the subject is very young in comparison to areas of human activity. Indeed several surprises come out every year in the subject. It is important to recall that the suggestion that all matter is composed of atoms is just about 210 years old. The chemical bond -- the basis of chemical transformations, is very recent. The idea of electron pair bond is as recent as 1916. Molecular structures became observable in the past several decades. We can combine/react molecules one at a time for the past several years. We are now talking about designer molecules with designed functions. The conclusion: Chemistry does give new avenues to discover.

2011 is celebrated as the international year of Chemistry (www.chemistry2011.org/). It celebrates the achievements of chemistry and theme of such activities is, "chemistry -- our life, our future". While it has helped shape our past and present, it is certain that it will define our future through molecular medicine, advanced diagnostics, nanotechnology, advanced materials and many others. It is considered as the most rapidly evolving areas of science today. The conclusion: Chemistry has future.

Although opportunities are numerous, the efforts involved are tremendous too. Lesson number one in science is that, there are no fast returns. But with true dedication, science will reward certainly. That reward will stay with you and world at large. It gives you a place anywhere you go. Science will not pay sky high salaries, but the scope is plenty. The world outside is built with science and therefore one can naturally expect a part of it. The value of discoveries such as electromagnetic induction, integrated circuit and many others are beyond an assessment yardstick today. Many of them are truly much

larger than the GDP of several nations, but they were all made by a few PEOPLE.

Plenty of opportunities

What are the typical opportunities after a degree in Chemistry? Chemists of all forms are needed in industry. The demand for organic chemists is generally much more. The pharmaceutical industry and those which undertake contract synthesis have large presence in India, especially near cities such as Hyderabad. Petrochemicals, inorganics, agrochemicals, paints and dyes, bulk drugs and specialty chemicals are the major sections contributing to the industry.

There is a large population needing education. The average age of India is around 24 today and it means that teachers are needed in plenty. Besides these opportunities, chemists are needed for research and development. By 2015, it is expected that we will need 30,000 PhD level scientists per year. Ten times more than this number of post graduate level scientists are also needed. It is likely that one fifth of this number will be broadly related to chemistry.

How to learn chemistry

The standard path of chemistry education is: BSc, MSc and then a PhD. Three year BSc, two year MSc and a four to five year PhD – that is the time it takes. In most of the Indian institutions of repute, PhD takes about five years. It has a one year teaching/course component and the balance is full time research. Following PhD, many do varying periods of postdoctoral training and then join a research or academic or industrial job. Typical post doctoral period is two to three years. Variations of this format exist in a few places where an integrated PhD is offered right after BSc and a dual MSc + PhD degree is awarded at the end. Chemistry allows you to branch into other areas as it overlaps with many other disciplines. In any case, path of chemistry is long. If one is an aspiring academic, life in chemistry is continuous hard work and there is no period of rest.

Exams conducted by the Council of Scientific and Industrial Research (CSIR) and University Grants Commission (UGC) are avenues for becoming research students. CSIR conducts exams twice a year for the Junior Research Fellowship (JRF, see for details, www.csirhrdg.res.in/jrfsrfa2.htm). The exam is in two stages, paper i and paper ii and typically 2000 students are awarded JRFs a year in all subjects put together. UGC also offers similar number of fellowships. Besides these, there are also other agencies/institutes such as Atomic Energy,



Indian Institute of Science (IISc) and Tata Institute of Fundamental Research (TIFR) which also conduct their own tests followed by interviews to select students.

Besides IITs and universities, CSIR and Defence Research Development Organisation (DRDO) laboratories also take CSIR/UCG qualified students for PhD. CSIR, DRDO and atomic energy institutions have their own universities now and the degrees are awarded by them. Other fellowships are also there for meritorious students. An example is the INSPIRE fellowships which are given to the top students of universities to pursue PhD (see for details, www.inspire.dst.gov.in/index.html). INSPIRE fellowships are also available to pursue undergraduate studies.

Besides these, there are several other opportunities to study chemistry as an associated subject. Biotechnology, biochemistry, chemical engineering and nanotechnology programmes in several universities have significant chemistry content. Indian Institute of Space Science and Technology (IIST, www.iist.ac.in/) also has a programme in which chemistry is a good component. But none of these will make it possible to give an all round appreciation of chemistry. For those who wish to get a good feel of chemistry, there is no substitute to doing a BSc or an integrated MSc programme. The science programmes in some of the institutions above give fellowships. The most common is the INSPIRE fellowship. 10000 INSPIRE fellowships at Rs. 80,000 per year are available. These fellowships are available for all students in IISERs, NISER, CBS UoM AE.

University of Hyderabad gave a fellowship of Rs. 5000 per month for students admitted in 2009. IIST also offers a fellowship. Central universities offer a smaller, but significant fellowship. Students who qualify in KVPY (www.kvpy.org.in/) also get fellowships for their studies. All of these programmes also have a possibility to do summer internships. Such programmes are supported by all the science academies of the country with financial support. JNCASR (www.jncasr.ac.in), several IITs and IISERs also offer summer research fellowships. These are additional opportunities for students to get exposed to other areas, especially to research.

Chemistry continues to be exciting and many giant problems are awaiting solutions. They touch upon all the basic aspects of life such as food, energy, water and environment. Artificial photosynthesis, clean energy, pure water and clean environment are all problems which need solutions of chemistry. Hopefully, some of them will come from young Indians.



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