also thrown on various challenges in the discovery of novel drugs in tuberculosis, along with pharmacokinetics, PK/PD parameters for efficacy prediction, kill kinetics and animal model for tuberculosis.

The second day of the workshop started with a detailed discussion by B. Gopalan (Glenmark Research Centre) about the therapeutic potential of phosphodiesterase inhibitors. These are the family of enzymes responsible for metabolism of cyclic nucleotides, cAMP and cGMP which are intracellular second messengers that mediate many physiological processes. Dyslipidemia is a major risk factor in the development of atherosclerotic cardiovascular diseases. Lipid regulation is proved to be effective in a variety of clinical conditions like coronary heart diseases. R&D in this area and developed novel therapeutic options have played a major role in understanding the pathophysiology of lipid-related disorders and in establishing the link between cardiovascular disease and lipid profile. This was the essence of the talk delivered by V. V. S. Swaroop Kumar (Glenmark Research Centre). Obesity is a chronic metabolic, stigmatized and costly disease opined Sreedharaswamy (Quest Institute of Life Sciences). He discussed in detail obesity management, health risk due to obesity, genetics of obesity, its molecular mechanism, treatment and the market potential of drugs related to this. In addition to this, he highlighted new therapeutic strategies for the treatment of obesity and new targets for anti-obesity drugs. Emerging need for the development of novel antibacterial agents and related strategies were covered by Mahesh Patel (Wockhardt Research Centre). He elaborated on antibiotic resistance, susceptibility shift, main antibacterial classes and their targets. He questioned the statement by US Surgeon General (1969) that ‘The war against infectious diseases has been won’. Allergy, the most common ailment of the 21st century, its etiology, biochemical events and design of related therapies were the focus of the deliberation by C. T. Rao (Sun Pharma). Various steroidal drugs and their mechanism of action, new anti-inflammatory drugs and monoclonal antibodies were also included in the talk. Nitric oxide is a wonder molecule; a balance of it in the body is crucial. The harmful and beneficial effects of NO and different categories of drugs which donate NO were discussed in detail by Kamala Vasu (PERD Centre). Special emphasis was given to NO.NSAIDS class of drugs.

Concluding remarks were given by Sudarsanam.

Harsh Puth, B.V. Patel Pharmaceutical Education and Research Development Centre, Thaltej-Gandhinagar Highway, Thaltej, Ahmedabad 380 054, India
email: perd@wilnetonline.net

In vitro fertilization in India*

In vitro fertilization (IVF) and embryo transfer were successfully introduced to treat human infertility in 1978 and the world’s first test-tube baby, Louise Brown, was born in the UK on 28 July of that year. Exactly 67 days later, Subhash Mukerjee announced the birth of the world’s second test-tube baby, Kamarupa, alias Durga, on 3 October 1978 in Calcutta. Both these announcements were received with skepticism and the scientists responsible for these births were severely criticized. Nevertheless, the British team carried on with their work and produced several more test-tube babies. In marked contrast, the Government of West Bengal proscribed Mukerjee from carrying out further work in this area and he was transferred to an eye hospital that did not have any facilities to enable him pursue his work.

Mukerjee could not publish all the details of his work. He was asked by the Government to submit details of his work, which he did. He also stated that he wished to carry out further work so that he could validate and standardize the various procedures he had used in his first and only success. His being prohibited to carry out further work by the Government of West Bengal and his untimely death left big lacunae in our understanding the rationale behind the techniques he used. However, in the report he submitted to the Government of West Bengal, which was signed by all the three investigators that were involved in carrying out this procedure, some details were given. These details clearly indicate that Mukerjee’s techniques were different from those used by the British team (Table 1).

IVF in India would have continued to languish but for the support from the ICMR to support IVF-ET that led to the birth of Harsha in Mumbai in 1986. Several other clinics soon followed suit and today there are reportedly over 200 clinics claiming to offer IVF all over India. A million test-tube babies have reportedly been born all over the world.

IVF has turned out to be a major scientific achievement of mankind during the last century. It has not only opened out novel ways of treating infertility involving third and sometimes fourth party parenting a child in a tandem manner, but also advanced our understanding of basic biology and pathology of human repro-

<table>
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<th>The UK approach</th>
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<td>IVF performed in a natural cycle</td>
<td>IVF after gonadotropin stimulation</td>
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<td>Ovarian response monitored by estimating urinary LH</td>
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<td>Embryo cultured in synthetic medium</td>
<td>Embryo cultured in uterine mucus</td>
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<tr>
<td>Embryo transferred in the same cycle</td>
<td>Frozen thawed embryo transferred in the next cycle</td>
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*Based on published data by Edwards and Steptoe and on the Report submitted to the West Bengal Government by Mukerjee and his team in 1978.

Table 1. Salient differences between UK and Indian approaches to IVF in 1978*
duction. With new developments occurring in the potential use of embryonic stem cells in the development of biotherapeutics, IVF is the only way to obtain pluripotent embryonic stem cells.

In view of these vast developments in the field of IVF it is only proper that the pioneers in the field be remembered and honoured. Britain celebrated the birth of Louise Brown with much fanfare on 28 July this year. The Indian Council of Medical Research in collaboration with the Inter Academy Biomedical Science Forum and Hope Infertility Clinic commemorated the silver jubilee of IVF in India, at a simple function held in the premises of the Indian Academy of Sciences, Bangalore. On behalf of the Director General of the Indian Council of Medical Research, Vasantha Murthuswamy, felicitated Kanupriya, Sunit Mukerjee, the only surviving member of Mukerjee’s team, and C. P. Puri, National Institute for Research in Reproductive Health, Mumbai for his personal contribution to the endocrine evaluation and monitoring of controlled ovarian hyper stimulation of women recruited for IVF, which was the cornerstone for the successful pregnancy to occur after IVF and embryo transfer. This was followed by a symposium on Spin-offs from Medically Assisted Reproductive Techniques. This meeting was aimed at informing the lay public as well as clinical faculty and scientists on some of the issues that have arisen out of greater understanding of human reproductive processes through medically assisted reproductive techniques.

Little known facts about male infertility were covered by N. Pandiyayan (Andrology and Reproductive Sciences, Apollo Hospitals, Chennai). Infertility is a personal tragedy in the lives of many couples. Male factors are equally responsible for infertility as are those of the female. Much has been written about the causes of male infertility. Sexual dysfunction, ignorance of sexual practices like using lubricants during intercourse also contribute to male infertility.

Semen analysis remains the single most important test for the evaluation of an infertile male, despite all its limitations. Computer Assisted Semen Analysis (CASA) has not replaced conventional semen analysis. Men with abnormal semen picture would require further investigations like semen FSH, scrotal Doppler and genetic studies. Serum LH, prolactin and testosterone estimations are required only in men with sexual dysfunction and loss of libido. Sperm function studies are of limited clinical value. Recent data indicate that in vivo spermatozoa movements are not random movements but are directed by chemotaxis and thermotaxis.

The introduction of Intra Uterine Insemination (IU), IVF and Intra Cytoplasmic Sperm Injection (ICSI) have all proven to be of immense value in the management of male infertility. However these new techniques have not eliminated the problem of male infertility as was claimed in the mid and late nineties.

The problem of male infertility still remains. Cloning, or haploidization or stem cell therapy may be the only answer for biological fatherhood for many of these men.

‘It is all in the environment: Incidence of male infertility varies between regions in infertile couples’ was presented by Rajvi Mehta (Hope Infertility Clinic, Bangalore). Nearly 50% of infertility is related to reproductive defects or disorders in the male; the rest is related to the female. There has been growing evidence to suggest that in some regions the incidence of male infertility amongst infertile couples varies between regions. Such evidence has been accruing from different parts of the world and also between different Indian cities.

A preliminary study in India shows that significant differences occur both in semen quality and sperm concentrations in fertile couples. There is reason to believe that environmental factors play an important role in this manifestation. There is a need to carry out a national study of environmental factors affecting male fertility.

‘It is all in our genes: Genomics of male infertility’ was presented by K. Kucheria, N. P. Gupta, and Rima Dada (All India Institute of Medical Sciences, New Delhi). Ten to 25% couples find difficulty to procreate. Micro deletion of the long arm of the Y chromosome is associated with spermatogenic failure and has been used to define three regions on Yq (AZFa, AZFb and AZFc) which are critical for spermatogenesis. These loci act at different stages of germ cell development and deletion of each locus results in a characteristic phenotype. Deletion of AZFa, AZFb and AZFc results in Sertoli Cell Only (SCO) syndrome, maturation arrest and hypospermatogenesis respectively.

One hundred and seventy five infertile males with idiopathic oligozoospermia and azoospermia were included in one study. Cytogenetic and semen analysis was done in each case. Testicular Fine Needle aspiration Cytology was collected whenever possible. Of the 175 cases, 22 were identified as Klinefelter Syndrome (KFS), 14 cases were mosaic KFS and 6 cases were variant KFS.

Various factors – genetic, epigenetic and environmental – modulate the effect of these genes. Thus, in a large number of idiopathic cases of male infertility there is a genetic basis. Therefore detection of Yq micro deletions encompassing the AZF loci determines the prognosis and management of these infertile cases.

‘The dawn of a new era in biotherapists: Embryonic stem cells for organ repair or replacement’ was presented by Satish Totey (Reliance Life Sciences, Mumbai). There has been much hope and hype associated with embryonic stem cells with reference to their possible use in futuristic biotherapies and regenerative medicine. However, as in the case of earlier hopes and even claims in areas such as use of monoclonal antibodies, gene therapy, etc. for treatment of diseases, there is as yet no clear evidence to support the concept of embryonic stem cells being taken up in the near future as biotherapeutic agents. This is because several basic questions need to be answered. Some of these questions pertain to:

1. Immuno-rejection of stem cells when transferred to another individual.
2. Identifying cells signals that drive the developmental course of undifferentiated stem cells.
3. Growing stem cells in medium free from animal products to avoid zoonoses.

‘Opportunities offered by the government of India for establishing co-operative research associations and assistance through program aimed at technological self reliance (PASTER)’ was presented by T. C. Anand Kumar (Hope Infertility Clinic, Bangalore). Research in infertility, to understand some of the unexplained conditions of infertility, developing new and better forms of treatment, attaining self-reliance in products used in the treatment of infertility requires substantial inputs of technical talents as well as funding. Most of infertility treatment lies in the private sector. CSIR has a scheme that supports private industry that is of a cooperative nature. Establishing a collaborative, co-operative research facility in
infertility research, which is a multi- crore business/industry, may be a good way of attaining self-sufficiency in this industry.

*In vitro* fertilization techniques are mainly offered by the private sector, which is very heavily dependent on imported drugs, equipment and devices including disposable plasticware used in *in vitro* culture. Consequently, the cost of IVF is extremely high in India and unaffordable to many. Research into aspects of human reproduction is almost non-existent in the private sector and there is hardly any scientific paper that emerges from Indian laboratories or clinics practising IVF. In the symposium, collaboration between the private and public sector funding agencies was stressed. Examples were given of the programmes available under the Department of Scientific and Industrial Research such as the Program Aimed at Technological Self-Reliance (PATSER) and Co-operative Research Associations that enable the establishment of research centres as a collaborative effort between the private sector and Government funding agencies. This aspect was appreciated by the participants who endorsed the view that similar collaborations must be established between private IVF clinics and even the ICMR to address issues that are of common interest and are aimed at improving patient care and more importantly, providing indigenous substitutes for imported equipment, supplies and drugs.

T. C. Anand Kumar, Hope Infertility Clinic, Bangalore 560 042, India e-mail: anand_kumar@vsnl.com

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**RESEARCH NEWS**

**An elegant synthesis of multi-walled carbon nanotubes**

*C. Srinivasan*

Since the exciting discovery of multi-walled carbon nanotubes (MWCNTs) by Iijima in 1991 and subsequent production of single-walled carbon nanotubes (SWNTs), research studies in carbon nanotubes (CNTs) have acquired the important status of one of the most active fields of nanoscience and nanotechnology. Several CNT characteristics like the mechanical properties, viz. Young’s modulus and tensile strength, field emission, possible storage of hydrogen in CNTs and others will have potential applications. There are several reports on the use of these nanotubes in catalysis. The electron emission characteristics of CNTs have motivated a Korean company to develop a flat-panel display for television and computer monitors. The switching times in devices fabricated from field-effect transistors with CNTs have been estimated to be very fast, allowing clock speeds of a terahertz, which is four times faster than the present processors. The recent observation of Ghosh et al. that the flow of a liquid in SWNT bundles induces voltage in the sample along the direction of flow, points out the device potential for CNTs as sensitive flow-sensors.

Several methods are now available for the production of CNTs and each method has its strength and weakness. The preparation techniques include arc-discharge, laser ablation, catalytic decomposition of hydrocarbons and electrolysis methods. The isolation protocol of CNTs requires a complex purification process to remove nanoparticles of catalyst and carbon and graphite pieces with considerable loss of CNTs, and these result in an escalation of production cost. In spite of the availability of a variety of methods for the production of CNTs, the cost of

![Figure 1. Scheme for the formation of MWNTs from graphite rod (reproduced from ref. 11 with permission from Zhenhui Kang and Enbo Wang).](image-url)