embryonic manipulation[4] and transgenic analysis[5]. Although zebrafish cell cultures have been shown to display some characteristics of embryonic stem cells, it remains to be seen whether these cells will contribute to germ line transmission after long-term culture.

Non-visibility of the egg nucleus of many fishes renders them not amenable for nuclear transplantation, like that achieved by Wilmut *et al.*[6]. In the 1960s attempts were made to transfer nucleus of uncultured blastula cells into the non-enucleated eggs of loach[7]. Like the Russians, the Chinese have also attempted to study the nucleocytoplasmic relation in fishes. Tung and his colleagues[8] at the Institute of Developmental Biology, Chinese Academy of Sciences, Beijing contributed a series of publications to report the successful transfer of nucleus of fertilized egg of one carp species to that of another. In 2001, Japanese scientists like Wakamatsu *et al.*[9] have successfully restored diploid and fertile medaka by nuclear transfer using blastula cells as donors. Obviously, the nuclei prepared from fresh blastula cells can be reprogrammed in fish to support embryonic and adult development. In an epoch-making publication, Lee and his Korean colleagues[10] have recently demonstrated the successful cloning of fertile zebrafish from long-term cultured cells, a technology that will allow targeted genetic manipulation in zebrafish.

The success of Lee and his colleagues in cloning the zebrafish is based on the development of two important techniques: (1) Using Hoechst staining, they could visualize the relative size and location of the pronucleus in an unfertilized egg of the zebrafish. Using the second polar body as a reference, the pronucleus was aspirated with a small amount of cytoplasm just underneath the polar body. (2) Enhancing the visibility of the nuclei of donors, namely blastula cells and embryonic fibroblast cells by infecting these cells with *GFP* reporter gene. *GFP* enhances the visibility of the nuclei under fluorescent light and helps to track the destiny of the transferred nucleus during embryonic development and in adult. Lee *et al.* generated two sets of donors, the first one using blastula cells and the second using embryonic fibroblast cells. Euploidy of the embryo was confirmed by karyotype and Southern analysis. These clones showed normal growth, aging process and fertility. Only 2% of the total number of eggs used for nuclear transplantation attained sexual maturity, and their F_1 and F_2 progenies continued to express *GFP* in a pattern identical to the founder fish. Incidentally, Wilmut and his collaborators at the Roslin Institute, Edinburgh had also used 400 and odd surgically recovered unfertilized eggs and 277 reconstructed eggs to generate only one 'Dolly'. Therefore, Lee *et al.* may legitimately claim that they are the first to achieve cloning the fish, a lower vertebrate.

In India, beginnings have been made to induce androgenesis in rohu, *Labeo rohita* at the National Bureau of Fish Genetic Resources, Lucknow and transgenesis in catfish, *Heteropneustes fossilis* at the Centre for Cellular and Molecular Biology, Hyderabad. At the Madurai Kamaraj University, sexually mature rosy barb, *Puntius conchonius* has been restored using its preserved sperm at – 18°C (ref. 11) and genome-inactivated surrogate eggs of the tiger barb, *P. tetrazona*[12]. This kind of interspecific androgenic cloning may not only restore an endangered fish species but also mass produce, say, carp seedlings almost throughout the year using eggs of the undesired tilapia. Notably, it is the untiring efforts of our Asian colleagues from China, Japan, Korea and sustained support by government agencies that have led to this spectacular achievement of cloning the fish. Indian scientists at Lucknow, Hyderabad and Madurai must soon place India in the map of cloning the fish.

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Oscillating neutrinos and the sun

N. Panchapakesan

Astrophysicists (and cosmologists) use the results of physicists from other branches, in their work. Once in a while they are also able to help out the physicists by providing a testing ground for their theories. Recent results from a set-up in Ontario, Canada to detect neutrinos from the sun have provided one such occasion which has been very satisfying for both astrophysicists and particle physicists.

Energy production in stars has been under study for more than a hundred years. The progress can be traced through a series of classical books by Eddington, Chandrasekhar, and Schwarzschild[1]. The role of nuclear interactions in energy production was understood in the late 1930s when Hans Bethe and others suggested the possible nuclear reactions that could produce the energy. Bethe received the Nobel Prize for this (among other things). Basically, energy production results from the fusion of two protons and two neutrons to form the nucleus of helium, which has less mass than the combined masses of the four particles. This does not happen at one go, but involves several intermediary reactions. When carbon nucleus acts as a catalyst, the chain is known as carbon cycle, otherwise as p–p interaction. Whether the energy production is by carbon cycle or p–p interaction depends on the temperature at the centre of the sun. Energy produced in the core of the sun (or any star) has to come out at the surface by convection or radiation. In convection, the particles or matter move from the hotter inside to the cooler outside, thus transferring energy from the inside to the surface. In the radiative process, the photon or electromagnetic radiation carries the energy from the inside to the surface. The hurdles to the transmission of energy from the interior to the surface, due to scattering and absorption of photons and the energetic particles can be characterized by an 'opacity' coefficient. Except for details of the opacity, which keep changing with increasing knowledge of the underlying processes, and result in the frequent update of computer codes, the physics of energy generation and transmission in stars is believed to be well understood.

The existence of neutrinos was first suggested by Pauli in early 1930s, to ensure conservation of energy and angular momentum in beta decays. These are decays of the nucleus in which an electron or a positron (anti electron) is emitted. A good example is the decay of a neutron into a proton and an electron. Conservation of energy and angular momentum requires that there should be another particle with no charge but spin value of half. Experimentally, the mass of the particle is below the observable value and hence consistent with zero. Neutrons also have no charge and have spin half. So the postulated particle got the name neutrino (baby neutron in Italian). There are also corresponding anti-neutrinos. It is an anti-neutrino that occurs in neutron decay along with the electron. Neutrinos were believed to have zero rest mass like the photon and also to travel with the speed of light. The neutrino is almost undetectable or elusive (like the fictional Scarlet Pimpernel), and requires lots of patience (and equipments) for its observation. It was experimentally detected in the 1950s near nuclear reactors. The interaction of the neutrino is much weaker than nuclear or electromagnetic interaction, and is now called as 'weak' interaction. The neutrino interacts also gravitationally due to the energy (equivalent to mass) carried by it, but this interaction is much weaker than even the 'weak' interaction. So the neutrinos emitted in the nuclear reactions in the core of the sun are able to come out of the sun with very little loss of intensity. They are also able to travel to the earth and even through the earth without much loss in numbers. As the interaction of neutrinos is weak, their detection requires huge amounts of the detecting substance (like dichloro-ethylene or water) to observe even a few events per week.

We know now that the electron is the lightest member of a triplet of particles called leptons. The other members are the mu lepton or muon and tau lepton or the taon. Taon is 3500 times, and muon is about 200 times heavier than the electron. These are referred to as different flavours of the lepton. Associated with each is a neutrino of the same flavour. Thus we have an electron neutrino, a muon neutrino and a tau neutrino. If the mass of the neutrino is not exactly zero, these neutrinos can mix or get converted into each other. This changing of flavour is also called oscillations of the neutrino flavour.

The p–p interactions are believed to be the energy-producing reactions in the sun. In these interactions, for every 25 MeV of energy produced, two neutrinos are produced. For the solar energy we receive (solar constant of $2\ \mathrm{cal/cm^2/min}$), we expect 6×10^{10} neutrinos/cm^2/s of all energies. In the observable energy range (greater than 6 MeV), the prediction for the number of neutrinos to be received on the earth, based on a detailed model of energy production in the sun is $5.05 \times 10^6/\mathrm{cm^2/s}$. Thirty years ago Davis, using chlorine (in chloroform) as the detectors, concluded that there was a deficit of solar neutrinos. Only one-third of the expected number seemed to be coming in. Changing input parameters of the predicting model, like the central temperature of the sun, did not help. As the experiment could detect only electron neutrinos, the idea, that the missing neutrinos may have got converted into other flavours like mu or tao neutrinos, started gaining acceptance. This is what the latest results have confirmed.

In 1985, Herb Chen[2] suggested the use of heavy water (in which deuteron, with proton and neutron, replaces hydrogen, with only proton) to detect all neutrino flavours through the interaction of neutrinos with deuteron splitting it up into proton and neutron. The electron neutrino has an additional interaction in which the deuteron breaks up into two protons and an electron. Heavy water also serves as a detector for the products of these interactions. The Sudbury Neutrino Observatory (SNO) was set up, 2 km underground, in an Ontario nickel mine with one kilo ton of ultra-pure heavy water. The results announced in April this year[3] agree remarkably well with the total number of neutrinos predicted[4], but only one-third of them are electron neutrinos. The electron neutrinos are emitted in expected numbers but get converted to neutrinos of other flavours on their way to the earth from the sun. The solar model calculations are vindicated as is the idea of oscillations, making everyone happy (for the moment!). Unfortunately, Chen did not live to see the results.

Earlier a huge facility had been set-up by Koshiba at Kamiakonde in Japan to detect decays of protons. No decays were seen, but the set-up detected neutrinos emitted by a supernova in a nearby galaxy. More recently, it has been detecting atmospheric neutrinos. The observed number of muon neutrinos had pointed to oscillations among neutrinos even before the SNO results. The Japanese scientists are now planning a new set of observations called KamLAND with better detectors which should sharpen the agreement[5].

The oscillations are possible only if the neutrino has a finite rest mass. This possibility was first suggested in 1969 by Gribov and Pontecorva[6]. More recently, it was suggested that the oscillations are enhanced near high density matter, like in the interior of the sun or earth[7]. This should produce a difference between day and night measurements. This is because the neutrinos detected at night, coming from the sun, pass through the earth before detection and hence have passed through more dense matter than the neutrinos received during the day. A difference in mass 'delta-m' and a mixing angle 'theta' characterize the oscillation phenomenon. It is found that delta-m ~ 0.01 eV, while theta $\sim 30°$. If the mass of the neutrino is of the same order as delta-m, it is too small to make a contribution to the mass density of the universe. Otherwise, its contribution could have been very significant, as suggested earlier by Cowsik and McClelland[8]. These findings also point to the need for going beyond the standard model of elementary particles. The particle physicists have already started going beyond the standard model of elementary particles some years ago for several reasons, including the possibility of mass for neutrino.

R. Davis of USA and M. Koshiba of Japan share half of this year's Nobel prize for physics for their work on neutrinos described above.

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FROM THE ARCHIVES

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"Pending clarification of these and other obscure points the Forest Research Institute has decided to withdraw its publication, 'Ascu'—A wood preservative, *Indian Forest Records* (New Series), *Utilisation*, Vol. I, No. 6, and to postpone its re-issue in a revised form until the results of further research and adequate service tests are available." This announcement is contained in a note issued by the Forest Research Institute, Dehra Dun, under the signature of Mr L. Mason, President of the Institute.

This very unusual procedure of formally withdrawing a scientific publication originally issued under official authority raises a number of points which are not rendered any simpler by the fact that the process in question is covered by a patent which has been commercially exploited in India and, it is learnt is under active consideration even outside. When reviewing the publication '*Ascu*'—*A Wood Preservative* (*Curr. Sci.*, 7, No. 3, p. 141), attention was drawn, in particular to two facts; first on the mass of data and a century of experience which the older creosote and zinc chloride processes had behind them and which 'Ascu' on account of its infancy could not possibly have, and secondly, on the lack of a bibliography of relevant literature in the publication. And although the Foreword to the *Record*, explicitly warned that it was "too early to pronounce a definite or final opinion on its merits or limitations", it must be confessed that this withdrawal was entirely unexpected. . . .

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The spate of comment and enquiry that has reached us since the publication of the article on this subject in the previous number of *Current Science* is indicative of the widespread interest taken in and the rather nebulous position created by the withdrawal of *Ascu Record* by the Forest Research Institute, Dehra Dun. The relative facts can be stated in simple terms. When wood preservation was not part of the normal technique of timber utilisation in this country, Ascu was brought into being at Dehra Dun. The new process was considered to be of such promise that the Railway Board—one of the largest timber consumers in the country—appointed a Committee presided over by Sir C. V. Raman to examine the claims of Ascu. This Committee opined that the data then available, justified further experimentation. In the meantime, although the Forest Research Institute in their publications indicated some of the points requiring further elucidation, they definitely and even enthusiastically advocated the adoption of the process. Indeed, such was their confidence that so lately as in 1937 Sir Gerald Trevor, then President of the Forest Research Institute, in an article "Wood Preservative in India—Creosote *vs.* Ascu" summed up that in a choice between the two "the answer is in favour of Ascu every time"; this is very high praise to a wood preservative. . . .