derivatives to constitute cell-based assays in the identification of drug targets and testing of potential therapeutics.

THE STEM CELL WISH LIST

For stem cell researchers, there are some key questions that need to be addressed and these can be considered as a stem cell application wish list. Firstly, depending on the application, it is important to make as many cells of the required type as possible. Issues related to scale-up of manufacturing processes and preservation of biological products needs to be addressed. From a therapy perspective, it is important that many of these survive in an *in vivo* setting and more importantly not be subject to any rejection due to the host immune system. It is also important that they are stable in culture and *in vivo*; and once injected into the body, they should continue with the natural differentiation process. From a researcher point of view, it is useful to have a stable funding, ethical and regulatory environment. Lastly and not the least important wish is that they be safe, when used in therapies.

FUTURE OF STEM CELL RESEARCH

Recent studies have focused on identifying key genes and molecules that define a stem cell. These will help in not only developing methodologies for maintaining stem cells in their nascent state but also in developing directed differentiation strategies for producing specialized cell types. Numerous studies over the past few years have demonstrated the proof of principle of deriving specialized cell types. An often overlooked area of study is the genetic integrity of embryonic stem cells. It is imperative that this issue is addressed as one cannot use cells that are genetically compromised in any therapeutic setting. Our group, along with others recently published data that highlights the need for preserving the genetic integrity of human embryonic stem cell lines. Interdisciplinary approaches between scientists, clinicians and engineers are thus needed to move this fascinating field forward. Technical advances in molecular and cell biology, combined with bioinformatics tools is providing opportunities for greater biological knowledge and understanding of stem cells. Simultaneously, advances in biomaterial and bioreactor technologies will aid in promoting applied engineering approaches to meet the needs of cell expansion, while preserving the biological attributes of the desired product.

LAB RESEARCH

The Stem Cell Bioengineering Laboratory is located in the School of Engineering at Virginia Commonwealth University. Research in my lab is at the interface of biology and engineering, with the goal of developing the enabling technologies for stem cell research. Systems biology approaches are being used to characterize and evaluate stem cells, so that we can develop appropriate step-wise processes for differentiation. Additionally, we work on engineering micro-environments to maintain stem cells or to differentiate them into specialized cell types.

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BY KRISHNAN BALASUBRAMANIAN (BITS '78)

Computational & Mathematical Concepts in Arts & Sciences

Summary of extramural Director's lecture at IIT, Madras Aug 17, 2005

RD Burman's *mere nainaa saavan bhaadon*, sung by Kishore Kumar and a 1982 song *there mere beech main kaisa hai ey Bhandon from the movie Ek Dhuje keliy* were both hits of their times and perhaps of all times. Then again, we have the song *jaane kahaa.n gae vo din*, 1970 Raj Kapoor's *mera naam joker*. Besides being great hits do they have anything else in

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common? Well they are all similar in tune or melody, as they have a similar form in some mathematical ways or they all derive from the same Hindustani Raga Shivaranjani. When we tune our ears to these songs don't we recognize a pattern or a mathematical form of melody and rhythm? This happens to be the topic of my recent lecture at IIT Madras.

Professor V. Krishnamurthy, retired deputy director and then a professor of mathematics had a strong early influence in shaping my ability to see mathematical and computational concepts in many fields, music, sculptures, movies, religion, Bollywood or Kollywood music to all branches of sciences.

One of the central themes of my IIT lecture was such mathematical and also computational concepts in arts and sciences as the first part of my talk. Quantifying similarity as in patterns of nature is part of non-numerical branches of computational science such as artificial intelligence. The field is not only of aesthetic interest such as machine or cognitive perception of music but also of pragmatic value such as in the field of computer aided drug discovery and molecular similarity.

Who said aesthetics is only for artists and not scientists or engineers? Is it not amazing that there could be some latent mathematical form in aesthetics? Is it possible that science and arts can really come together? Well a part of my talk at IIT dealt exactly with that- the role of mathematical concepts originating from symmetry, asymmetry and duality with examples of ancient temples of Chola and Pallava of Tamil Nadu to Orissa temples. Consider one of the slides that I used in my presentation shown as Fig 1. This is from Kailasa Nadha temple located in Kancheepuram, a temple town about a 2 hour hop from Chennai. The temple stands out as a monumental piece of sculptural aesthetics of the Pallava Empire. A recurring mathematical pattern that emerges from many of these temple sculptures is the union of concepts of symmetry, asymmetry and duality. For example there is overall symmetry of the flanking dancers and yet the niches have some asymmetry and duality built into them as if there needs to be a global balance beyond the usual symmetry. By duality I mean on one side you have an image of a young person and the other side an old. Some times you find the image of a demon and the other side an angel. In a more general sense I explored the role of symmetry, asymmetry and duality in India's versatile and rich culture, religion and philosophy. While we understand symmetry in math as invariance under point group operations such as rotation, reflection, inversion, and improper rotation, concept

Number Theory

All numbers are created equal
Yet some are more prime.
But then why some are real
And others are truly imaginary?

All numbers are created equal
Yet all numbers are complex.
But then why some numbers
Are more rational than others?

All numbers are created equal
And many numbers are integral
But then why some are positive
And others are negative?

All numbers are created equal
And many numbers have values
But then why there is a number
That's zero like an empty tumbler?

Are there equal numbers?
Or is it only in my slumber
That I see transcendental numbers
And the eternal infinity?