The promise of molecular programming: a short course

- Niranjan Srinivas, Caltech (niranjan@caltech.edu)

Compile Phone

- Repeat 100 times:
  Grow 1 mm longer
  Grow 0.3 mm wider
- Repeat 10 times:
  Grow button

If we want to manufacture a mobile phone, why don't we compile a program like the above into molecules, and "grow" it? Sounds crazy? Well, if you really think about it, growth *is* a manufacturing process. Look around you - most of the world has been grown, rather than built. Growth is the manufacturing process of the biological world.

The more one thinks about this idea, the more natural it seems. A seed has all the information required to grow into a tree, it requires merely raw material and suitable conditions for the "developmental program" to unfold. In fact, reproduction and growth are fundamentally information processing tasks; organisms specify their offspring through the genetic code, and this information directs structure and behavior through the biomolecular implementation of the growth program. Inspired by biology, can we compute with molecules? What prevents us from writing programs that are compiled to and implemented by molecules?

Why would we want to? There are several amazing possibilities: for example, we could carry out intelligent cell-by-cell diagnosis and treatment, or grow intricate molecular machinery and nanoscale materials, which cannot be manufactured by any other means. Apart from engineering applications, we will make scientific breakthroughs, for this is not merely an engineering endeavour, but a *synthetic* approach to science. In other words, instead of studying something "out there", we try to build our own machinery, in the hope that we will identify essential design principles in the process. After all, in the words of Richard Feynman, what we cannot create, we do not understand.

In this short course, I will argue that there is no logical or physical obstacle to molecular programming - indeed, the biological world is *living proof*; we simply don't yet know how to do it. I will also discuss the considerable advances that have already been made by exploiting the programmability of nucleic acids like DNA. If time permits, I shall present some fascinating applications to bioengineering and nanotechnology. There are no pre-requisites.