New Realities for the Biological and Mathematical Sciences

Carlos Castillo-Chavez

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I would like to thank Calvin Williams from NSF for the invitation to speak this morning.

Motivation:

Technological innovations, globalization and related social/political responses have generated "irreversible" perturbations at various levels of aggregation from regions, counties and the world.

A key (if not the key) driving force from biology (at this point) comes from GENOMICS RESEARCH.

The sequencing of the human genome is playing a central role in medicine (cloning, etc.), evolution, cell biology, immunology, epidemiology, law enforcement, behavior, homeland security (see DIMACS report), etc.

The sequencing of many genomes (new technologies) has generated huge data bases, forced the reformulation of scientific problems and instigated the expansion and opening of new possibilities (area of research). Furthermore, ethical considerations have made it to the forefront of social, political, moral and economic discussions as a result of this "revolution."

There is tremendous student interest in three directions—bioinformatics, computational biology and genomics. Interests in these areas come from students from very different backgrounds and areas of research. The nature of the questions and the convergence of interests from multiple groups raises some important questions.

What are the definitions/boundaries of these fields?

What is an appropriate curricula for these areas?

Who should be trained in these fields?

How will their growth affect traditional fields like mathematics, applied mathematics, computer science, statistics, etc.

Response?

There are no unique responses and the danger may in fact derive from efforts to provide a unified "general" response.

Local change depends on

(i) Local human resources—who is there?
(ii) The development of clear and integrated programs in CS/Math/Stats and Bio that are tailored to the needs of SEVERAL types of students. We need FLEXIBILITY and NO DOGMA.

(iii) We need the development of materials while providing opportunities to faculty to update their knowledge and information levels. These efforts must be continuous and the opportunities must be there at all times—particularly for resident and incoming faculty from traditional fields who may feel threatened by the changes but who (at the same time) are essential for the success of this new revolution.

(iv) We need real incentives to encourage the re-tooling of resident faculty and we must provide time and support for the development of courses and instructional materials for these NEW audiences (our expanded clientele).

(v) We need systematic approaches for the dissemination of advances from national and international research.

(vi) We must establish new majors (or redefine old ones) that fit these new areas and that can accommodate students with different interests and levels of mathematical and computer training.

(vii) We need to provide expanded opportunities for all students via REU programs, internships and other experiences.

We need a multilevel effort. The new questions raised by biological research have begun to expand the scope of traditional fields. These fields must now find ways to provide access and opportunities to students with computational skills.

Traditional programs must open their doors to students and faculty who can provide links to computational approaches. In fact, one could argue that these students and new faculty must be at the center of many traditional programs (otherwise they may lose their ability to attract the best and in the process lose their leadership role).

Whatever we do, the mathematical and computational sciences must influence biological research the way molecular biology has in the past. That is, new computational and modeling approaches must become pervasive to most (if not all) "biology" programs in the nation.

PROBLEMS

Currently, all these math groups target the same student population (math/comp/stats types).

We need to bring individuals who know and love biology—typically those who are not members of the 'traditional" pool.

Faculty, to a great degree, are trained in traditional fields that see a REAL expansion and broadening of curricula in math/stats/computer science as a potentially debilitating force in the training of real mathematicians. (There was a somewhat similar problem with the introduction of calculators, computers, MAPLE, MATHEMATICA, etc.) Furthermore, there are limited incentives provided to faculty who want to seriously reinvest their time in re-defining or retooling themselves. (Again, a somewhat similar situation occurred with the necessary expansion of computer science to every college and university in the nation.)

Finally, addressing the problems raised by the generation of so much raw data (like genomics data) and the impact of the new technologies that are being developed to collect and analyze these data are central to the long-term well being of our society. It is imperative to the national interest that we develop the necessary human resources that are required to address these challenges. I would argue that we have no choice. There will be barriers set by tradition. However, the overwhelming impact of this research will continuously challenge them. Furthermore, most young people will be driven to these new fields. Ignoring that fact is not a wise decision.