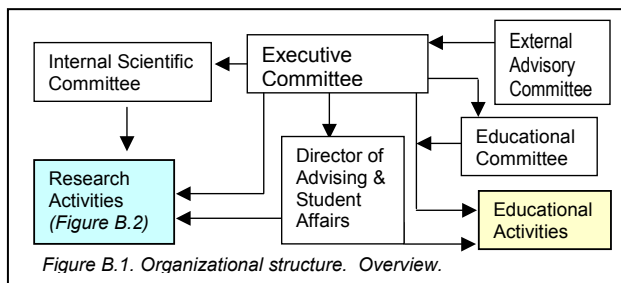


## B. Organizational Activities

### B.1. Organizational Structure: Overview.

The overall organization is designed to initiate and establish mutually beneficial collaborations between researchers from different disciplines, including biomedical sciences, basic sciences, computer science, and engineering. A tentative diagram of the organizational structure of the Pre-NPEBC is presented in Figure B.1. The establishment of a fully functional organizational and operational structure will be a major focus of the first phase (Phase I) of pre-NPEBC activities, in addition to the aims 1-3 presented in part A, and the developmental projects DP1 – DP3, to be described in § C.1-3.



*External Advisory Committee (EAC).* The EAC has the primary responsibility for policy, evaluation and oversight of the program to ensure that the interdisciplinary goals and focus are maintained. Members of the EAC will be leading scientists in computational biology, modeling of complex biological processes, or biomedical aspects of cell cycle regulation, apoptosis, DNA damage, and cell signaling. Ralph Roskies (Scientific Director, PSC) has agreed to poll the members of PSC's External Biomedical Advisory Committee (C. Cantor, CSO, Sequenom Inc.; C. Johnson, Director, Sci Comp & Imaging Institute, Univ. Utah; J. Mesirov, Assoc. Director, Whitehead Institute; J.P. Miller, Director, Center Comp. Biol., Montata St. Univ.; G.N. Reeke, Jr., Rockefeller Univ.; C.F. Stamer, Assoc. Prov. for IT, Med. Univ. S. Carolina; J. Wooley, Assoc. Vice Chanc. Res, UCSD) for suggestions on EAC membership. Regular biannual visits of one or more members of the committee are anticipated.

*Executive Committee (EC).* The EC ensures that the quality of the scientific and educational activities of the program remains high, plans and implements educational and research program policies, oversees the operation of the overall Center. The EC Chair and/or Co-Chairs serve as a liaison with the Chairs (or Directors) of the participating Departments (or Centers), and with the EAC members. EC members are Bahar (Chair, Comp Biol & Bioinformatics, Pitt), Stiles (Co-Chair, PSC/CMU), Brown (Co-Chair, Biology, CMU), Madura (Co-Chair, Chem & Biochem, Duquesne), Ermentrout (Mathematics, Pitt), Rosenberg (Biology, Pitt), and Ho (Biology, CMU). These individuals are committed to these positions for the duration of the pre-NPEBC. For an eventual full Center, two members will be renewed annually to ensure diversity and continuity. The PI's of the DPs, Billiar (Surgery, Pitt), Wood (Molecular Oncology, UPCI), and Lazo (Pharmacology, Pitt), will serve as adjunct members (to avoid potential conflicts of interest). Monthly meetings are planned, in addition to the meetings with other Committees.

*Internal Scientific Committee (ISC)* will (i) evaluate the progress of developmental projects in coordination with the EAC, and make recommendations to the EC regarding project continuation or termination, (ii) review newly proposed projects for the Center (see § B.4) for selection and implementation, and (iii) coordinate, facilitate and review the submission of new proposals (RO1 and others) to NIH and other funding agencies. For the planning stage, its membership is the same as the EC. For a full center, 3 EC

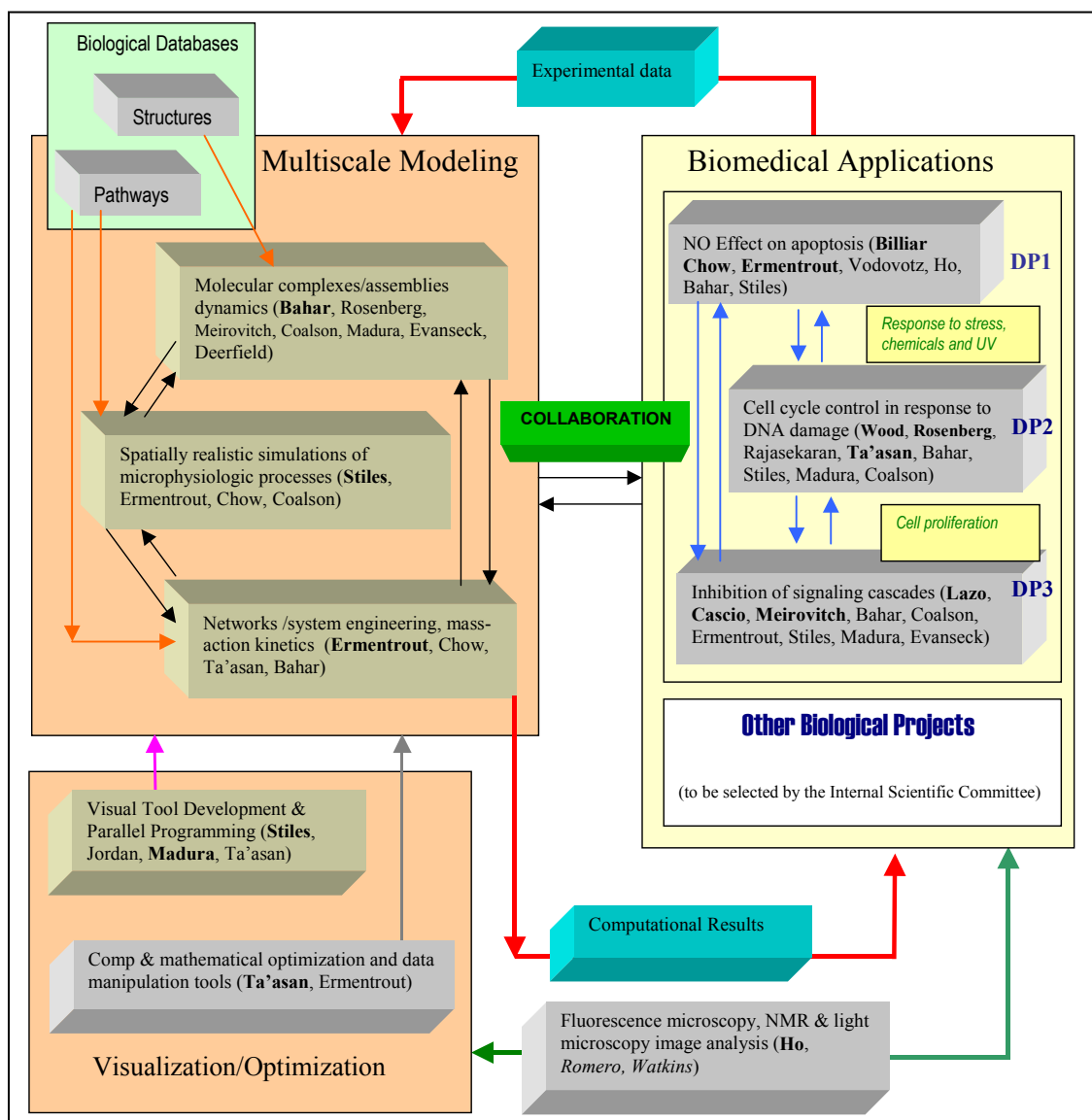
and 5 NPEBC members distinguished by scientific achievements will constitute the committee (1-2 years term-of-office). Quarterly meetings will be held, matching visits of EAC members.

*Director of Advising and Student Affairs.* M. Cascio (Mol Gen & Biochem, Pitt) will serve as a primary interface between Committees and students, postdocs or fellows, to provide a unified program and common experience to all applicants/trainees. Responsibilities will include (i) guiding potential and existing students and postdoctoral fellows toward programs, people and resources; (ii) coordinating outreach and ongoing education activities; (iii) facilitating exposure of students to career opportunities in computational biology and bioinformatics; and (iv) overseeing the Center's website to ensure updated lists of resources and activities, and dissemination of information to existing and potential members of the center. Changes in the staffing of this position will be at the discretion of the EC, on a two year basis.

*Education Committee (EDC)* is responsible for (i) overall policy and oversight of educational activities for training a new generation of bio-computation researchers, (ii) coordination of the organization of symposia, fora, workshops, (iii) monitoring the level, breadth, effectiveness of educational activities, (iv) planning, negotiating and coordinating curricula and academic affairs with the different departments of the participating institutions, and (v) admissions and/or recruitment of students, trainee and/or investigators. Members are Rosenberg (Chair, Biology, Pitt), Ermentrout (Math, Pitt), Deerfield (Co-chair, PSC/CMU), Bahar (Comp Biol & Bioinformatics, Pitt), Jordan (Chem, Pitt) and Evanseck (Center for Comp Sci, Chem & Biochem, Duquesne), and Phillips (Dean of Graduate Studies, School of Med, Pitt).

**B.2. Organizational Structure of Research Activities.** A diagram of the organizational structure of the Pre-NPEBC research activities is displayed in Figure B.2. On the left, the computational and mathematical aims, grouped under Multiscale Modeling and Visualization/Optimization are presented. Multiscale modeling comprises three levels of simulations (Specific Aim 1), linked into an integrated model of the multiscale dynamics (Specific Aim 2). Visualization/Optimization also includes database and software organization and dissemination (Specific Aim 3). On the right, the Biomedical Applications are shown. These comprise the Developmental Projects DP1-DP3 described in § C.1-3, as well as any other projects to be defined and activated within the scope of the pre-NPEBC, or a later full NPEBC. Key researchers are listed for each group of Table B.1. Group leaders (biomedical, PI; computational co-PI) are shown in boldface. The Multiscale Modeling and the Biomedical Applications groups will closely collaborate, via iterative cycles of refinement, for improving the predictive power of the newly developed models and methods, and for testing the theoretical predictions. Other sources of information for multiscale modeling are databases of structure (PDB) and pathways (e.g. KEGG, BIND, SPAD, ExPAsy, Biocarta, etc).

Figure B.2 Organizational Structure of Research Activities



*Pre-NPEBC Associate Members.* In addition to the pre-NPEBC key personnel (or so-called *Pre-NPEBC Full Members*) listed on page 4 and in Figure B.2, a large group of scientists from Pitt, CMU and PSC, have expressed their enthusiasm and willingness to contribute to our efforts, and already participated in our Brown Bag seminars or other organizational meetings before and after submission of the original proposal. Their affiliation and research interests are listed in Table B.1. We expect these Pre-NPEBC Associate Members to be actively involved in the educational and core activities of the pre-NPEBC as well as in future developmental projects of the pre-NPEBC and NPEBC (see below).

<b>Table B.1. Pre-NPEBC Associate Members</b>		
<b>Name</b>	<b>Organization</b>	<b>Interest</b>
P. V. Benos, Ph.D.	Pitt, Comp Biol & Bioinformatics	Modeling of protein-DNA interactions
B.G. Buchanan, Ph.D.	Pitt, Computer Science	Computational tools, AI
A.J. Connolly, Ph.D.	Pitt, Physics and Astronomy	Multiscale modeling, optimization
D. Curran, Ph.D.	Pitt, Chemistry	Fluorous chemistry, pharmacology
B.W. Day, Ph.D.	Pitt, Pharmaceutical Sciences	Computational pharmacology
D.B. DeFranco, Ph.D.	Pitt, Pharmacology	Subcellular trafficking, cell regulation
U. Diwekar, Ph.D.	CMU, Eng and Public Policy	Optimization, system engineering
M. Erdmann, Ph.D.	CMU, Computer Sciences	Structural computations/graph theory
C.P. Friedman, Ph.D.	Pitt, Center for Biomed Informatics	Education, biomedical Informatics
V. Gopalakrishnan, Ph.D.	Pitt, Center for Biomed Informatics	Education and bioinformatics tools
R.W. Hendrix, Ph.D.	Pitt, Biological Sciences	Multiprotein interactions
D. Jasnow, Ph.D.	Pitt, Physics and Astronomy	Dynamics of complex processes
H.A. Karimi, Ph.D.	Pitt, Information Sci and Telecomm	Information technology
A.S. Levine, M.D.	Pitt, Mol Genetics and Biochemistry	DNA damage recognition
M. Madrid, Ph.D.	PSC & CMU	MD simulations, NMR data analysis
J. Minden, Ph.D.	CMU, Biological Sciences	Proteomics, apoptosis, education
H.B. Nicholas, Ph.D.	PSC & CMU	Molecular simulations, education
S.L. Phillips, Ph.D.	Pitt, Mol Genetics and Biochemistry	Education in the School of Medicine
V. Rasic-Otrin, Ph.D.	Pitt, Mol Genetics and Biochemistry	DNA repair mechanisms
R. Ravi, Ph.D.	CMU, Computer Science	Large database searches, education
G.G. Romero, Ph.D.	Pitt, Pharmacology	Signal transduction, GFPs
R.Z. Roskies, Ph.D.	PSC & Pitt, Physics	Large scale computations
J.E. Rubin, Ph.D.	Pitt, Mathematics	Mathematical modeling, dynamics
G.S. Rule, Ph.D.	CMU, Biological Sciences	NMR molecular structure-function
T.E. Smithgall, Ph.D.	Pitt, Mol Genetics and Biochemistry	Receptor tyrosine kinases, signaling
R.H. Swendsen, Ph.D.	CMU, Physics	Monte Carlo methods
P. Tang, Ph.D.	Pitt, Anesthesiology	Comp chemistry, structural biology
A. Vogt, Ph.D.	Pitt, Pharmacology	Rational drug design, cell regulation
A. Wells, M.D.	Pitt, Pathology	Modeling cell regulation
S.C. Watkins, Ph.D.	Pitt, Cell Biology and Physiology	Biological Imaging
P. Wipf, Ph.D.	Pitt, Chemistry	Combinatorial synthesis
Y. Xu, Ph.D.	Pitt, Anesthesiology	NMR, receptor-ligand interactions
Q. Zhan, M.D., Ph.D.	Pitt, Radiation Oncology & UPCI	DNA damage and repair

### **B.3. Organizational Structure of Educational Activities**

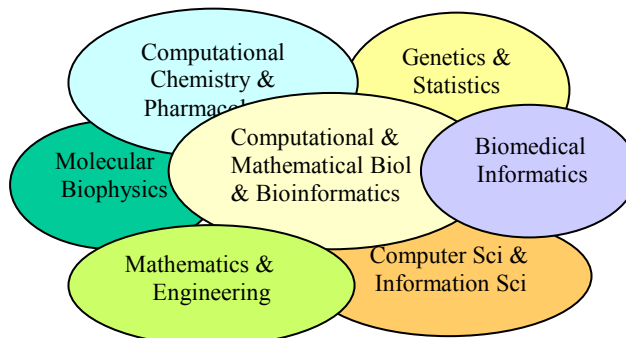
The Pittsburgh area is uniquely positioned for a dramatic growth of educational programs in two areas of strength - biomedical and computational science. Aside from the academic programs at CMU, Pitt, and Duquesne, and the computational resources of PSC, additional research institutions and resources related to an eventual NPEBC educational program include: Pittsburgh NMR Center for Biomedical Research (CMU/Pitt), the University of Pittsburgh Medical Center, the University of Pittsburgh Cancer Institute, the Pitt Centers for Biomedical Informatics (CBMI), Computational Biology & Bioinformatics (CCBB), Molecular & Materials Simulations (CMMS), Combinatorial Chemistry (CCC), and Biologic Imaging (CBI), and the Center for Computational Sciences (CCS) at Duquesne. Notably, the Directors of the NMR Center (C. Ho), CBMI (C. Friedman), CCBB (I. Bahar), CMMS (K. Jordan), CCC (P. Wipf), CBI (S. Watkins), and CCS (J. Evanseck) are all participants or associate members in the Pre-NPEBC.

A wide variety of new educational and outreach activities will be organized and implemented during the pre-NPEBC phase, spanning undergraduate, graduate and post-doctoral levels, as well as continuing education of Faculty and other Members of the Center. Should a full NPEBC result in the future, such activities will culminate in a new cross-institutional Graduate Degree Program in Computational Biology. The educational goals outlined in the present proposal include (i) enrichment of existing activities, and (ii) planning and implementation of new programs.

### B.3.1. Enrichment of existing educational activities

**B.3.1.1. Existing educational activities.** A summary of activities from the past academic year relevant to the goals of the pre-NPEBC can be found at <http://www.health.pitt.edu/pcbc/>; login: pcbc; password: team2001). These include in particular (i) an innovative mechanism for faculty, student and postdoctoral interactions across multiple departments and institutions in a seminar course (ISSP 2081; <http://dev.health.pitt.edu/bioinformatics/schedule.asp>) organized by the Center for Biomedical Informatics at Pitt; (ii) a new Faculty-level course by J. Minden (Biology, CMU) for teaching 'biology' to computer scientists; and (ii) a variety of Faculty/graduate level workshops offered by PSC's Biomedical Applications Group for over ten years in specialized areas of large scale biomedical computing, including a recent workshop on "Realistic Microphysiological Simulations Using MCell" organized by J.R. Stiles.

Figure B.3 gives a description of the position of a possible program in Computational Biology and Bioinformatics (CBB), or Computational & Mathematical Biology (CMB) in relation to a number of relevant educational programs already existing at the participating institutions. As depicted in the figure the CBB/CMB field is highly interdisciplinary, and overlaps with many disciplines. The pre-NPEBC members are distributed among these and other disciplines, and the existence of established or newly initiated programs in these disciplines will facilitate the development of a CBB/CMB program. For example, a new Biomedical Informatics Ph.D. Program offering a concentration in Bioinformatics started this year at Pitt School of Medicine with the support from NLM (T15 training grant), which could serve as a mechanism for supporting students interested in conducting research/thesis in the areas conforming to the pre-NPEBC goals (see support letter from the Director of this Program, Dr. C. Friedman). Another program, Molecular Biophysics, initiated by Dr. Rosenberg, which is at the final stages of official approval at Pitt as a new inter-departmental program between the School of Medicine and the Faculty of Arts & Sciences, will have a computational biology option, and students in this program will benefit from the educational efforts of the pre-NPEBC.



**Figure B.3.** Schematic view of the relation and interaction of a newly planned Computational & Mathematical Biology (& Bioinformatics) Program with existing programs at the institutions participating in the pre-NPEBC.

**B.3.1.2. Establishment of new educational activities.** New activities to be implemented during the pre-NPEBC phase will augment and expand upon existing activities, and will include:

- (1) *New Courses* along the pre-NPEBC research and educational goals, for students already enrolled in the different programs (Figure B.3) but pursuing theses/research projects on computational and mathematical biology. One such course to be offered by Ermentrout in the Fall 2002 is "Mathematical Biology", which will touch on genetic and biochemical models as well as population, ecology, and immunology models. Another course has been jointly taught by Bahar and Meirovitch in the present semester, which introduces the theories and methods of computational structural

biology, largely based on a graduate level textbook in preparation by I. Bahar, R.L. Jernigan, H.S. Chan and K.A. Dill. Two new courses in the Chemistry Dept (Fall 2002) are “Introduction to Computational Science” (undergraduate) and “Modern Computational Chemistry” (graduate), by Coalson and Jordan.

- (2) *Short Summer Courses* for entering graduate students: The material from existing PSC workshops will be redesigned for entering graduate students and taught as a three-week short course each Fall. Approximately one week will be devoted to molecular simulations and their coarse-grained extensions; a second week to microphysiological simulations, and the third to mathematical models that integrate material from the first two weeks.
- (3) *Annual Retreat*: In order to provide all students, faculty and post-doctoral fellows affiliated with the Center the opportunity to interact and contribute as a community, we will organize an annual retreat. It will include a forum of internal and external distinguished speakers, poster sessions from students and post-doctoral fellows and possibly computational competitions.
- (4) *Seminar Series*: Speakers in monthly organized seminars will include all the pre-NPEBC members (Full and Associate) to build a common language and knowledge base between the different groups, as well as invited outside experts in related disciplines.
- (5) *Brown Bag Lunch Meetings*: In order to facilitate and maintain interaction among students and postdoctoral fellows, we will organize monthly brown bag meetings for discussing ongoing research in computational and mathematical biology.

**B.3.1.3. A new cross-institutional course by pre-NPEBC participants.** As part of this planning grant we will develop a course, jointly taught, to train *post-doctoral fellows and graduate students* in the biomedical sciences. The goal of this course is to develop skills in visualization, programming, simulation methods and analysis, as well as in critical thinking. The course will be modular in design so that the material to be taught will be determined by its constituents. The topics of this course include:

- **Visualization:** Two main ideas will be developed in this module: visualization of complex data using software such as OpenDX, [www.opendx.org](http://www.opendx.org), and visualization, representation and manipulation of large structures using software such as MOE, [www.chemcomp.com](http://www.chemcomp.com). (*Madura and Stiles*)
- **Programming:** Application of the material presented in the previous section through the introduction of a programming language. Along with the syntax of the programming language numerical methods essential for accurate computer simulations will be presented. In addition to single processor coding, parallelization methods will be explored. (*Evanseck, Madura, Jordan, Deerfield*)
- **Multi-length and Multi-scale Simulation Methods:** Different methods used to study biomedical phenomena on the mesoscale, nanoscale, and at microscopic detail will be presented, along with the basic theory of MD, BD and MC methods, and the application of non-linear dynamics to study reaction pathways (*Madura, Coalson, Ermentrout, Bahar, and Ta'asan*)
- **Simulation Analysis:** Analysis of the simulation data in terms of structure, dynamics, and thermodynamics will be presented. The connection between simulations and experiments will be explored (e.g. experimental vs. computed local densities, radial distribution functions, mean-square fluctuations, diffusion coefficients, binding energies) (*Evanseck, Stiles, Bahar, and Madura*)

### **B.3.2. New Programs**

**B.3.2.1 Fellowship Programs.** Graduate students and post-doctoral fellows wanting to be affiliated with the Center may apply for a fellowship. The benefits and requirements are the same for both groups: (i) an honorific title, (ii) access to retreat and special workshops, (iii) advising services, and (iv) travel funds to attend a pertinent national meeting. The EDC will be in charge of approving the fellowship and ensuring that requirements are met by the Fellows. The requirements would be: (i) research/ thesis in a sub-area of computational biology; and (b) participation in pre-NPEBC seminars and brown bags.

**B.3.2.2. Certificate Programs.** There is a clear need within the Pittsburgh region for programs of study in computational biology and/or mathematical biology tailored to the background of the students. An immediate task of this organization will be the development of appropriate curricula that will become areas of concentration within other degree-granting programs of the three participating universities. Another area of focus will be in the development of new courses that could combine expertise that exists in the different universities. The development of new courses will also go hand-in-hand with reducing course redundancy. Cross-registration of students across the universities is a mechanism that has already worked well for enhancing the educational experience of students in this region. A major goal of the proposed center is to prepare the proposals and set up the administrative structures within the participating institutions that will administer the following undergraduate and graduate programs.

**B.3.2.2.1. Undergraduate Certificate Program in Computational Biology:** The goal of this program is to supplement existing majors such as Biology, Chemistry, Physics, Mathematics, Engineering and Computer Science, from all three institutions, with documented biomedical computation training. The curriculum will include (i) selected courses, either existing or to be developed, from across all three institutions (ii) workshops that cater to the needs of the undergraduate students by providing canned problems that are designed to provide the necessary hands-on experience, and (iii) undergraduate research or participation in ongoing research projects in the laboratories of the pre-NPEBC members.

**B.3.2.2.2 Graduate Certificate Program in Computational Biology:** The goal of this program is to supplement existing Ph.D. programs and provide documentation of computational expertise. Two target populations are (1) students in biological and medical programs, whose projects contain a significant computational component, (2) students in chemistry, physics, mathematics and engineering departments, interested in applying their basic sciences or engineering background and computational /mathematical abilities to complex biological problems. The curriculum would comprise the same requirements as fellows (see above) and selected courses. At least one Center faculty member should be on the Dissertation/Thesis Advisory Committee.

The Fellowship and Certificate programs outlined above will provide necessary infrastructure to develop a full-fledged degree-granting program. The fellowship and certificate programs are our goals achievable in the first one or two years. The M.S. and Ph.D. degree-granting programs will be initiated after we have structured the multi-disciplinary multi-institution interaction, in the year 3 of the pre-NPEBC.

**B.3.2.3. Graduate Program in Computational Biology.** Our long term goal is to provide a comprehensive set of educational opportunities that provide a full range of

background and research exposure across the scope of pre-NPEBC activities. Consistent with our goal, we plan to create additional programs as necessary to be integrative in the spirit of Figure B.3. In particular, we consider a cross-institutional graduate degree-granting program in Computational Biology, with two possible options: Computational Biology & Bioinformatics, and Computational & Mathematical Biology, aimed at the two groups of students listed in B.3.2.2.2. The pre-NPEBC activities will support the second option, and contribute to the first. An important and appealing feature of this novel program will be for students from any of the participating universities to share a common curriculum and opportunities for research experiences. Thus, teaching and research faculty from all three universities and PSC must contribute to the Program. We recognize that preparation of a joint proposal across institutions, and shepherding such a proposal through the administrations of each institution, will be a challenging task. Furthermore, the ultimate administration of the Program may take different forms, and we are prepared to pursue whatever route will lead to the Program's success. One possible mechanism would be for students to apply to, and graduate from, one particular institution while participating in the common course work and research opportunities. Another mechanism would be to apply directly to the multi-institutional degree program, to pursue common course work, and choose a thesis project at one institution that will grant the degree.

#### **B.4. Developmental Project Decisions**

##### **B.4.1. Selection of the presently proposed developmental projects (DP1-DP3)**

The selection of the present DPs has been motivated by (i) the experimental and computational expertise of the participants in the proposed biomedical problems, (ii) the fact that all three DPs are linked by a common theme, signaling and regulation of cell proliferation or apoptosis in response to different agents or stimuli, - NO in DP1, DNA damage in DP2, and inhibitors of signaling cascades in DP3, (iii) the availability of experimental data for starting computational studies and/or accessibility of experimental and computational resources for acquiring preliminary data, and (iv) the strong willingness of the participants to engage in a multidisciplinary interaction, as evidenced by the collaboration already started by several members of the pre-NPEBC. Examples of cross-departments/institutions recent collaborations are; Vodovotz (Surgery, Pitt) and Chow (Math, Pitt) on the NO mediation of inflammation; Smithgall and Cascio (Mol Gen & Biochem, Pitt) and Bahar (CCBB, Pitt) on the interaction dynamics of c-Src and Stat3; Rule (Biology, CMU) and Erdmann (CS, CMU) on the determination of protein folds from the graph representations of sparse NMR data; Rule (Biology, CMU) and Bahar on the interpretation of NMR relaxation data. Earlier relevant interdepartmental collaborations include; Billiar (Surgery, Pitt) and Ho (Biology, CMU) on the effect of iNOS induction on ischemia reperfusion injury (137); Wood (Molecular Oncology, UPCI), Levine (Health Sci, Pitt) and Ropic-Otrin (Mol Gen & Biochem, Pitt) on the translocation of damaged DNA binding proteins (138) and the binding of repair proteins to damaged sites (139); Gopalakrishnan (Biomed Informatics, Pitt), Rosenberg (Biology, Pitt) and Buchanan (CS, Pitt) on the development of artificial intelligence methods for crystallography (140); Lazo (Pharmacology, Pitt) and Wipf (Chemistry, Pitt) on the inhibitors of dual specificity phosphatases (141-143). More importantly, new collaborations across disciplines and institutions are initiated within the scope of each DP (§ C.1-3).

##### **B.4.2. Selection of new DPs and evaluation/termination of existing DPs**

The mechanism by which new developmental projects will be accepted into the pre-NPEBC, and, more importantly, into an eventual full NPEBC, will be published on the Center's website and circulated within the departments and administrative offices of the

participating institutions. Interested investigators will be required to submit a five-page mini-proposal, similar to those included here for DP1-3. Such proposals will be reviewed by the ISC, and one or two ad-hoc reviewers, if necessary, and recommendations on acceptance/rejection will be sent to the EC for a final decision. Rejected proposals will be returned with a summary of reviewers' concerns and recommendations, revised proposals will be considered.

PIs of existing DPs who wish to continue their project will be required to submit annual progress reports similar to the noncompetitive NIH progress report. Upon review by the ISC and final decision by the EC, the project will be: (1) continued for the next year; (2) continued with a recommendation to pursue independent outside funding; or (3) terminated. Projects that have obtained satisfactory preliminary results, but which require additional data for independent funding, will fall into the first category. Projects that have obtained sufficient preliminary results, and are progressing well, will fall into the second category. In this case, the Center's support will be continued while external grant proposals are prepared and reviewed. If external funds are successfully obtained, Center support will cease. If the external proposal(s) is (are) not funded, the reviewers' comments must be submitted to the ISC, which will then recommend continued funding through another external submission cycle, or termination. Termination in this case, or the third category above, will be recommended if it is apparent that the project has little or no chance to obtain competitive outside funds. In all cases, final decisions will be made by the EC.

### **B.5. Core Facilities**

The major resource for computing is PSC, one of the four original NSF-funded supercomputing centers in the USA. PSC received in the Fall of 2000 an NSF award of ~\$45 Million to build the Terascale Computing System, which is the largest and fastest supercomputer in the world available for academic use. PSC has many other computing systems at different scales, and all will be readily available to DPs through standard code development accounts. Some DPs will undoubtedly grow beyond the development stage and require large amounts of computer time, and in this case they can follow the established PSC policies for requesting time and resources. In addition, part of the pre-NPEBC budget has been allocated to PSC technical support and consulting (particularly for code parallelization and model visualization), and the PSC's Training Center will be available for workshops and short courses. Aside from the PSC, several participating centers listed in § B.3 have local medium-scale computing resources (e.g., UNIX workstations, PC clusters) that will be used by pre-NPEBC participants. Each of these centers has in-house system administration and hardware maintenance. All participating institutions are fully interconnected via multimedia, multiprotocol networks with high-bandwidth access. The Center for Biologic Imaging (CBI) will provide microscopic and imaging support and expertise for the cellular level modeling efforts. The CBI's equipment includes a Cell Imaging System, Nikon TE300 inverted microscope, BioRad imaging densitometer for quantitative analysis of polyacrylamide gels and immunoblots, a semi-automated system for chromatography of recombinant proteins and a Cellomics ArrayScan II Cytometer that is an automated fluorescence microscope for determining the subcellular distribution of fluorescent molecules. The Pittsburgh NMR Center for Biomedical Research will serve as a core facility characterizing protein dynamics, for imaging and flow dynamics experiments. See also the Resources pages and relevant support letters for other equipment and facilities.