

BIOMEDICAL SCIENCES

The Applied Physics Laboratory conducts a biomedical program in collaboration with the Johns Hopkins Medical Institutions (JHMI) as part of its mission to develop and apply science and technology to solve problems of national and global significance. These efforts, performed by the staff on a part-time basis, use the strengths developed in other tasks at APL. They illustrate the breadth of skills available at APL and demonstrate our commitment to other divisions of our University. As part of its diversification program, the Laboratory is attempting to expand the program and use our privileged relationship with JHMI to establish a significant program in health care and biomedicine. The past success of the program and the emphasis that the nation is giving health care suggest that efforts in this area should be particularly rewarding. Essentially all of our efforts are either supported by Independent Research and Development (IR&D) funding, or are part of projects funded by outside agencies that were initiated under IR&D support. The IR&D Biomedical Advisory Council (IBAC), with representatives from both APL and the Medical School, helps to formulate and evaluate our efforts in this area.

Since 1965, JHMI physicians and researchers have teamed with APL engineers and scientists to develop more than 100 products important to clinical care, to conduct physiological and clinical research, and to develop commercial devices. Major biomedical contributions have been made to the Departments of Cardiology, Oncology, Neurology, and Ophthalmology. For 30 years, APL has pioneered the design of medical devices utilizing technology transfer from space and defense systems. These devices include ophthalmic lasers, the rechargeable cardiac pacemaker, an intracranial pressure monitor, the one-time-use disposable syringe, and the programmable implantable medication system. Other successful projects include powered prosthetic limbs, wheelchairs for paraplegics, computerized clinical information systems, systemization of radiological treatment, and fetal heart monitoring. International award-winning research at APL has been conducted on neurophysiological mechanisms of pain, cornea physiology and damage, and retinal disease. Current investigations continue this research, as well as tasks related to radiation oncology management, brain slice sterology, ultrasonic imaging of brain blood perfusion, medical informatics, early breast cancer detection, and hypovolemic shock prediction.

The Biomedical Sciences Thrust Area is organized into three projects: Medical Informatics and Health Care, Biomedical Devices and Instrumentation, and Research and Development. An objective of this IR&D

thrust is to position the Laboratory for work in these areas. Contributed and invited proposals are sought in each project, and are aggregated into themes determined by each coordinator. Subsequently, the IBAC (chaired by Dr. Vincent Pisacane of APL, and co-chaired by Dr. Richard Johns of JHMI) reviews the theme projects with the coordinators for approval. Technical quality is a prime factor in selecting tasks to be included, but selecting tasks that lead to outside sponsorship is of vital importance if this thrust is to lead to a new primary business area for APL.

The emergence of medical informatics as a new discipline is due in large part to advances in computing and communications technologies, which are also important to many APL programs. Availability and dissemination of information is a critical, and often pervasive and expensive, element in a health care system. Descriptive, diagnostic, therapeutic, prescriptive, financial, and investigative health care information has proven difficult to standardize and costly to store and disseminate.

Military operating forces are faced with the challenge of maintaining operational and combat readiness and delivering the best possible care in stressful environments. For the military, medical informatics involves complex processes and systems that significantly impact contingency planning, medical logistics, quality of health care in forward combat areas, and overall force effectiveness. Particular areas of interest are interoperability and effectiveness of medical information systems in joint and allied missions, medical readiness reporting and tracking systems, integration or insertion of commercial informatics technologies into military systems, delivery of medical care in areas near the conflict, and portable terminals supporting diagnostics, decision making, and/or data, voice, and video communications functions.

The health care system of the United States is undergoing change. The advancing age and increased mobility of the population, rising costs of health care, and increases in the number of patients discharged from hospitals sooner than in the past are drivers for developing technology for home health care services. Particular areas of interest are patient surveillance and security, imaging and wound care, physiological monitoring, patient and family education, patient record administration and management, and portable terminals supporting diagnostics, decision making, and data, voice, and video communications functions.

Work in military and home health care systems is of special interest to the **Medical Informatics and Health Care** Project. However, tasks outside the realm of military and home health care also are evaluated and considered for funding. The project consists of research

and/or development tasks that show great promise for a rapid transition to a challenging science or engineering task sponsored by a government organization. The report of the APL Biomedical Research and Health Care Systems Development Action Team suggests that this project area has an enormous growth potential at APL.

Advances in biomedical instrumentation can help answer the national demands to reduce cost and increase quality and accessibility of health care. Moreover, advanced biomedical instrumentation is a particular need of the military services. The close association of APL and JHMI and the past collaborations in biomedical instrumentation provide an established framework to undertake new and larger-scale projects. Biomedical instrumentation development is also consistent with APL strategic directions. The main technological elements required for many biomedical instrumentation projects include electronics, electromechanical systems, telecommunication, optics, sensors, signal and image processing, and algorithms and software development. The technologies involved in biomedical instrumentation are important to APL's DoD-sponsored projects, and, indeed, a major emphasis is to serve military medical needs.

Tasks leading to devices and signal processing for minimally invasive technologies are of particular interest to the **Biomedical Devices and Instrumentation** Project. The project consists of a few tasks selected on their merits with respect to medical need, strengths of the investigations and medical collaboration, and potential for transition to formal, direct funding. Direct funding may come through many channels, including the recently formed Maryland Health Care Alliance. Biomedical instrumentation is also a good candidate for opportunities in dual-use and technology transfer, and, by definition, it involves hands-on prototype development. Typically, these instruments would be installed at JHMI, evaluated, and further developed over several years. Health care products form one of the most effective avenues for developing good community and public relations.

Biomedical research fulfills parts of the mission of the Laboratory by providing the staff with the opportunity to do basic and applied research in this area of obvious national importance, and by fostering participation in the educational mission of the University through mentoring and the part-time master's program in engineering and applied physics of biomedicine. Some of the current research is directed at medical problems unique to the military environment, and, moreover, techniques developed in biomedical research often have direct application to other military problems. By its nature, biomedical research encourages interdivisional

collaborations at the Homewood and East Baltimore campuses, the importance of which is recognized at all levels of the University. Biomedical research is performed by small research teams whose efforts are guided by a principal investigator. Currently, active outside funded programs include corneal structure studies (funded by NIH, AMRDC, the Army Environmental Hygiene Agency, and an Alcon Honorary Award), neurophysiological and psychophysical investigations of pain (funded by several NIH grants, one of which received an honorary Javitz Award), and studies of retinal perfusion (which also received an Alcon Award). An essential ingredient for success is active encouragement and participation by the appropriate department at JHMI. Currently, there is strong support for new collaborative programs at the School of Nursing and in the Departments of Radiology, Biomedical Engineering, Urology, and Orthopedics at the School of Medicine.

The primary goal of the tasks in the **Biomedical Research and Development** Project is to use engineering and physical sciences approaches on problems of importance to the medical community, especially those of importance to our colleagues at JHMI. Investigations that establish long-term collaborations that show great promise for being funded by external agencies receive special emphasis. Each participant is expected to write one or more proposals to external agencies per year.

THE AUTHORS



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HARVEY W. KO is a member of the Submarine Technology Department and of the APL Biomedical Advisory Committee. Dr. Ko holds six biomedical engineering patents. He received a B.S.E.E. degree in systems engineering (1967) and a Ph.D. in electrophysics (1973) from Drexel University. He joined APL in 1973 as an investigator of analytical and experimental aspects of ocean electromagnetics, magnetohydrodynamics, radar wave propagation, bioimpedance, biomagnetic processing for encephalography, and brain edema. In 1966, he

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RICHARD A. FARRELL is a Principal Staff Physicist and Group Supervisor of APL's Theoretical and Biomedical Problems Group. He received his B.S., M.S., and Ph.D. degrees in physics from Providence College (1960), the University of Massachusetts (1962), and The Catholic University of America (1965), respectively. Dr. Farrell is currently a part-time associate professor in the departments of Biomedical Engineering and Ophthalmology of the Johns Hopkins Medical School, and is the chairman of the Engineering and Applied Physics of Biomedicine

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