When asked by our Editor to write a guest editorial on Biomaterials for this issue, I began to look for a theme that would crystallize my thoughts. The 21st century is less than 5 years away. That is approximately the time scale of many research projects sponsored by the VA Rehabilitation Research and Development Service. Thus, I face the same challenge that researchers do in trying to develop new or improve already existing materials in the quest for improving our quality of health, extending life spans, or freeing us from pain—where do we go from here?

At present, the biomaterials scientist has the entire gamut of appropriate materials to choose from—metals, alloys, ceramics, polymers, composites—the choice being predicated on a number of factors: location, function, compatibility, availability. Of course, always in mind is the dual concern—the material(s) do not act inimically on the body and vice versa, the body does not affect the material(s) inimically. Thus, we now have joint implants made of various combinations of metals or composites used with ceramics and/or polymers to restore function when it is lost due to accident or pathology; the metals and composites providing the appropriate stiffness and rigidity to support loads; the ceramics and polymers providing low friction surfaces for joint movement. We have sight and sound restored in many instances by the use of biomaterials. Where function involves some sort of stimulus, as in pacemakers or cochlear implants, the electrical systems and the leads must be properly encapsulated in biocompatible materials able to withstand the body’s inimical environment for long periods of time. It is similar for synthetic heart valves and vascular replacements. Artificial skin combining synthetic materials with the naturally occurring biopolymer, collagen, saves the lives of burn patients. Many drugs, whose use is required for a specific target (e.g., pills for birth control or nitroglycerin tablets for angina), are taken systemically, which means larger doses than might be required on site. External patches over the heart, which release small amounts of the drug continuously, keep the condition under control. Implantable time-release systems in situ for birth control mean significantly lower dosages are possible; thus reducing the potential for side effects. Other areas of time-released drug delivery are being developed at present.

In the area of limb prostheses, new composite materials, lighter but with appropriate stiffness and rigidity, are being developed. Direct skeletal attachment of arm and leg prostheses also involves the biomaterials scientist, as stability and longevity of the bone-biomerals interface in direct skeletal attachment of prostheses is a complex problem.
requiring significant research and clinical studies. Dudley Childress, PhD, addressed this issue, in part, in his Guest Editorial in Vol. 30 No. 2, 1993, pp. vii–viii of this Journal.

I have covered only a small part of the exciting areas in which biomaterials play a significant role in our lives. However, in the midst of all the glow, a dark shadow has appeared affecting the future in many areas of biomaterials use. Recent law suits on the use of silicone breast implants (often based on very little scientific evidence) have resulted in large settlements. This has, in fact, caused Dow-Corning, producers of medical grade silicone, to declare bankruptcy, solely because of this issue. However, this is not the worst of it. Other major producers of medical grade polymers, used in all manner of implants, now have adopted a policy of not making any polymers of medical grade available for either clinical use or research. The amount of polymers needed for medical purposes is a minute portion of the production of these companies, while law suit settlements can be the major portion of their legal problems. Clearly, any use of such polymers for medical purposes produced by these companies is now prohibited. This is a serious problem that must be addressed and solved by our nation, or the use of biomaterials in the 21st century will be seriously inhibited. Even now, key clinical areas requiring the use of polymers, such as vascular grafts, hydrocephalic shunts, etc., will be severely affected. Research areas, such as the artificial heart program, requiring blood compatible biomaterials, will also suffer setbacks.

We have touched on the past and the present. These help establish the bases for future innovations in biomaterials design and use setting the stage for Biomaterials in the 21st Century. The purely synthetic and generic materials are the museum pieces of the 20th century. Advances and new innovations in scientific instrumentation and techniques for studying material properties and function down to the atomic and molecular level are providing new insights into material-tissue interactions involving interfaces, adhesive characteristics, compatibility, etc., that will permit the design of “tailor-made” materials for specific uses. The ability to study the interaction between blood components and various synthetic material surfaces using scanning force microscopy utilizing a variety of probes should lead to blood-compatible materials for all sorts of applications. Acoustic microscopy at gigahertz frequencies (billions of cycles/sec) is providing information on elastic properties at sub-micrometer resolution. This information, coupled with electron microscopy for structural studies, could lead to the understanding of how certain tissues, such as bone, are resorbed and regenerated in response to forces. It might then be possible to combine mechanical and biological methods for the regeneration of such tissues rather than use synthetic materials. Natural tissues are also a part of biomaterials research. When tissue regrowth is not a solution, the techniques mentioned above, along with other material procedures, will lead the way to developing biomimetic materials. Biomimetics is the development of synthetic material systems based on information derived from biological systems. Regeneration of natural tissues and biomimetics will be two of the key areas of biomaterials research in the 21st century.

I paraphrase a statement made many years ago by a famous wit—it is very difficult to make predictions, especially about the future. Artificial organs, such as heart, pancreas, kidney, etc.; synthetic blood; regeneration of bone and cartilage; synthetic tendons and ligaments; direct skeletal attachment; artificial vision; spinal fixation; external orthoses and prostheses; pacemakers; vascular grafts; timed drug release; joint replacements, etc.; all depend on biomaterials research. Many are in clinical use at present but are continually undergoing improvement. Many now exist only in the research laboratory or in the minds and notebooks of scientists and clinicians. I predict all these and many other biomaterials usages not listed above will be our heritage in the 21st century.

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