

A History of Biomaterials

BUDDY D. RATNER

At the dawn of the 21st century, biomaterials are widely used throughout medicine, dentistry and biotechnology. Just 50 years ago biomaterials as we think of them today did not exist. The word “biomaterial” was not used. There were no medical device manufacturers (except for external prosthetics such as limbs, fracture fixation devices, glass eyes, and dental devices), no formalized regulatory approval processes, no understanding of biocompatibility, and certainly no academic courses on biomaterials. Yet, crude biomaterials have been used, generally with poor to mixed results, throughout history. This chapter will broadly trace from the earliest days of human civilization to the dawn of the 21st century the history of biomaterials. It is convenient to organize the history of biomaterials into four eras: prehistory, the era of the surgeon hero, designed biomaterials/engineered devices, and the contemporary era leading into a new millennium. However, the emphasis of this chapter will be on the experiments and studies that set the foundation for the field we call biomaterials, largely between 1920 and 1980.

BIOMATERIALS BEFORE WORLD WAR II

Before Civilization

The introduction of nonbiological materials into the human body was noted far back in prehistory. The remains of a human found near Kennewick, Washington, USA (often referred to as the “Kennewick Man”) was dated (with some controversy) to be 9000 years old. This individual, described by archeologists as a tall, healthy, active person, wandered through the region now known as southern Washington with a spear point embedded in his hip. It had apparently healed in and did not significantly impede his activity. This unintended implant illustrates the body’s capacity to deal with implanted foreign materials. The spear point has little resemblance to modern biomaterials, but it was a “tolerated” foreign material implant, just the same.

Dental Implants in Early Civilizations

Unlike the spear point described above, dental implants were devised as implants and used early in history. The Mayan people fashioned nacre teeth from sea shells in roughly 600 A.D. and apparently achieved what we now refer to as bone integration (see Chapter 7.8), basically a seamless integration into the bone (Bobbio, 1972). Similarly, an iron dental implant in a corpse dated 200 A.D. was found in Europe

(Crubezy *et al.*, 1998). This implant, too, was described as properly bone integrated. There were no materials science, biological understanding, or medicine behind these procedures. Still, their success (and longevity) is impressive and highlights two points: the forgiving nature of the human body and the pressing drive, even in prehistoric times, to address the loss of physiologic/anatomic function with an implant.

Sutures for 32,000 Years

There is evidence that sutures may have been used as long as 32,000 years ago (NATNEWS, 1983, 20(5): 15–7). Large wounds were closed early in history by one of two methods—cautery or sutures. Linen sutures were used by the early Egyptians. Catgut was used in the Middle Ages in Europe.

Metallic sutures are first mentioned in early Greek literature. Galen of Pergamon (circa 130–200 A.D.) described ligatures of gold wire. In 1816, Philip Physick, University of Pennsylvania Professor of Surgery, suggested the use of lead wire sutures noting little reaction. In 1849, J. Marion Sims, of Alabama, had a jeweler fabricate sutures of silver wire and performed many successful operations with this metal.

Consider the problems that must have been experienced with sutures in eras with no knowledge of sterilization, toxicology, immunological reaction to extraneous biological materials, inflammation, and biodegradation. Yet sutures were a relatively common fabricated or manufactured biomaterial for thousands of years.

Artificial Hearts and Organ Perfusion

In the 4th century B.C., Aristotle called the heart the most important organ in the body. Galen proposed that veins connected the liver to the heart to circulate “vital spirits throughout the body via the arteries.” English physician William Harvey in 1628 espoused a relatively modern view of heart function when he wrote, “The heart’s one role is the transmission of the blood and its propulsion, by means of the arteries, to the extremities everywhere.” With the appreciation of the heart as a pump, it was a logical idea to think of replacing the heart with an artificial pump. In 1812, the French physiologist Le Gallois expressed his idea that organs could be kept alive by pumping blood through them. A number of experiments on organ perfusion with pumps were performed from 1828–1868. In 1881, Étienne-Jules Marey, a brilliant scientist and thinker who published and invented in photography theory, motion