CARL SAGAN is credited for the axiom “extraordinary claims require extraordinary proof.” For those familiar with magnetic therapy, it is quite clear that extraordinary claims have been advertised.¹ For many years, the only “proof” of magnetic therapy effectiveness was testimonials from individuals who claim to have benefited from it. Because anecdotal reports are not considered a reliable source of evidence, many in the scientific and medical communities view magnetic therapy to nothing more than deception and quackery.² This skepticism has been reinforced by the U.S. Food and Drug Administration and Federal Trade Commission having taken action against magnet manufacturers, distributors, and web-sites that made claims of medical benefit without evidence to support them.³

Clinicians would probably be more receptive to using magnetic therapy if it were not marketed as a panacea. Unfortunately, it is unlikely that these claims will disappear anytime soon. Sales of static magnets for therapeutic purposes have been estimated to be $500,000,000 dollars annually in the United States.⁴

A systematic review published in the Journal of Alternative and Complementary Medicine (2005) examined randomized controlled trials to determine if magnetic therapy is an effective analgesic agent for various conditions including inflammatory, neuropathic, rheumatic, musculoskeletal, fibromyalgic, and post-surgical pain.⁵ The literature search yielded 21 randomized controlled trials in which subjects with pain were randomly assigned to either magnetic therapy or a placebo, independent of the cause or location of the pain. The strength of the magnetic fields, duration, and mode of application (head bands, necklaces, mattresses, and foot pads) were quite variable. Of the 21 trials, 13 reported significantly less pain in the magnetic therapy group compared to that of the placebo-control group. When the studies with less methodological rigor were eliminated, 11 of the 18 high-quality studies demonstrated a significant analgesic effect. Although this is not the sort of evidence that Carl Sagan might deem extraordinary, it is enough to make some consider the clinical use of magnets for analgesia.
**Magnetism**

Magnetism is the phenomenon that is observed when a material exerts an attractive or repulsive force on another material. One of the fundamental laws of nature is that a moving charged particle (electron or ion) creates a magnetic field. An electrical circuit has great potential to create magnetic forces, such as those generated by an electromagnetic crane used to lift discarded automobiles. The movement of charged particles creates magnetic fields, and conversely, moving magnetic fields create electric fields that can cause a current to flow through a conductor. This interaction of electric and magnetic fields is called electromagnetism. Clinically, we utilize electromagnetism in the form of shortwave diathermy and pulsed electromagnetic fields for deep tissue heating and bone healing, respectively. Hence, it is clear that some types of magnetic fields alter human physiology.

Magnet therapy utilizes static magnets that have constant magnetic fields. Forces from static magnets are created by the collective, synchronized movement of electrons as they orbit and spin about the atomic nuclei within a material. Most materials are comprised of atoms that have paired electrons, with opposite directions of spin and orbit. The natural diametric spin and orbit of the electron pair produces no magnetic force. Some atoms have unpaired electrons, and if more electrons are orbiting in one direction than another, a net magnetic force is created. Depending on the orbital alignment of the unpaired electrons in the material, it may be classified as ferromagnetic or paramagnetic. Ferromagnetic materials demonstrate some degree of spontaneous alignment of unpaired electron orbits that provide a strong attraction to magnetic fields. In contrast, paramagnetic materials are not inherently magnetic. Paramagnetic materials have randomly aligned unpaired electron orbits which will temporarily align in the presence of a magnetic field, producing a weak attraction toward the magnetic field.

The strength of a magnet, or magnetic flux density, is measured in Gauss (G) or Tesla (T; 1 T = 10,000 G). The strength of a magnetic field is greatest at the poles of the magnet. The strength of the magnetic field weakens as the distance between the target tissue and magnet increase, based on the inverse square law. However, the magnetic field is relatively undisturbed by human tissue, allowing the field to penetrate relatively deep within the tissue.

**Biophysics**

There are three recognized biophysical mechanisms that describe potential interactions between static magnetic fields and living tissue: (a) forces on moving charged particles, (b) magnetomechanical effects, and (c) electronic interactions. The Lorentz Force Law describes the interaction of charged particles moving through static magnetic fields. The force applied to the charged particles depends on the strength of the magnetic field and the velocity of the charged particle. The direction of the force is perpendicular to both the original velocity of the charged particle and the magnetic field. Thus, ions traveling through blood vessels, neurons, or muscle fibers can be displaced in a direction perpendicular to the flow of ions when a magnetic therapy device is applied. The force predicted by the Lorentz Force law, however, is extremely small compared to hydrostatic and osmotic forces naturally found within the tissues.

It was previously hypothesized that when a magnet was placed over flowing blood, ions would accumulate and provide resistance within the blood vessel creating molecular friction and heat. Extremely high magnetic fields may impede blood flow due to the Lorentz force, but the strength of most therapeutic magnets (100-4000 G) is far less and does not produce heat or increase blood flow in the tissue. However, a 4024 G static magnetic field has been demonstrated to reduce blood flow in humans. It was speculated that changes in the dynamics of calcium ions may have accounted for the reduced blood flow. Low-intensity static magnetic fields have been shown to exert a significant mechanical effect on calcium ions in living tissue, which may result in altered cellular proliferation and maturation, signaling across the cell membrane, cell membrane excitability, and transcription of genetic information. Because calcium ions are vital for transmission of neural impulses and cause depolarization of nociceptors, an alteration in the actions of calcium ions may provide a tenable hypothesis for the reduction of pain.

The second biological mechanism for interactions between magnetic forces and biological tissue is the magnetomechanical effect. It is the result of attractive forces between a magnet and paramagnetic or ferromagnetic materials. Some substances in the human body are attracted to magnetic fields; however, the attraction is very weak. It has been demonstrated that a