and/or resonant acousto-EM energies to detect the presence of and/or identify biologic structures.

In accordance with the aforesaid objects the present invention provides for the detection of inorganic or biologic structures and/or disruption and/or augmentation of growth and/or functions of a biologic structure using resonant acoustic and/or resonant acousto-EM energy.

Applying principles of acoustic resonance, the resonant acoustic frequency of a biologic system is the natural free oscillation frequency of the system, and thus a biologic system can be excited by a weak mechanical or acoustic driving force in a narrow band of frequencies. Also, depending on the size, shape, and composition of the biologic structure, there can be more than one naturally occurring resonant acoustic frequency, as well as numerous subharmonic and superharmonic resonant acoustic frequencies.

When a structure, both inorganic and biologic, goes into acoustic resonance, energy builds up in it rapidly. The energy is either kept in the system or released to the surrounding environment. Energy kept in the structure can enhance the structure's functions or cause disruption of the structure. A small amount of the energy in a resonant system is either intrinsically dissipated, as electromagnetic energy, or is transmitted as acoustic energy to the nearby medium. The intrinsically dissipated energy is of particular interest, because it is dissipated through molecular and atomic vibrations, producing EM energy. This EM energy is referred to as acousto-EM energy because it is produced when a structure is in acoustic resonance and some acoustic energy interacts with the structure and is converted into electromagnetic energy which is intrinsically dissipated into nearby media. The properties, fields and/or frequencies of EM energy produced depend on the unique molecular and atomic components of the structure in question. Thus, the induction of acoustic resonance in a structure leads to the production of a unique acousto-EM signature for that structure, which can be used to detect and/or identify it as disclosed in the present invention. Conversely, if a structure is targeted with EM energy equivalent to its acousto-EM signature, the energy dissipation pathway is reversed, and a state of acoustic resonance can be induced. Reversing the energy dissipation pathway with an acousto-EM signature can be used to produce the same augmentation, detection, and disruption effects that the original resonant acoustic energy field produces. The resonant acousto-EM signature can be used either by itself, or in

combination with resonant acoustic energy. Using the resonant acousto-EM and acoustic energy together, allows for the use of lower power levels of both types of energy, lessening the potential adverse affects of electromagnetic energy and/or acoustic energy on nearby or adjacent nontargeted structures.

Electromagnetic energy may interact with and complement an acoustic energy wave in a system in at least four ways: via the piezoelectric effect, intrinsic dissipation of electromagnetic energy and via the acoustoelectric or magnetoacoustic effect.

In the piezoelectric effect, acoustic vibratory energy is converted interchangeably with EM energy by a transducer. Biologic piezoelectric structures can modulate the same conversion of energy, thereby acting as living transducers. When an EM field is applied to a biologic piezoelectric structure, an acoustic wave is produced. Likewise, when an acoustic wave is applied to a biologic piezoelectric structure, EM energy is produced. The piezoelectric effect in biologic structures has many useful applications (see below.) This effect becomes even more useful when principles of acoustic resonance are applied. In the present invention specific biologic structures can be targeted with an acoustic wave or EM energy at power levels that dramatically affect the target structure, but have virtually no effect on adjacent, nonresonant structures. Although not previously postulated by others, biologic structures functioning as living, resonant piezoelectric transducers which modulate the conversion of mechanical and EM energy is undoubtedly one of the major underlying mechanisms responsible for the interaction of EM fields with biologic structures.

In the acoustoelectric effect, the passage of an acoustic wave through a semiconductor induces an electric current. The passage of an acoustic wave through the material is postulated to cause a periodic spatial variation of the potential energy of the charge carriers. This results in an electric field across the ends of the semiconductor as long as the acoustic wave is traversing the semiconductor. Free electrons carriers are bunched in the potential-energy troughs, and as the acoustic wave having a specific frequency propagates, it drags the bunches along with it, resulting in an electric field such as a DC field pulsing at the specific acoustic frequency or an AC field having a frequency equal to the specific acoustic frequency. The effect is enhanced where there are both positively and negatively charged carriers, and where there are many different groups of carriers - conditions which are frequently found in biologic systems. The attributes of the current

produced depend on the unique molecular and atomic components of the structure in question. This aspect alone provides a means to perform acoustoelectric spectroscopy on biologics many of which are semiconductors, and depending on the selected frequency, the acoustoelectric effect in biological structures has many potentially useful applications. Thus understood, a targeted structure can be irradiated or exposed to acoustic energy having non-resonant frequency and an electromagnetic energy pattern of the acoustoelectric effect in the structure can be detected. This detected electromagnetic energy pattern can be used as a signature to detect and identify the targeted structure.

However, the acoustoelectric effect becomes even more useful when principles of acoustic resonance are applied. Augmentation, detection, and/or disruption of biologics can be targeted to specific structures at power levels that dramatically affect the target structure, but have virtually no effect on nearby, nonresonant structures. The current produced by the acoustoelectric effect in a resonant structure will be much stronger than any current produced by neighboring non-resonant structures, and may be of an alternating nature. The large signal to noise ratio obtained from a resonant structure improves accuracy of acoustic and EM pattern identification and detection. Similar to reversal of the piezoelectric effect and acoustic resonance intrinsic energy dissipation pathway (see above), application of the resonant acoustoelectric EM pattern to a targeted structure will amplify the acoustic wave (acoustoelectric gain which peaks at the frequency for which the acoustic wavelength is the Debye length, where bunching is optimum). Thus, combined use of the resonant acoustic and acoustoelectric EM fields can allow for greater tissue penetration of high frequency acoustic energy that would otherwise be highly attenuated and have poor tissue penetration. Using the resonant acoustic frequency and acoustoelectric EM fields together also allows for the use of lower power levels of both types of energy, lessening the potential effects on other nontargeted and nonresonant structures.

The magnetoacoustic effect is the magnetic-field-dependent attenuation of an acoustic field in a monotonic, oscillatory, or resonant manner, depending on the electronic properties of the substance in question. This variability in result, depending on structural composition, provides a further enhancement of resonant acousto-EM spectroscopy in relation to biologics and other structures, via addition of a magnetic field. Also, the addition of a magnetic field provides the means to amplify or attenuate an acoustic field, thus improving or modulating

the penetration of the acoustic field in biologic tissues.

Similarly, resonant acoustics combined with acoustic cyclotron resonance (ie. resonant acoustic cyclotron resonance) and Doppler-shifted resonant acoustic cyclotron resonance presents a powerful, and precise means of selectively causing augmentation, detection and/or disruption of structures.

The present invention provides a method that applies the principles of acoustic resonance to biologic structures for the purpose of disruption and/or augmentation of functions of the specifically targeted biologic structure. The resonant acoustic frequency of a biologic structure may be determined by performing resonant acoustic spectroscopy using methods and systems well know in the art. Particularly, a resonant acoustic frequency of a biologic structure may by determined by the steps of:

a) applying acoustic energy to the biologic structure and scanning through a range of acoustic energy frequencies; and

b) detecting at least one specific frequency which causes a maximum signal output from the biologic structure indicating the biologic structure being induced into acoustic resonance by the at least specific frequency.

The specific frequencies causing the maximum signals are the resonant acoustic frequencies of the biologic structure which are defined and used herein as the acoustic signature of the biologic structure. Once determined, at least one resonant acoustic frequency may be applied to the biologic structure to affect functioning therein and/or to determine its acousto-EM signature.

The acoustic energy including the resonant acoustic frequencies is applied at a power level sufficient to affect functioning of the biologic structure. Depending on the power intensity of the acoustic energy and the type of targeted structure that is induced into acoustic resonance, the structure may have its functions affected, such as disruption and/or augmentation.

At lower power levels functions of the biologic structure can be augmented while at higher power levels disruption of the structure may occur. Augmentation as used herein encompasses beneficial effects on the biologic structure. Such augmenting of functions or enhancing effects include but are not limited to enhancement of growth, reproduction, regeneration, embryogenesis, metabolism, fermentation, and the like. The results of such

enhancement include but are not limited to increase in bone mass or density, increase in number and maturation of eggs, increase in number and/or function of leukocytes, increase in fermentation products in beer, wine and cheese manufacturing, increase in plant germination and growth and the like.

There are some situations where the ability to selectively disrupt a structure with resonant acoustic energy is very useful as disclosed in the present invention. As stated above, disruption as used herein refers to deleterious effects on the biologic structure. Such deleterious effects include but are not limited to structural failure of the biologic structure resulting in lysis, shattering, rupture or inactivation of the biologic or of one or more components of the biologic structure. Disruption as used herein also includes within its ambit inhibition of vital processes required for growth, reproduction, metabolism, infectivity and the like. Components which may be targeted for disruption include, but are not limited to DNA, RNA, proteins, carbohydrates, lipids, lipopolysaccharides, glycolipids, glycoproteins, proteoglycans, chloroplasts, mitochondria, endoplasmic reticulum, cells, organs and the like. In the case of virulent organisms, the virulence factors may be specifically targeted for disruption to prevent or inhibit the growth, infectivity or virulence of the organism. Such virulence factors include but are not limited to endotoxins, exotoxins, pili, flagella, proteases, ligands for host cell receptors, capsules, cell walls, spores, chitin, and the like.

Organics, biologics or one or more targeted portions thereof which are amenable to disruption using the methods of the present invention include but are not limited to viruses, bacteria, protozoans, parasites, fungi, worms, mollusks, arthropods, tissue masses, and the like. The organics or biologics to be disrupted may be isolated, present in a multicellular organism or portion thereof, or other complex environment.

It is postulated that disruption of the targeted biologic structure without affecting nearby tissue or structures occurs due to acoustic resonance being induced only in the targeted structure which until now has not been considered a mechanism to affect a biologic structure. This is very different from that disclosed in the prior art which contemplates only three mechanisms for affecting a biologic structure which include cavitation, thermal and mechanical.

At specific power levels, such as in lower levels, that do not cause the actual disruption of a structure, resonant acoustic energy can intrinsically dissipate within the