

Physiological Effects of Qigong

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The three major areas of physiological mechanisms initiated and enhanced by Qi Gong and Yoga/Pranayama practice are:

1. Oxygen Metabolism
2. Lymph System
3. Brain and Nervous System

Chart of Physiological Effects of Qigong

Physiological mechanisms and the activities in Qi Gong and Yoga/Pranayama which are their triggers:

| I. OXYGEN | | |
|---------------------------------|----------------------------------|------------------------------|
| Physiological Mechanisms | Structures and Substrates | Qigong Activity |
| 1. Energy Generation | Oxygen Uptake | Movement/Breath |
| 2. Aerobic Water | Oxygen Uptake | Movement/Breath |
| 3. Immune Enhancement | Oxygen Uptake | Movement/Breath |
| 4. Free Radical Neutralization | Oxygen Uptake | Movement/Breath |
| II. LYMPH | | |
| Physiological Mechanisms | Structures and Substrates | Qigong Activity |
| 1. Aerobic Generation | Oxygen | Movement/Breath |
| 2. Propulsion | | |
| a) Aerobic | Oxygen | Movement/Breath |
| b) Intrinsic Contraction | Interstitial fluid volume | Breath and Relaxation |
| c) Muscle Pump | Muscle Contraction | Movement |
| d) Gravitational | Body position | Postures and Movement |
| e) Breath Apparatus | Lungs, diaphragm, cisterna chyli | Breath Activity |
| 3. Immune Function | Propulsion (2a-e) | Breath, movement and posture |
| 4. Cerebrospinal Fluid Flow | Propulsion (2a-e) | Breath, movement and posture |
| 5. Nutritive Function | Propulsion (2a-e) | Breath, movement and posture |
| | | |

III. NERVOUS SYSTEM

| Physiological Mechanisms | Structures and Substrates | Qigong Activity |
|-----------------------------|--|--|
| 1. Autonomic | Brain, neurochem., nervous system | Relaxation and Breath |
| 2. Neurotransmitter Profile | Hypothalamus | Relaxation and Visualization |
| 3. Microcirculation | Hypothalamus | Relaxation |
| 4. Immunity | Macrophages, leucocytes, neurotrans. | Relaxation, Meditation |
| 5. Brain Hemisphere Control | Brain, nervous system | Alternate Nostril Breath and Right /Left Side Movement |
| 6. Brain Wave Frequency | Brain, nervous system | Meditation |
| 7. Neuroreflex Stimulation | Neuro-reflex system | Rubbing Points |
| 8. Brain Structures | Hypothalamus, pituitary, pineal, 3rd ventricle | Intention, Meditation and Visualization |

The most ancient and refined systems of health self care, Qigong and Yoga/Pranayama, originated in China and India. Both systems have similar activities which include breath practice, postures, motion, self massage, relaxation, concentration, visualization and meditation. Science is currently recognizing the value of investigating such ancient health care systems. It appears that a broad spectrum of physiological and bio-energetic events are triggered by Qi Gong and Yoga and that these mechanisms can be modified and refined by conscious and concentrated practice. This review will explore some of the major physiological mechanisms activated by the practice of these simple, self applied health enhancement techniques of China and India.

Actual research on Qigong and Yoga in the western world is in its infancy although some work has been done on the physiological parameters that may be influenced by voluntary control of the body's self regulating systems.(1,2,3) There is, however, substantial research from numerous disciplines of western science, (exercise physiology, behavioral medicine, psychoneuroimmunology, neurology, hematology, immunology and lymphology) that explores states or responses that are similar to states or responses initiated by Qigong and Yoga practice.

Techniques such as meditation, progressive relaxation and autogenic training have been found to alter heart rate, blood pressure, brain wave activity (EEG), neurotransmitter profile, peripheral blood volume, skin temperature and muscle control. (EMG).(1,2,3) Exercise that initiates only minimal to moderate body movement has been found to be effective and beneficial. Moderate body movement that occurs within a context of deep relaxation, for example, is common to both Qigong and Yoga. Western research on exercise, relaxed states and other triggers of specific physiological responses are clearly implicated as useful resources that may help to begin to build a body of scientific information on the self applied health maintenance methods of the Asian systems of traditional medicine. Key words such as "breathing exercises", "respiratory muscle training", "respiratory relaxation training", "correction of breathing", "physical training", "exercise therapy", "mild exercise", "dynamic exercise", "relaxation therapy", "autogenic training" and "meditation" lead to useful sources in the literature. This paper will draw actively on the recent literature of western research to point toward mechanisms which may be operating in Qigong and Yoga practice.

Research from the Asian cultures is more ample, however, much of it remains untranslated. In addition, until recently, the rigors held as essential to research in the western model of scientific inquiry were generally misunderstood in the more empirical model of the Asian sciences. In 1988, The First World Conference on

the Academic Exchange of Medical Qigong was held in Beijing, China. The abstracts of 128 papers, many of which are on scientific subjects with necessary controls, have been translated into English.(4) Further, excellent controlled studies on Qigong, from China, and Yoga, from India, have begun to appear on the Med-Line data base, primarily under "breathing exercises".

A major stumbling block in writing on subjects from the traditional Asian systems of medicine and health care is the "Qi" of the Chinese and the "Prana" of the Indians. These words are not generally considered to have English equivalents. There is a broad array of possible translations including: bio-electro-magnetic energy, bio-energy, subtle energy field, sum of all optimal human function, vital energy, awareness, intention and others. Over half of the scientific research articles from the 1988 conference in Beijing have the word "Qi" in the title. Until Western science has either come to accept "Qi" and "Prana" into the scientific language, or to have generated agreeable definitions, research literature using these words will probably remain somewhat inadmissible in the West.

Bioenergetic research is not unknown to Western science. Harold Saxton Burr in 1935 described a system of electro-dynamic fields.(5) He worked with the electromagnetic currents in the bodies of salamanders and then in humans which he finally named L-fields (life fields).(6) Robert Becker reconfirmed Burr's work and applied DC current to regenerating salamander tails and healing human bone fractures. In his work with the National Institutes of Health (NIH) Becker clarified that the perineural (nerve sheath) network is highly conductive.(7) B.E.W. Nordenstrom has described the Vascular interstitial closed circuit as a system of preferential ion conductance pathways comprising a network of biological circuitry.(8) There is some suggestion that even more subtle energies resonate in the human system and may be projected over substantial distances.

One of the most interesting features of the Qigong tradition is the phenomenon known as "Qi emission" or "external conductance of the Qi". Besides the self applied aspects of Qigong through breath, movement and meditation there is an application of Qigong to others performed by a Qigong master or Qigong doctor over a distance. This same phenomena has a rich history in the West as psychic or mental healing. Healers in the Soviet Union have been observed exchanging energy and heat into patients to help balance their biological function.(9)

This area is of great interest and raises fundamental questions in the interface of biology and physics. Such expert applied techniques are a potential distraction from the possible revolution in health care and medicine that self applied Qigong, Yoga and other forms of self care could provide. Whether self applied or procured from masters the benefits of Qigong and Yoga/Pranayama, to be embraced by Western science, will have to have a clear physiological basis. Such a physiological foundation may actually comprise the conductive media for the "Qi" and "Prana". In any case an exploration of the physiological mechanisms activated by the practice of Qigong and Yoga/Pranayama is needed. In instances, where it is clear that a particular mechanism is highly probable but not assured through specific research on Qigong or Yoga practitioner subjects, we will refrain from absolute statements and defer to "may", "possibly", "seem", "likely", etc with these words pointing to areas where research is needed to demonstrate the mechanism clearly.

Oxygen Metabolism

The human system will begin to disorganize and die after several minutes without oxygen. It is a logical progression of thought that leads to the possibility that altering oxygen metabolism might be curative for diseases that have an oxygen deficiency component to their etiology. Both moderate and vigorous body movement and the accompanying muscle work increase oxygen demand in the cells. Evidence from research in exercise physiology demonstrates that muscular activity accelerates the rate of oxygen uptake from the blood(10,11,12,13). It has been shown that training and practice increase ventilatory threshold, anaerobic threshold and mechanical efficiency.(14,15) This suggests that regular body movement with increased breath activity supports adaptation toward increased functional efficiency in the uptake and utilization of oxygen from the blood.

One early source (1896) suggests that just the muscular activity of the breath mechanism itself is enough to increase the uptake of oxygen from the blood.(16) This is not a widely accepted idea. However, most traditional systems of medicine include elaborate methods of breath practice. Some exploration of this mechanism for the absorption and utilization of oxygen is being undertaken.(17) A recent animal study demonstrates that the movement of the breathing apparatus alone may generate oxygen demand(18). Both

Qigong and Yoga/Pranayama include breath practices where there is no body movement except of the breathing apparatus itself. Such research suggests that simple breathing techniques alone may increase the amount of oxygen absorbed from the blood. Individuals who are restricted in their movement due to health problems may have access to some of the benefits that have traditionally been reserved for those who do vigorous exercise.

Certain dynamic (active, moving) Qigong and Yoga methods increase the oxygen uptake by virtue of the greater requirement for chemical energy by the cells. Other more quiescent (inactive, still) methods tend to decrease oxygen uptake due to the lowering of metabolic activity. It has been found that some practitioners of these traditional practices have refined their ability to the point where they actually enter into altered states where the physiological need for food, air or sleep have been almost completely suspended.(3)

The Framingham Study on risk factors for cardiac disease, completed in 1970 by the National Heart and Lung Institute, found that decreased vital respiratory capacity (breath volume in relation to tissue uptake) was directly associated with increased mortality.(19) In Australia an extensive 13 year study completed in 1983 which measured similar parameters of long life, demonstrated that respiratory capacity was "a powerful determining variable", more significant in predicting longevity than tobacco use, insulin metabolism or cholesterol levels. (20)

Recently there has been a tremendous amount of activity in both research and clinical practice which suggests that many deficiency disorders and degenerative diseases are, at least partially, attributable to oxygen metabolism dysfunction, oxygen deficiency or hypoxia. (21,22,23). This view is supported by many of the great names in research; Albert Szent-Gyorgi, Otto Warburg, Emmanuel Revici and Linus Pauling. The Asian systems of self applied health maintenance like Qigong and Yoga/Pranayama proposed this view and developed specific methods for application centuries ago.

The practice of Qigong and Yoga increase oxygen availability which potentially:

1. Supports energy (ATP, AMP, ADP) generation.
2. Generates water as a by product of energy metabolism which contributes a major portion to the lymph supply.
3. Enhances immune function.
4. Supports the body's ability to neutralize free radicals.

Energy Generation

It has been well established that the energy necessary for cell work and body heat regulation is supplied through the reaction of oxygen and glucose to form high energy phosphate bonds.(24) There is a direct relationship between oxygen demand, the impulse to breath and the basal metabolic rate (BMR, the rate that the cells in the body consume oxygen and glucose to produce water, carbon dioxide and energy). Hydrolysis of adenosine triphosphate (ATP) is accompanied by the release of chemical energy for cellular and muscular activity.

Preliminary research demonstrates that ATP may be an analog to one aspect of what the Chinese call "Qi" and what the Oriental Indians call "Prana", the vital force or life energy. The aspect of the Qi that is the "basic dynamic force of all vital function" is called Zhen Qi (Genuine Energy).(25) A study presented at the 1988 World Conference on the Academic Exchange of Medical Qigong revealed that blood ATP content increased with exercises which cultivate the Qi.(26) When the mysterious practice of Qi emission was performed the subject's ATP was found to have decreased.

The simple methods of Qigong practice, movement, breath practice moderated with concentration, relaxation and intention may bring a primary substrate of Qi or Prana production, namely oxygen, into the body's energy metabolism cycle. This chain of events is called the "cycle of the transformation of energy" by the Chinese.(27) It is likely, however, that this is only one of the components of the broad array of possible energetic mechanisms involved in acupuncture, Qi Gong and other oriental health practices.

In the west we generally characterize ancient medicine as unscientific or even primitive. The Chinese "formula" for the transformation of Qi seems overly simplified. Gu Qi (grain qi), the essence or life force of food, mixes with Kong Qi (28) or Qing Qi(25) (natural air qi), the essence or life force of air to form Zhen Qi (true qi) or the life force of the body.(25,28,29)

| | | | | |
|----------------|---|----------------|---|-------------|
| Gu Qi | + | Kong (Qing) Qi | = | Zhen Qi |
| Energy of Food | + | Energy of Air | = | Body energy |

However, it is this same basic formula, disguised in the vocabulary of Western science, that is used in modern physiology.

| | | | | | | | | | | |
|-----------------|---|---|---|-------|---|--------|---|------------------|---|-------------------|
| 6O ₂ | + | C ₆ H ₁₂ O ₆ | + | (BMR) | = | Ergs | + | 6CO ₂ | + | 6H ₂ O |
| Air | + | Food | + | (BMR) | = | Energy | + | carbon dioxide | + | water |

Oxygen (O₂) plus glucose (C₆H₁₂O₆) through BMR yields energy in the form of high energy phosphate bonds (especially ATP) plus water (H₂O) which dissolves carbon dioxide (CO₂) and facilitates the hydrolysis of energy yielding phosphate bonds. It seems that the chinese knew, without a particularly refined scientific method, that only a portion of the air and food, the essence, was employed in the process: only 20% of air is oxygen and glucose is approximately 60% of food.(24)

The Chinese knew about circulation of the blood approximately 2000 years before William Harvey described it in 1616.(25,28,29) They knew about the energy generating relationship of food and air 2300 years before the elaboration of the Krebs cycle.(25,28,29) The simplicity of the Chinese formula encourages the use of the movement and breath as a health enhancing factor while the complexity of the Western scientific formula tends to mask the importance of the breath and makes the benefits of simple breath practice less accessible to the average health seeker?

Water Production

A second critical benefit of increased oxygen metabolism generated through the practice of moderate body movement and breathing exercises is linked to the lymph system. Besides the production of energy, in the phosphorylation cycle, there is also the generation of pure water as a waste product or by product.(30) This water is dramatically and directly increased when oxygen consumption is increased at the cell. Because this water becomes involved with the internal cleansing performed by the lymph it is a major link between the breath and lymphatic system function. (Discussion follows in lymph section)

Immune Function

ATP drives the activity of every cell. Therefore, immune function as well as the production of immune resources (white blood cells, lymphocytes, t-cells, killer cells, etc) are indirectly dependent on oxygen consumption. These activities become deficient in individuals who are unwell. It has been shown that exercise can mobilize the effect of natural killer(NK) cells.(31) In individuals who exercise so vigorously that they exceed the aerobic level and cross the anaerobic threshold immune function is decreased.(32,33) Both suggest that oxygen deficiency leads to decreased immune function and that moderate exercise increases immune function.

In his research, Nobel Prize recipient Otto Warburg found that oxygen deficiency was typical of cancer cells.(34) There are numerous studies that associate reduced oxygen intake with increased mortality (19,20) and reduced resistance to disease. In studies with elders immunodeficiency was found to be one of several consequences of reduced oxygen metabolism.(35).

Oxygen's effect on the immune function has been demonstrated through research studies on two nutrients that have been shown to have immunomodulating capability. Germanium, an element that bonds easily with oxygen, is thought to increase the efficiency of the use of oxygen in the mitochondria of the cell. In addition, it may help to decrease free radicals in the blood. In a German study it was found that in elderly, injured, stressed and hospitalized individuals the arterial oxygen content is often reduced from normal levels.(36) Administration of oxygen was found to elevate the arterial oxygen content and increase recovery rates. The experimental addition of germanium to the treatment protocol increased oxygen utilization and further accelerated the healing process.(36)

Blood studies on patients with AIDS revealed, in addition to deficient immune capability, low concentrations of Co enzyme Q10, a co enzyme present in all healthy cells. The patients were administered CoQ10 and their symptoms as well as blood immune factors improved.(37) Co Q10 apparently improves the ability of oxygen to produce ATP. Both germanium and Co Q10 enhance the ability of oxygen to support immune function with the implication that increased oxygen through Qigong or Yoga/Pranayama may have a direct impact on immune deficiency states.

Free Radical Balance

There are multiple factors that modify oxygen demand and uptake besides the cell work of body movement and organ function. Such factors include the effects of chemical and environmental stress caused by foods, water and airborne pollution. Emotional, relational or career stressors, the stress of injury and the stress of infection also effect the body's ability to absorb and utilize oxygen. Accumulation of these effects can negatively impact on oxygen metabolism and precipitate functional imbalances in the human system.

The normal activity of energy metabolism creates a certain number of by-products. These molecules are called free radicals. With the impact of the above mentioned stressors greater amounts of free radicals are produced. All normal molecules have paired electrons in their outer electron orbits. Free radicals are unstable molecules with an unpaired electron in their outermost electron orbit. In an effort to return to a stable state these renegade molecules steal electrons from healthy molecules causing tissue damage and aging.

The body produces a number of antioxidant enzymes, superoxide dismutase, catalase, glutathione peroxidase and methione reductase, whose job is to neutralize the free radicals produced in normal energy metabolism. However, in an imbalanced or unwell system demand for antioxidant enzymes is high and natural productivity, due to pathology, may be low.

When slow, deep breathing and moderate body motion is activated there is an increased demand for oxygen molecules which are taken up from the blood. The potential for free radicals to bond with this available oxygen, neutralizing the free radical population, may be greatly accelerated when regular Qigong or Yoga/Pranayama is included in a person's daily health routine.

There are a number of strategies for resolution of oxygen deficiency disease (ODD) including the use of antioxidant nutrients (Vit. A, C, E and selenium), antioxidant enzymes, coenzyme Q10, germanium and germanium bearing herbs and hyperbaric oxygen. There is, however, nothing more available, inexpensive and obvious than oxygen itself taken in maximum daily doses through moderate exercise and breathing exercises.

Lymph

The lymphatic system has been much neglected in most Western scientific traditions. Contrasted with the heart, for example, the lymph is relatively unexplored. Perhaps, because lymph and lymph vessels are generally translucent they drew little attention in early anatomical study compared to organs, blood vessels, muscles and bones.

Hippocrates and Aristotle referred to "white blood" and "colorless fluid" but in the Middle Ages medical knowledge declined and the lymph was temporarily forgotten. In 1627 Asellius, in Milan, recovered the knowledge of the lymph.(38) The structure and action of the lymph system was still undefined by 1900(39)

and the both the immunological function of the lymph and the actual lymphogenic process are not clearly understood even today.

In general, the lymphatic system is a network of organs, tissues, vessels, nodes and flow potentials. It collects interstitial fluid, infused with the by products of cellular activity, and transports it centrally where it rejoins the blood system. In this role it regulates endogenous metabolites and waste products.(40)

In addition, the lymphatic system is a primary component of the immune system helping to protect the body from a broad range of pathogenic factors.(40) It carries fluids infused with bacteria, virus, fungus into immuno-active lymph nodes where lymphocytes, reticular cells and macrophages kill or neutralize toxic or enemy cells, substances and organisms. In this role it regulates exogenous disease inducing agents.(40)

The lymphatic system also has a nutritional function wherein it assists in bringing nutritional factors into proximity with the tissues. This was noted by Asselius in his original discovery of the chyle filled vessels of a recently fed dog.(38) In the 1970's the broad based nutritional (or trophic) function of the lymph system began to get deeper exploration.(41)

Like the early medical explorers in Europe, the founders of Oriental medicine also did not specifically note the lymph, except non-specifically as a component of the body fluids.(28,29) However, there is an important difference between the empirical science of Asia which did not clearly delineate the lymph and the deductive science of the West that gave the lymph little note.

In Western science, until recently the nearly invisible lymph, received little of the focus it deserves and few if any health generating strategies or modalities were based on its function. In the orient, where science is based on trial and error and the invisible "Qi" is honored, the results of healthy and unhealthy lymphatic function were noted in healthy individuals and contrasted in unhealthy individuals. Even though the lymphatic function itself was unknown and unnamed, its effects were generally ascribed to the proper action of Qi or Prana (energy) and fluids. In Asia an elaborate system for generating and circulating lymph was developed through the self care practices of Qigong and Yoga/Pranayama.

When we look carefully at these practices in relation to what we now know about lymphatic function and its healing role it appears as if much of Qi Gong and Yoga/Pranayama practice were developed specifically with the enhancement of lymphatic function in mind. Breath, movement and posture all have specific effects on the production and circulation of the lymph.

In the West we have divided the body fluids (blood, lymph, cerebrospinal fluid, synovial fluid, extracellular fluid, intracellular fluid) into specific categories. From the paradigm of the west it seems the Chinese may have overlooked important information with their broad, non specific view of "Qi, blood and fluids". However, the lymph fluid is actually part cellular water and part blood plasma. The blood plasma is actually comprised, in part, from lymph fluid.(38) Some of the cerebrospinal fluid finds its way into the lymphatic system.(42) In this way each of the individual fluids really make up one fluid. Do we miss something by the reduction of integrated systems into a multitude of separate categories and parts? May we learn something by simultaneously embracing or, at least exploring, the more simplified view of the Asian traditions?

Qi Gong and Yoga/Pranayama practice appear to activate a number of mechanisms associated with the lymphatic system:

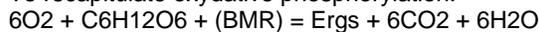
1. **Lymph generation**
2. **Lymph propulsion**
3. **Immune function**
4. **Cerebrospinal fluid circulation**
5. **Nutritive function**

Lymph Generation

The actual generation of the lymph has long been attributed to the filtration of blood plasma from the capillaries (40). As recently as 1985 this was recognized as the primary source of the lymph. This idea overlooks a significant detail that is at the essence of the tremendous health benefits of Qi Gong. A major

portion of the body's lymph is produced by the identical physiological process that generates the body's chemical energy.(68)

To recapitulate oxydative phosphorylation:



Six molecules of water are generated for each six molecules of oxygen that are metabolised in energy production.

In a moderately active 70 Kg human between 2100 and 2800cc of lymph enters the blood stream daily at the sub-clavian vein through the thoracic duct. Through the calculations of the Krebs cycle the cells are producing approximately 950cc (30) of pure interstitial water daily. In a vigorously active person or one engaging in minimally strenuous exercise, such as walking, Qi Gong or Pranayama up to 1400cc of aerobically generated interstitial water can be produced, circulated and eventually passed into the subclavian vein daily.

Not only is the formula for oxidative phosphorylation the basis of chemical energy production but it is a primary source of lymph fluid production as well. Therefore, Qigong and Yoga practices can increase the amount of lymph which serves as the fluid carrier for endogenous waste products as well as exogenous pathogenic factors. In this context the metabolizing cells are continually contributing pure H₂O into the interstitial spaces.

This water, then, is the vehicle of transport for metabolic by-products into the lymph vessels. From the tissue spaces it is propelled, as lymph, to the immunopotent nodal treatment sites and finally to the elimination organs via the blood. Increasing body movement and activating the breath potentially accelerate O₂ absorption which generates more H₂O and increases the volume of lymph fluid which enhances the removal of the by products of metabolism and pathogenic factors.

Lymph Propulsion

The blood circulatory system has the powerful heart muscle to propel its fluid. The lymph, however, under the same 14.7 pounds per square inch of gravitational pressure, has no distinct heart in humans. The quest for a "lymph heart" added little to the traditional ideas of propulsion until the mid 1900's when studies of birds and reptiles revealed specific lymph hearts.(43). In humans, however, the propulsion of lymph was found to be carried out by an assembly of several mechanisms. The movement of lymph against gravity is accomplished with the help of a system of vessels that are liberally equipped with one way valves. It was known that the lymph was somehow pumped forward and upward enabling the valves to prevent it from flowing back with gravity.

Even as late as 1941 several important aspects of the lymph heart concept in humans remained obscure.(44) By 1949 spontaneous intrinsic pulsatory contraction of the peripheral lymphatic vessels was demonstrated in humans with a rhythm unassociated with either the heart or the breath.(45,46) This intrinsic contractility mechanism of the peripheral lymphatics was seen by many as the long sought after lymph heart.(40)

The subject of the lymph is complex and very much unsettled. The current literature is crowded with a wide range of questions raised by research. What factors might stimulate the intrinsic contractile mechanism, what regulates lymph protein concentration, what effect does passage through the lymph nodes have on the proliferation of immune cells from within the nodes(47) and what is the nutritive role of the lymph(41) are several such questions.

Due to the excitement over the intrinsic pumping mechanism, the effect on the lymph of one of the classic propulsion mechanisms, the activity of the respiratory apparatus, was eclipsed. The breath, through two mechanisms, has a significant effect on the propulsion of the lymph: 1). aerobic production of water and 2). mechanical pumping of the breath apparatus. These will likely gain recognition as primary components of the multiple features of the lymph heart. A number of additional propulsive mechanisms are initiated by body movement and body posture.

Tentative agreement exists on at least five mechanisms for accomplishing the propulsion of the lymph that are stimulated by Qigong and Yoga practices. These include:

- a. aerobic production
- b. intrinsic smooth muscle contraction
- c. movement of striated skeletal muscles
- d. gravity
- e. mechanical shifting of pressure gradients in the body cavities.

a. Aerobic Propulsion

The aerobic production of lymph contributes to lymph propulsion by the cellular production of water as a by-product of oxygen metabolism. The liquid holding capacity of the tissue spaces is naturally limited. As the limit is reached, the presence of additional lymph drives the excess into the smooth muscle vessels of the lymphatic system.(39,40,43,47)

In Qi Gong this mechanism is triggered by the coordination of the breath with gentle movement which increases oxygen demand in the cells. In response there is an increased availability of oxygen which fuels chemical energy productivity and consumption. The resultant contribution of water as a by product increases tissue fluid volume and drives the overflow into the vessels to become lymph.(42)

It is noteworthy here that in Traditional Chinese Medical theory it is taught that the "lungs regulate the water passages"(48). To students from the west this seems quite unusual and unfounded. However, we here can see that the lungs and the breath both produce and circulate the water in the body.

b. Intrinsic smooth muscle contraction: autonomic propulsion-

The automatic response of the smooth muscle tissue of the peripheral lymphatic vessels is to contract when filled and stretched to a certain tolerance.(46) This moves the lymph along in the vessel with the assistance of the one way valves in much the same way as the heart moves the blood.(42)

In Qi Gong and Yoga this mechanism is triggered by the breath's contribution to lymph volume, as well as the elevation of interstitial pressure caused by the postures and the movement of the extremities. In addition, this mechanism may be accelerated or enhanced by the shift of autonomic function in the relaxation state that is a feature of Qigong and Yoga.

c. Striated Skeletal Muscle: voluntary propulsion-

Even the slight movement of skeletal muscle in a sedentary individual propels the lymph in the one way vessels. In an active person the lymphatic pumping of the striated skeletal muscles is greatly multiplied. The effect of muscle contraction on lymph is one of the classic explanations for lymph motion.(40,42) In Qi Gong and Yoga this mechanism is triggered by both the mechanical action of the musculature of the breath apparatus and the action of the skeleton through the relaxation and contraction of the striated muscles in the moving forms of the practice.

d. Gravitational Propulsion-

Because gravity exerts such a substantial force and because lymph has so far to climb to get to the thoracic duct's entry into the sub-clavian vein any inversion of the limbs or even the prone body position allows for a free flow of lymph unencumbered by the effects of gravity. Elevation of the lower limbs is often prescribed for health problems characterized by a pooling of interstitial fluids.

In Qi Gong and Yoga the thousands of different postures and forms, including lying prone and motionless, often create this mechanical dynamic where the lymph is actually propelled centrally by gravity. In many methods of Qigong there are postures and movements that invert the limbs. In certain walking forms the practitioner is constantly but slowly moving all of the limbs in beautiful circular motions that recurrently activate this mechanism. In Yoga many of the asanas (postures) invert the limbs. In the head and shoulder stands the whole body is inverted.

e. Breath Apparatus: Mechanical Propulsion-

The most powerful of the multiplicity of mechanisms that work together to form the "lymph heart" is the

mechanical action of the breathing apparatus itself(43). The concentration of lymphoid tissue just above and just below the diaphragm is many times more dense, and contains greater fluid volume, than any of the lymphoid tissue at the periphery, or even in the moderately prolific lymphoid areas of the axilla or groin.(40) Lymph that has been carried from all over the body accumulates centrally and is then propelled by the breath/diaphragm in a final rush through the thoracic lymph duct into the blood at the sub-clavian vein where it leaves behind its identity as lymph and is transformed into blood serum.(49)

Above the diaphragm the thoracic duct of the lymphatic system is a central collecting vessel. Its size is many times that of a peripheral lymph vessel. Below the diaphragm a substantial dilation of the thoracic duct forms a collecting capsule for lymph, called the "cisterna chyli" (cisterna=cavity, receptacle or reservoir) Chyle is a milky fluid infused with nutritional factors absorbed from the small intestine by the lacteals, which is passed into the circulating blood through the thoracic duct. The fluid that fills the cisterna chyli is a mixture of the nutrient rich chyle from the lacteals and the lymph that carries the metabolic by-products from the tissue of the organs, muscles and glands.

When full inspiration of the breath occurs, the diaphragm drops downward and a tremendous negative pressure is generated in the thoracic cavity. As air rushes into to fill this negative pressure the lungs are fully expanded. This compresses the thoracic duct. Due to the one way nature of the valvular system lymph is forced upward into the sub-clavian vein.

Simultaneously, when the diaphragm drops downward on full inspiration it compresses the abdominal and pelvic organs including the cisterna chyli which empties under the pressure. The contents of the lymphoid reservoirs and vessels are forced by the same one way system of valves upward toward the thoracic duct. In research done by Dr. Jack Shields (49) moving X-ray films were used to study subjects in various actions and breath patterns. It was demonstrated that deep inspiration pumps the lymph at a rate that is dramatically increased over average resting inspiration and other activities.

Immune Function

The immunologic aspect of the lymphatic system is well represented in the literature.(42,44,47,50) The bone marrow, thymus, spleen and lymph nodes participate in the interaction of the lymph and immunity. The composition of the lymph fluid itself includes a number of immune active agents such as lymphocytes and macrophages.(47)

Lymphocytes that exit with the lymph fluid from the nodes come from three sources: 1) inflowing with lymph from the tissues in the peripheral vessels, 2) exchanged from the blood that enters the node's own vascular system and 3) formed by local proliferation in the node itself.(42) Lymphocytes naturally collect within the node, especially when flow is sluggish. Greater numbers proliferate when lymph flow is greater and the numbers circulated out of the node increase with flow volume as well.(42)

Excellent recent research has clearly delineated, localized and quantified the development of specific antibody forming cells in lymph nodes.(50) In addition, it has been found that there are neurotransmitter receptor sites on lymphocytes where they actually interface with neurotransmitters.(51) This demonstrates an important link between neurochemistry and immunity through the medium of the lymph system.

Cerebrospinal Fluid (CSF)

The cerebrospinal fluid (CSF) system has classically been perceived as a closed system. One view held that CSF was actually in an open system that allowed the fluid to flow through the arachnoid villi and into the venous blood. However, by the 1970's it was generally acknowledged that the CSF travels along the cranial and spinal nerves and into the perineural lymphatics.(52)

Some recent research using the microinjection of tracers has suggested several possible pathways for the passage of both the CSF and the cerebral interstitial fluid (CIF) to exit the arachnoid space.(42) By 1985 the flow of CSF and CIF into the lymphatics was well documented.(42) Consideration has even been given to the effects of pressure and posture on this flow(42), both of which are primary effects that are enhanced in Qi Gong and Yoga/Pranayama practice.

The presence of CSF in the lymphatic system and the presence of neurotransmitter receptors on immune cells(53) suggests a powerful association between neurotransmitters and immune function in the reticuloendothelial system. While the effect of Qi Gong and Yoga/Pranayama on this mechanism is not clearly defined, it is likely that it occurs through lymph propulsion as has been discussed. Research to quantify and delineate this aspect of the lymph system and explore the action of lymph and CSF as a transport system for specific neurochemicals is clearly a priority.

Nutritive (trophic) Function

The importance of a broad availability of nutritional factors to the tissues is fully accepted. However, the role of the lymphatic system in this activity was barely understood before 1972.(41) The original findings of Assellius in dogs revealed the route of absorption of nutrients from the small intestine via the lacteals.(40) The effect of the breath apparatus through the action of the diaphragm, during deep inspiration, on the cisterna chyli and the small intestine may enhance the rate or effectiveness of nutrient absorption. This may be an especially important mechanism in the absorption of nutritional factors and the delivery of the pharmacologic potential of herbal formulas that are commonly used in both the Chinese and Indian traditional medical systems.

In addition, free extracellular proteins participate in lymph fluid and as plasma proteins in the blood. They carry constituent amino acids that may be utilized by the tissues. These may become conjugated proteins which carry essential minerals, fats, carbohydrates and enzymes to their respective destinations.(41) The clarification and understanding of the trophic function of the lymph suggests a simple but profound effect of the enhanced lymph volume and flow rate activated by Qigong and Yoga/Pranayama

Nervous System

Much of what is described in traditional medical systems as the "balance" of forces, such as yin and yang in the Chinese system, can be associated with the dualistic components of the nervous system. In the central nervous system yin is rest and yang is action. Balance is the state between rest and action called dynamic equilibrium. This is the state that training in Tai ji and Qigong seeks to refine. In the autonomic nervous system yin may be associated with the parasympathetic and yang may be associated with the sympathetic. The balance of yin and yang is associated with homeostasis.

Because the western world view has generally had a difficult time understanding and accepting the concepts of Qi (chi), prana or vital force from the Asian systems, there has been a strong trend toward explaining the effects of yoga, qigong, acupuncture, etc through the mechanisms of the nervous system.(25,54,55) While while these practices do have a definite effect upon neurological function, with consequent effects on body systems, the neurological mechanism may actually be an intermediary for a more refined and less quantifiable system of subtle energies. However, a great deal of research has been done that reveals the neurological mechanisms that may be activated in Qigong and Yoga and it is appropriate to explore them here.

There are a number of mechanisms associated with the brain, nervous system and other related systems that Qigong and Yoga/Pranayama practice enhance including:

1. Initiation of the "relaxation response" (RR), para-sympathetic aspect of the autonomic nervous system or resting aspect of the basic rest activity cycle (BRAC).
2. Shift of the neurotransmitter profile.
3. Dilation of blood capillaries initiating increased microcirculation in the periphery, brain and organs.
4. Supports the brain/neurological aspects of immune function.
5. Balance right/left brain hemisphere dominance.
6. Induction of alpha, and sometimes theta wave forms in EEG.
7. Affecting neuroreflex mechanisms through the stimulation of acupuncture response points.
8. Generating an affect on the function of the hypothalamus, pituitary, pineal, third ventricle complex within the brain.

Initiation of the relaxation response

When the predominance of autonomic nervous system activity is sympathetic the human system is working, expending energy and breaking down tissue. This is associated with the action phase of metabolism, and referred to as catabolic. This is associated, in its extreme, with the "fight or flight response" with increased heart rate, breath rate and blood pressure. It is also called the stress state and has been associated with adrenal exhaustion and collapse (56).

This state, when overactive and not balanced to homeostasis by ample parasympathetic activity, contributes to the production of positively charged hydrogen ions. As mentioned in an earlier section on free radicals these hydrogen ions bind with oxygen. This can cause a net oxygen deficit and a general acid pH in the internal environment. Biological stress is conducive to the proliferation of a number of diseases or syndromes including hypertension, pain, depression, immune deficiency and inflammation.(57)

The opposite aspect of autonomic activity, parasympathetic, is a phase of rest and tissue regeneration. It is associated with the conservative phase of metabolism, anabolic. In its extreme this state is associated with the "relaxation response" (RR)(57), characterized by decreased heart and breath rate and a lowering of blood pressure. This is also associated with the resting phase of the basic resting activity cycle (BRAC).(58) Conscious deactivation of the sympathetic function with the activation of certain parasympathetic features of autonomic activity can neutralize the negative effects of "fight or flight" overactivity. The primary steps to initiate this state are deep, slow breathing coupled with the intention to relax.(57) These are the identical initiating steps for the practice of Qigong and Yoga. The literature alludes liberally to traditional Asian health maintenance practices as the historic source of techniques for generating the relaxation response(RR) and the typical biofeedback response(3).

With the addition of gentle movement and stretching extra oxygen is demanded from the blood, which may help to reduce the presence of hydrogen ions and initiate a swing toward a more anabolic level of activity. This may help to produce a less acid internal environment and a net greater availability of free oxygen with increased energy productivity and tissue regeneration.

Controlled, deep, slow breathing accompanied with the intention to relax initiates the RR and the resting phase of the BRAC, which are para-sympathetic/anabolic/alkaline responses, generally recognized as healing and regenerative. Increased oxygen to hydrogen ion ratio is also recognized as conducive to healing and regeneration.

Neurotransmitter profile

Much of the new science of psychoneuroimmunology is founded upon findings in the area of neuro-hormones, neuropeptides or neuro-transmitters. It has already been mentioned that neurotransmitter receptor sites have been found on lymphocytes. A particular profile of neurotransmitters is present in a person who is experiencing pain, anxiety or depression. (59) In contrast joy, comfort or celebration produce unique neurotransmitter profiles as well. (60)

In hypertension, pain and inflammation, which which have been associated with the hyperactivity of the sympathetic aspect of the autonomic nervous system, a number of specific neurotransmitters are present in the blood. In patients suffering from pain increased norepinephrine, reduced cholinesterase and depressed beta endorphine were found to be typical.(59)

When methods are employed that regulate the sympathetic function through the hypothalamus a neurotransmitter profile characterized by decreased norepinephrine, elevated cholinesterase and elevated beta endorphine emerge.(59) The neurotransmitter profile present in the parasympathetic and usually more anabolic (alkaline) environment is recognized as able to reduce pain and depression(59), reduce cravings for addictive substances(61) and promote healing. Chinese research has quantified neurotransmitter activity specific to Qigong exercise. It was found that the Qigong effect is associated with specific shifts in the monoamine neurotransmitter content of the blood.(62) 5HT and 5HE generally tend to be decreased by Qigong practice. Noradrenaline and dopamine tend to increase. The aspects of Qigong and Yoga that quiet the mind and relax the body induce a neurotransmitter profile that is conducive to healing.

Increased microcirculation

A classic body response in Qigong and Yoga is the elevation of skin temperature. In the fight or flight state, hyper-sympathetic, the arterioles in the skin, muscles and certain organs constrict. During the systematic deactivation of sympathetic function, typical in Qigong and Yoga/Pranayama, vasodilation occurs with the accompanying warmth of the surface of the skin. This is one of the primary goals in biofeedback training and was found as a typical response when the skin temperature of meditators was evaluated in research.(3)

A number of studies from China explore the microcirculatory mechanism very thoroughly and conclude that this mechanism is a major reason for the continued successful application of such an ancient health maintenance method. (63,64,65,66,67,68)

In traditional Chinese medicine it is said "the blood is the sister of the Qi". (28,29) Because Qi and blood are in a direct relationship the inhibition of the circulation of one tends to inhibit the circulation of the other. In addition, the theory suggests that when the blood is optimally circulating in a part of the body that the Qi or vitality is circulating there as well. If the Qi is a bio-electrical, electromagnetic or subtle energy aspect of the human being, the presence of increased blood circulation and its accompanying heat may also signify the presence of increased electromagnetic or other subtle energy potential. This may be a key to explain how Qigong practitioners and mental healers are able to support the healing process in a person from a distance through "Qi emission" or "external conductance of the Qi".

Brain/neurological aspects of immune function

In the classic tradition of Western science it has been thought that the immune system was an autonomous self regulating system, operating on its own. A tremendous amount of research has demonstrated that this view was incorrect. Mental emotional states have been found to effect resistance to disease and infection.(60) Immune organs including the thymus gland, spleen, lymph nodes and bone marrow have been found to be invested with nerve endings.(60) Lymphocytes and macrophages have been shown to have receptors for neurochemicals, including catecholamines, prostagandins, serotonin and endorphin.(60) There is a definite relationship between brain and nervous system function and immune capability.

In the practice of Qigong and Yoga, as has been discussed, the hypothalamus regulates the autonomic nervous system function toward a lessening of the sympathetic activity, which is associated with the stress response.(3,57) A number of studies have demonstrated that the hypothalamus has an influence over immune function.(60) Meditation, progressive relaxation, deep breathing and slow relaxed movement all tend to move the practitioner out of the sympathetic state and induce the relaxation response. Research on the effect of relaxation and visualization sheds some light on the effect that the Qigong and Yoga states may have on immune function. Groups of elders who received relaxation training had significant increases in the activity of "natural killer cells" while control groups did not. Chinese research has corroborated the positive effect of Qigong practice on the status of the immune system. (65,69,70,71,72)

Brain Hemisphere Dominance

Thousands of years ago the oriental practitioners of self care disciplines intuitively developed an awareness of an alternating cycle of the predominance of body activity from the right side of the body to the left side. One particular Qi Gong practice, Tai ji, is founded on a constant, flowing of the limbs in circular motions, alternating from right to left. The side of the body that bears the weight is planted, stable, and associated with the Yin. The side that is free to move and kick is active and associated with the Yang. Constant alternation of right and left side activity are thought to balance the forces of yin and yang in the body. Focusing on the right and left sides alternatively activates, and reputedly balances, the right and left motor centers in the brain.

The channels or circuits that conduct the human resonating energy field, according to yogic medicine, are called nadis. Ida nadi and Pingala nadi associate with right and left brain activities.(72,73) In addition this association effects right and left nasal passage activity as well as the physiology of the right and left body. These channels alternate in their predominant activity over a 2-3 hour cycle causing the dominant nostril to be clear and the non-dominant nostril to swell and become congested.(73) This phenomena was not noted in the Western world until 1889 when the German physician R. Kayser recorded his observation of the "nasal cycle". (74) Much of the research on this phenomenon up through the 1980's was motivated by the quest to develop pharmaceuticals for nasal congestion. (72)

It has been demonstrated that the nasal cycle is coupled with the alternating lateralization of cerebral hemispheric activity. (73) It was found with research subjects, that when a shift occurred in either nasal dominance or brain hemisphere dominance there was an associated shift, within moments, in the other as well. The right nasal cavity, associated with pingala nadi tends to be more open and the left more congested when the left hemisphere of the brain is more active. This is associated with the active phase of the BRAC and increased general sympathetic tone.(72) In contrast the right brain hemisphere is more active when the left nostril is open and dominant and the individual is in the resting phase of the BRAC or the para-sympathetic mode.

A number of different physiological states have been found to be associated with the dominance of one or the other nostril.

- deep sleep is initiated more quickly with left nostril dominance.
- appetite and digestive ability are enhanced during right nostril dominance.
- sexual intercourse is most satisfying when the man is dominant in the right nostril and the woman in the left.
- left nostril, right brain dominance is more conducive to receiving new ideas, while right nostril, left brain dominance is an advantage during discourse.
- it is possible to alter the pattern of "thought waves" by consciously alternating nasal dominance by exercising the congested nostril by forced nostril breathing.(75)

A specific Qi Gong and Yoga breath technique which has been practiced for centuries is the right and left singular nostril breathing. Dr. Shannahoff-Khalsa of the Salk Institute has done extensive research with this technique, originally prompted by his work with the Kundalini Yoga tradition. The studies done by he and his associates has shown that forcing the breath through the constricted nostril can increase the EEG amplitude of the contralateral hemisphere of the brain.(76) It has been demonstrated that certain psychopathologies are brain hemisphere specific.(77,78) It may be possible, therefore, that the use of single nostril breathing may be applicable as therapy in cases where lateralized dysfunction has been found.

It was discovered that there is a direct correlation between nasal dominance, brain dominance and the lateralized biochemical activity in the peripheral body parts. Recent studies of the nasal cycle comparing plasma catecholamine levels in the venous circulation of the right and left arms found that levels of norepinephrine alternated with the rhythm of sympathetic dominance of the nostrils.(79)

Induction of alpha/theta brain wave activity

The intention to relax and deepening of the breath are the classic initiating actions that trigger the relaxation response(RR). Research with practitioners of Yoga(3) and Qigong(4) has shown that during practice brain wave frequency tends toward the alpha range and in certain cases theta frequency brain activity is achieved.

Alpha level brain function is a result of relaxation and is conducive to healing. The slowing of heart rate, reduction of blood pressure and elevation of skin temperature are common physiological features of the alpha state. Theta is a deeper trance like state that has been found in research with individuals with extraordinary capabilities to be associated with paranormal skills like sitting on beds of nails and immediate wound healing without bleeding.(3)

In Qigong and Yoga it is a goal to bring the lowest frequency of brain wave activity to the practice. In the quiescent Qigong, where there is no movement, deep states of consciousness with low frequency brain waves are more easily attained than in the dynamic (moving) Qigong. Similarly, in Yoga, there are methods involving movement and methods that primarily involve stillness. The pure meditation state lends more easily to the theta range of brain activity.

EEG studies from China have concentrated on the quiescent state, meditation with no movement (80,81,82). However, it is very likely that the dynamic or moving methods are most effective if the alpha or theta state can be simultaneously achieved. In both Qigong and Yoga it is a primary focus to "allow the body and energy to sink and relax" and to "relax into the posture".

Neuroreflex Stimulation

Pressing points, holding reflex areas or thumping and stroking "energy pathways" are all aspects of health maintenance systems of ancient cultures. The usual explanation for the mechanism of these effects involves what were originally called Head's zones named for Dr. Head who originally researched the relationship between sensory areas on the surface of the body to organ function.(83) In a similar and more current approach to a like idea, dermatomal zones are the segments on the surface of the body that are innervated by sensory neurons from specific segments of the spine which also have links to the autonomic ganglia. For example, the dorsal aspect of the foot is innervated from the 5th lumbar spinal nerves and the central area of both the dorsal and palmar aspect of the hand are innervated by the 7th cervical spinal nerves. The spinal nerves from the 2nd thoracic to the 1st lumbar innervate the dermatomes directly adjacent to their areas of the spine on the front, back and lateral aspects of the chest, abdomen and pelvis.(24)

A stimulus at the dermatome is carried to the the spinal segment where it has the opportunity to effect, through a reflex arc, neurons from the autonomic ganglia.(84) Surface stimulus may effect organ function through this neuroreflex mechanism. This mechanism has been cited as a rationale for how acupuncture works. (54)

In Qigong especially, and to a certain extent in Yoga, there are numerous techniques for massaging, thumping and stroking the surface areas of the body. When twisting to loosen the spine and warm up to do Qi Gong the practitioner hits the hands against the lumbar space in the back and the lower ribs in the front. This is done to stimulate the function of the kidneys, liver and spleen. It is likely that one mechanism through which this may occur is the neuroreflex mechanism.

Certain methods of Qigong practice focus totally on techniques of self applied massage or stimulation of channels and reflexes. One method called Mei Yin Jian Shen Gong is comprised primarily of self massage gestures. In another method the hands stroke near the acupuncture channels: up the inside of the legs, out the inside of the arms, along the outside of the arms and on to the head and finally down the lateral side of the torso and legs to the lateral aspect of the feet. In the western model this would be referred to as reflex stimulation. However, in the oriental energy model this method is referred to as a form of "Qi" circulation.

Interface of Neuro-endocrine Structures of the Brain

In both Qi Gong and Pranayama a primary goal is to circulate the "energy" to the crown of the head. In Qigong this is referred to as the "point of one hundred gatherings" (Bai hui, GV or Du 20). In Yoga/Pranayama this point is the target of the kundalini energy and is known as the Crown Chakra or "thousand petaled lotus". This area has had recognition in the christian tradition through the halos of angels. In the Jewish tradition this same area is where the men wear the yarmulka.

Science has corroborated the significance of this region with its identification and investigation of several anatomical structures thought to be the primary hierarchy of neurological and endocrine function. These include the pituitary gland, pineal gland, hypothalamus and third ventricle of the cerebrospinal fluid system.

In the ancient traditions it is suggested that these structures function as antennae-like conductors for the electrical, magnetic and subtle energy bio-fields. It may be premature to agree with this theory but it is very clear from the current literature that the hypothalamus and the pituitary are structures that participate in the subtle endocrine modulation of many physiological and emotional processes.(3,60)

Earlier we explored the research that links cerebrospinal fluid (CSF), the lymph and immunity. The CSF has the richest mixture of neurochemicals in the whole body. It interacts directly with the hypothalamus whose lateral walls and floor comprise the third ventricle, an important reservoir for CSF. Research has found over 60 neuropeptides or neurotransmitters. Candace Pert and her team at the National Institutes of Mental Health demonstrated that there are 40 times more neurotransmitter receptor sites in the hypothalamus than in any other location of the brain or nervous system. (85, 86)

Neurotransmitter activity has been found to be in a direct relationship with pain and depression (59) and to have a specific relationship to immune function (51,87). Focusing one's attention on a physiological outcome

has been shown to have a potential effect on physiological function.(88) Therefore, it is a strong possibility that the intention to circulate the Qi or Prana to the "crown" has the potential to effect the levels of neurotransmitter and endocrine activity, not only in this section of the brain, but throughout the entire body. In work with voluntary control of biological function it has been found that deminishing or quelling sympathetic function is accomplished by regulating the activity of the hypothalamus.(3) When practitioners of Qigong circulate the Qi in the Ren and Du vessels, "circulate the light in the microcosmic orbit"(89), or when Yoga/Pranayama practitioners bring Prana up along the spinal in the Kundalini channel, the focus of the method is to achieve peace, or in more scientific terms, reduce sympathetic activity and slow brain wave frequency toward the theta range. The anatomical structure which is the target is the the anatomical hypothalamus, which is the sympathetic control center.