2.1. BREATH - THE HEART OF LIFE

A normal human being inhales between 18,000 and 20,000 breaths per day, totally an average of 5000 gallons of air. In weight alone, this is 35 times as much as we take in from food or drink. We can go weeks without food, days without water, hours without heat (in extreme cold), but only minutes without air.

Air is also the most quickly distributed element in the body. Unlike food, which takes hours or even days to digest each inhalation of air almost immediately enters the blood stream. Oxygen must be constantly applied to each and every cell, or else the cells quickly die. For these reason the body has a thorough and elaborate transportation system to distribute oxygen throughout the entire body. This is our circulatory system, mastered by the heart. Each breath nourishes and feeds this system.

The importance of the breath cannot even be expressed in these simple facts. Aside from maintaining basic life functions, the breath is one of our most powerful tools for transforming ourselves; for burning up toxins, releasing stored emotions, changing body structure and changing consciousness. Without breath we could not speak, for air is the force behind our voice. We could not metabolize our food without oxygen. Our brain could not think. Breathing is a grossly underestimated source of life-giving healing and purifying energy.
2.2 RESPIRATORY SYSTEM

Our respiratory system has a special feature that it is both voluntary and involuntary. The higher centers of the brain are the instruments through which prana and mind work. These higher centers govern the lower brain as well as the total body physiology. The hypothalamus, which is situated above the midbrain, is the master of lower brain governing and controlling all the autonomic functions in the body. It works through two of its subordinates: the Autonomic nervous system and Endocrine nervous system to change the entire body physiology.

Normal inhalation and exhalation go on automatically governed by this autonomic control. The lower brain houses this control. If the voluntary functions go on like a clockwork set up through the hypothalamus, the higher centers of the brain govern the voluntary functions through the ‘voluntary nervous system’. The connection between this voluntary nervous system and the hypothalamus is essentially through the higher centers of the brain and is very feeble in normal human beings.

The respiratory system is also innately connected by the nerves of this nervous system. Hence we can voluntarily change the breathing rate, pattern, rhythm, etc by directing our will towards the same, essentially bringing the voluntary nervous system to override the ‘Hypothalamic autonomic control’.
2.2.1 BREATHING PATTERN

The breathing cycle consists of three parts: Inhalation, exhalation and suspension. Inhalation is an active expansion of the chest by which the lungs are filled with fresh air. Exhalation is a normal and passive recoil of the elastic chest wall by means of which the state air from the lungs is emptied. Suspension is a pause at the end of each inhalation and exhalation. The breathing affects the heart rate as well as the quality of blood pumped by the heart to the various regions of the body including the brain.

If one observes his own breath carefully, the manner in which the air flows in and out of the nostrils, he will notice that most of the time respiration takes place through one nostril only. It appears that respiration occurs through both the nostrils simultaneously but this is not so. By analyzing the breath one will find that usually one nostril remains open for a
certain duration of time and the breath comes and goes through that nostril only. In course of time, this nostril closes and the other nostril opens. Physiologically it implies that it must have an impact on the nervous system, producing a certain type of stimulus.

Furthermore, it must have a specific influence on the brain, which requires very systematic regulation. It is generally believed that when air is flowing through the left nostril the mental energy is predominant and when the breathing is through the right nostril the physical energy is predominant. The left and right nostril breathing act like the positive and negative potentials in an electrical circuit. When air is flowing through the right nostril, it is said that the bio-energy is flowing downwards and stimulates the body functions. Whereas, when the air is flowing through the left nostril, the bio-energy is flowing upwards and stimulates the mental faculties.

The role of two nostrils for breathing is not very clear. If it is only for the sole purpose of taking in oxygen (inhalation) and dispensing of carbon-dioxide (exhalation), why have two nostrils when one should have been perfectly right? Western Medical Science has virtually neglected this simple yet significant question. On careful observation one would notice that the breath does not come through both nostrils in equal volume, except for a very brief periods during the cases of severe emotional disturbance. Normally one breathes through one or the other. Observation over time will reveal further that breath alternates between the nostrils according to a regular pattern. And one who makes observation of the breath a personal science will notice that the nature of consciousness changes according to the dominance of one nostril over another [17].
The ancient Indians have developed a comprehensive method of controlling the breathing in a rhythmic pattern referred to as Pranayama in Yogic literature. Some of the Pranayama techniques involve breathing through one nose at a time and some involve breathing through the noses. These are hypothesized to provide different beneficial effects on the body.

2.2.1.1. Normal breathing:

Normally, air enters and leaves the lungs at the rate of 14 to 16 times per minute without one being aware of it. The depth and rate of normal breathing is regulated peripherally and autonomically to meet the supply of oxygen needed by the cells to discharge the carbon-dioxide accumulated in it. It is interesting to note that in a normal subject, there is a right-left asymmetry of breath flow. Breathing is predominant either through the left nostril or through the right nostril. If nothing is done to interfere the rhythmic functioning of the body, this will tend to alternate in a periodic fashion. The predominance of breathing through one nostril lasts for 1-2 hours after which it shifts to other nostril. The flow increases in one side until it reaches its peak, and then begins to decrease. Finally most of the air starts flowing through the opposite nostril.

2.2.1.2. Controlled breathing:

Pranayama can be described in simplistic terms as the controlled intake and outflow of air, consciously, in a firmly established posture. Contrary to the normal breathing where there is right-left asymmetry, the most commonly followed method of Pranayama employs controlled breathing through both the nostrils and also subjects’ holds breathe for a specific amount of time. The theory of Pranayama says that by training the lungs, breathing is made more efficient by changing the rate and depth thus
improving the overall metabolic activity and longevity. It is also believed that it can affect the nervous system. The improved blood circulation caused by controlling the breath in turn also increases the efficiency of the brain.

Perfusion refers to the delivery of oxygen and a nutrient to organs and cells by means of regional blood flow and is a critical aspect in vertebrate physiology. In many organs, especially in brain, regional blood flow and metabolism are coupled. The tree of life is said to have its roots above and its branches below, for nervous system has its roots in the brain. Though the human body is a combination of flesh, blood and bone at the physical level, it is now believed that it is a storehouse of vital energy referred to as bio-energy.

2.3 ANATOMY OF BREATHING

Scientific investigations have shown that many autonomic and voluntary functions of the body are related to breath. It has been reported that obstruction of the nasal passage can slow the heart rate and blood circulation and thereby preventing proper tissue oxidation. Further complications are the alteration of the flow of lymphatic fluid disturbance of the alkaline base reserve in the blood and cellular tissues, leading to a concentration of chloride and calcium. The sudden death syndrome amongst the newborn babies is a well documented event, which is caused by involuntary stoppage of breathing for couple of minutes. It is interesting to note that the proportion of autonomic nerve fibers in the nasal cavity is said to be twenty times greater than in the other parts of the central nervous system. Therefore, the nose has been described as a ‘peripheral organ of the autonomic nervous system.
In maintaining good health the quality of the breathing process plays an important role - that is the manner in which oxygen is inspired and carbon-dioxide is expired. The external nose serves to gather air and accelerate its flow, forming a rapid jet that enters the cavity within the face, the internal nose. The internal nose is strategically located with respect to the brain as shown in Fig.2.3. Thus the air going through the nose is closely related to the brain, the nervous system, the pituitary gland, which is located at the floor of the brain and many other strategic structures. In addition, the olfactory nerve responsible for the sense of smell enters the nasal cavity and has its nerve endings in the uppermost parts of that compartment. The breathing has thus a profound effect on man is physical and psychological functioning since it is a link between body and mind.

As the tissue covering the turbinate and the septum within one nostril swell, the tissues on the other side tend to become less swollen. As a result, one nostril gradually and increasingly becomes obstructed so that the flow of air is shifted to the other side. Consequently, there is a right-left dimension of breath flow: it can flow either predominantly through the right nostril or predominantly through the left nostril. If nothing is done to interfere with the rhythmic functioning of the body, this will tend to alternate in a predictable fashion. The breath will be flowing predominantly through one nostril for about some time after which it becomes predominant in the other side, for flow increases in one side until it reaches a peak, and then begins to decrease. Finally most of the air is flowing through the opposite nostril.

2.4 ASYMMETRY IN BREATHING

It is believed that the nature of consciousness changes according to the dominance of one nostril over the other [17]. The answer to this enigma
can be found within the confines of the skull. Here in the form of gray matter, electromagnetic energy in the body reaches in greatest concentration and intensity.

Only on very rare occasions is energy equally distributed in both halves of the brain. Under normal conditions, electrical activity – as manifested in the form of brain waves – is concentrated more in one hemisphere than the other. Observations by brain researchers show that each hemisphere has unique characteristics of behavior, and that these behaviors are normally present only when electrical activity centers in that hemisphere.

Only in rare moments is energy distributed equally. At these times consciousness undergoes major changes and one either becomes extremely tranquil or extremely agitated or disturbed.

2.4.1 Breathing and Hemisphere

The movement of energy from one hemisphere to another occurs simultaneously with the change of breath from one nostril to the other. When the right nostril dominates, left hemisphere dominates; when left nostril dominates, so does the right hemisphere dominates. When both nostrils operate, both hemispheres operate in unison [17].

The simple act of changing the breath from one nostril to the other reverses brain hemisphere dominance, altering chemical reactions taking place throughout the organism. Willful control of the pattern of breath enables conscious control of the body chemistry. Human feeling states are the product of the body chemistry. Changing the breath pattern changes the body changes body chemistry, and thus affects a change in the feeling state. Diseases states are the product of body chemistry. Changing the breath
pattern changes body chemistry, and thus affects the prevention of disease if done at the onset of symptoms.

### 2.4.2 Mechanism of Action

The interplay of sensory stimulation, convection cooling and ionic balance links breathe pattern with brain activity. The breathing system is connected to the hemispheres through the olfactory bulbs, which has a proven physical connection with the two hemispheres of the brain and is also connected with the breathing system by sense of smell.

![Connection between breathing and Brain Hemisphere](image)

*Fig 2.2: Connection between breathing and Brain Hemisphere.*
Air of a temperature at variance with normal body temperature passes through the nostrils at relatively high velocity, exciting the sensory nerves lining the inner passage. These nerves are extensions of the olfactory bulbs on the underside of either lobe – an organ directly linked to the large, complex structure of the Rhinencephalon or “Smell Brain”. This organ controls vast network of associate nerves linked with every structure of brain. Breathing through one nostril cools the hemisphere on the same side and also stimulates the opposite hemisphere. Differences in ionic stimulation, electrical activity, blood flow and skin temperature can always be detected between the two halves of the body – except when both nostrils operate.

The influence of breathing in brain activity has been studied by experiments [18]. It has been suggested that when one is breathing through the left nostril, the right side of the brain is activated through the supply of oxygen and vice-versa. A temperature sensor which reflects the changes in the breathing is introduced into the left nostril of the subject and changes in the right side of the brain as seen by the optical sensor are recorded simultaneously. From this figure (Fig. 2.3), it can be seen that when there is a sudden change in the breathing pattern, there is a corresponding change in the right brain activity as recorded by the optical sensor.
Fig 2.3: Sudden changes in breathing pattern accompanied by corresponding changes in PPG recordings (arrow shown).

Although the Asymmetry has been proved here more experiments in different types of patients are needed in order to confirm it. The effect of forced nostril breathing on Brain hemispheric activity has been shown experimentally using EEG signals by researchers in this field [19]. This research is intend to show the correlation of ECG, breathing signals(right & left) with optical sensor(PPG) signal and Low frequency rhythm is identified with the help of spectral analysis like frequency and Power Density Spectrum for numerous subjects.
2.5. CARDIOGRAPHIC SIGNAL

Electrical activity of heart is mentioned in the form of Cardiograph (ECG). This Electrocardiogram provides valuable information about a wide range of cardiac disorders such as the presence of an inactive part (infarction) or an enlargement (cardiac hypertrophy) of the heart muscle. ECG is a quasi-periodical, rhythmically repeating signal synchronized by the function of heart, which act as a generator of bioelectric events. This generated signal can be described by means of a simple electric dipole (pole consisting of a positive and negative pair of charge). The dipole generates a field of vector, changing nearly periodically in time and space and its effects are measured on the surface. The waveforms thus recorded have been standardized in terms of amplitude and phase relationships and any deviation from this would reflect the presence of an abnormality. Therefore, it is important to understand the electrical activity and the associated mechanical sequences performed by the heart in providing the driving force for the circulation of blood.

The heart has its own system for generating and action potentials through a complex change of ionic concentration across the cell membrane. Located in the top right atrium near the entry of the vena cava, are a group of cells known as the sino-artrial node (SA node) that initiate the heart activity and act as the primary pace maker of the heart. The SA node is 25 to 35mm in length and 2 to 5mm thick. It generates impulse at the normal rate of the heart, about 72 beats per minutes at rest. Because the body acts as a purely resistive medium, the potential filed generated by the SA node extends to the other parts of the heart. The wave propagates through the right and left atria at a velocity of about 1 m/s. about 0.1 s are required for the excitation of the
atria to be completed. The Action potential contracts the arterial muscle and the impulse spreads through the arterial wall about 0.04s to the AV(atria-ventricular) node. This is located in the lower part of the wall between the two atria.

The AV node delays the spread of excitation for about 0.12s, due to the presence of a fibrous barrier of non-excitable cells that effectively prevent its propagation from continuing beyond the limits of the atria. Then, a special conduction system, known as the bundle of His carries the action potential to the ventricles. The atria and ventricles are thus functionally linked only by the AV node and the conduction system. The AV node delay ensures that the atria complete their contraction before there is any ventricular contraction. The impulse leaves the AV node via the bundle of His. The fibers in the bundle, known as Purkinje fibers, after a short distance split into two branches to initiate action potentials simultaneously in the two ventricles.

Conduction velocity in the Purkinje fibers is about 1.5 to 2.5 m/s. since the direction of the impulse propagating in the bundle of His is form the apex of the heart, ventricular contraction begins at the apex and proceeds upward through the ventricular walls. This results in the contraction of the ventricles producing a squeezing action which force the blood out of the ventricles into the arterial system.

The PR and PQ interval, measured from the beginning of the P wave to the R or Q wave respectively, marks the time which an impulse leaving the SA node takes to reach the Ventriclees. The PR interval normally lies between 0.12 to 0.2s. The QRS interval, which represents the time taken by
the heart impulse to travel first through the interventricular system and then through the free walls of the ventricles, normally varies from 0.05 to 0.10s.

The T wave represents depolarization of both ventricles les. The QT interval, therefore, is the period for one complete ventricular contraction. Ventricular diastole, starting from the end of the T wave extends to the beginning of the next Q wave. Typically amplitude of QRS is 1mV for normal human heart, when recorded in lead 1 position.