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The Art and Science of Adaptation

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I am indeed grateful to the Aero Medical Society of India for bestowing this unique honour on me. That I prove worthy of their decision, is my earnest and fervent desire now. This Oration is delivered in appreciation of the late Air Marshal Subroto Mukerjee,



the first Indian officer to become the Chief of the Air Staff after Independence. He laid the foundation

of the present Indian Air Force. It is largely due to his unflinching interest and foresight that a well established Medical Service to cater to the needs of Air Force came into existence.

The Institute of Aviation Medicine, the first of its kind in Asia, owes its existence mainly to his patronage and support. Humanism, gentleness, sincere concern and interest in all ranks earned him the devotion of everyone who served with him.

Air Marshal Mukerjee was the first patron of the Aero Medical Society of India formed in 1952. The untiring efforts of this pioneer and his dedication have gone a long way to promote the growth of this Society.

In 1971, the Aero Medical Society of India instituted this Oration in his name to be delivered during the annual meeting of the Society. Today in this regard we complete one decade. During this period I see only two men of 'Wings' - Gp Capt Peter Howard, Royal Air Force and Air Vice Marshal M.M Shrinagesh who delivered this Oration providing the confidence that the Society has width and indulgence to invite scientists with different specialisations to present their contributions to this august audience.

Now to the subject of this Oration - The Art and Science of Adaptation. The scope of this will include three subjects: evolution of man, social and cultural adaptation - adaptation in the context of environment and lastly the inner or self adaptation.

The attainments of man since the dawn of history have been the result of three interacting forces, the conditioning effect of his native culture, the challenges presented by the physical forces of his environment and the totally unpredictable forces of his inner self or individuality.

Culture or the social structure conditions and moulds ones potential along predictable paths leading towards the objectives that have been accepted by historical events as desirable goals for they contribute towards the overall welfare of the entire social structure. Certain cultures still accept an imperial system and sustain past practices and privileges as the guardians of traditions and constitution. Those who are dissidents are fall-outs and against conservation of any structured system. In fact, being against conventions, such a group alienates itself from a patriarchal approach. However, certain ground approach conduct rules are observed for the sustenance of this new ideological concept as well. Today there is evidence, on one hand of ever changing values and perspectives which reject the need for any collective betterment and in contrast promote rugged individualism. On the other hand there exists a political ideology in many regions where they reserve for the state the right of influencing the masses by the use of all means and media to accept the establishment's approach to achieve social ends. The ultimate goal of any present day system is reallocation to itself greater power and strength through accumulative economic advantage.

Taking this further, in the emerging world one of the greatest source of power seems to be scientific and technological superiority. Science and technology in many regions is no longer the handmaiden of social structure to improve the lot of the common man but subservient as a source of political advantages. Toffler⁹ has very appropriately stated in *Future Shock* that by the application of conscious technological policy alongwith other measures, we can contour the culture of tomorrow. In other words, a new technology of sociobiology is emerging, and it claims to lead to universal prosperity and further advancement of the human race. The implications of such processes are likely to generate new

attitudes and behaviour patterns. However, one feels the necessity of guarding against this total submerging of individual behaviour to a new technological culture. It is only through continuity in human history that one finds the vitally important ingredients of living for individuals, communities and social orders.

Charles Darwin, who propounded the Theory of Evolution, realized genetic continuity — germ cells containing material representative of all parts of the body and forming the basis from which a new individual emerges. It was, however, Mendel's concept that characterised preservation of characteristics of species.

Today molecular genetics identify this self replicating DNA in providing the physical and chemical basis for the unbroken chain of life of which any individual is an ephemeral part. Such a sequence, however, would be sterile perpetuation of the past if it were inflexible. There is an inherent variability in the system, and mechanisms have evolved that ensure that variations occur. Many factors modulate such changes and provide new adaptations.

The concept of selection of the organism best adapted for life in a particular environment is perhaps the basis of any evolution. However, for realization of the fullest human living experiences developments in somatic or psychic characterization are expectantly being formulated.

Man's flight to harness nature is a challenge to his physical capabilities and endurance. Thus the desire to overcome environmental barriers, to seek what is "beyond" is overwhelming. Conquest of extreme environmental obstacles provides the fulfillment to man's adventurous nature. Rugged mountain peaks, rough high seas, lonely desolate deserts, cold arctics or cosmos beyond space — all have become accessible to man. Ample scientific data exist of the various expeditions so as to equip any prospective traveller in such unknown spheres with a calculable risk. The perspective of locating new wealth or making new habitations in such locales is involving the present political rivalries. I will here

refer in some depth to the experiences regarding space and altitude and the various physiological effects on man for his likely adaptation.

Altitude

High altitude environment became a national problem for our country in 1962, when our Services were pressed to safeguard the Himalayan heights.

High altitude exposes one to decreased atmospheric pressure and proportionate reduction in the partial pressure of oxygen in the inspired air (at 3,000 m, inspired air tension starts to fall below 100 mm of mercury and arterial oxygen tension below 85%).

For a resident from the plains exposed to high altitude, there is decreased cardiac performance or depressed left ventricular function and aerobic work capacity is reduced (cardiac output falls during exercise). There is a considerable blood volume shift in different parts of the body. The high altitude natives are, however, better adapted in their cardio-respiratory performance. Clinical syndromes recognised at high altitude include: pulmonary oedema, and acute and chronic mountain sickness. High altitude pulmonary oedema is the more serious of these events⁵.

High altitude pulmonary oedema (HAPO): This is usually observed at heights beyond 3,000 m. It is a pure form of non-cardiogenic pulmonary oedema, mechanisms involving lung circulation whereby pulmonary arterial blood pressure is elevated and pulmonary vascular resistance is high, whereas pulmonary wedge pressure is normal. Thus alveolar capillary leakages take place. Clinically the presentation resembles severe pneumonia. It has been observed in 23 to 155 per thousand of Indian soldiers in the Himalayas. There are various hypotheses for HAPO:

- (a) Hypercapnoea augmented hypoxia—hypoxia altering the pulmonary capillary permeability or depletion of surfactant.
- (b) Failure of normal diuresis and in turn increased central blood volume.

- (c) Acutely increased intravascular coagulation and impaired fibrinolysis.

HAPO responds dramatically to treatment with oxygen, furosemide, morphine and removal to lower altitude.

Acute mountain sickness: There is decrease in oxygen tension, and hypoxic stimulation of the respiratory chemoreceptors so that there are symptoms of cerebral dysfunction as well as tachypnoea.

Observations have been made on the social and cultural characteristics of the population living at high altitude and a lack of competitive spirit has been noticed amongst them. This presumably would suggest that ordinarily the plain man is not optimizing his maximum oxygen consumption. With training, super-athletes are continuously breaking records implying that there is scope for better adaptability to higher altitude.

Space

Space travel has two major factors affecting the physiological functions⁶, (i) acceleration and (ii) weightlessness.

Acceleration: There are two phases in manned space flight: (a) to leave the earth's gravitational field, and (b) to enter earth's orbit. To meet high forces required for these events construction characteristics of the modules are such that physiological alterations have been adequately taken care of and the cosmonauts function proficiently.

The various gravitational forces are expressed in terms of displacement of $\pm G_x$, $\pm G_y$ and $\pm G_z$. In a high G environment, there is decrease in stroke volume with compensating mechanisms of sympathetic activity such as tachycardia, premature ventricular contraction and T wave changes.

Respiratory changes include fall in arterial oxygen saturation while the mean alveolar to mean arterial P_{O_2} difference is greatly increased. Respiratory dead space is increased. There is uneven distribution of ventilation and perfusion with V/Q inequality. Overall manifestation is anoxaemia. Renal blood

flow gets reduced and in turn renin release is augmented and free water clearance is decreased.

Improvement in tolerance to increased G forces with physical training is doubtful.

Weightlessness: Problems of weightlessness have been summarised from various studies as follows:

In the cardiovascular system, there is orthostatic intolerance, i.e., increased lability of blood pressure, increased pulse pressure and pulse rate exceeding 100 per minute. There is decrease in the plasma volume (7-15%), water loss of 10% body weight and this relates to decrease of ADH and aldosterone. In respiration, there are regional inhomogeneities of ventilation and perfusion. However, reserve is so large that no impairment has been observed so far. Regarding skeletal system, hydroxyprolin excretion is increased and is indicative of dissolution of bone matrix with demineralization.

Work capacity is affected and exercise tolerance is decreased (oxygen consumption is 75% of pre-flight value). There is as well negative nutritional balance.

For the main theme of this presentation, I would now like to refer to the individual's adaptation at the subconscious level. This refers to the adjustment made by the individual primarily to bring about greater work performance and contribute to actualization of personal potential.

Such an adaptation encompasses improving ones leading capacity on one hand as well as the process of optimising response to stress. These responses seem efficiently organised below the level of consciousness or at a subcortical level, but demand an individual's positive role, while the process is self-reinforcing with each successful adaptation. The manifold interactions between somatic and psychic reaction as well as the importance of defensive adaptative responses had all been more or less clearly recognised. Hans Selye* identified that any stress stimulus elicited a response

that included the secretion of the corticosteroids which prepared the body for a fight or flight reaction. At this stage, one is justified to hypothesize that there may be interlinking of the hormonal responses with these modulations or a new preparedness or self-adjustment through integration of body and mind function. For this purpose, one needs to elaborate on Yoga.

Yug (Sanskrit) means to join or unite, the entities being *chaitanya* (consciousness) and *chitta* (mind) - what separates is the mind function through thought processes (*chitta vrithi*); yoga is then the blocking of *chitta vrithi* (mind function).

Patanjali¹ has described the following eight steps as basic to the practice of yoga:

1. *Yama* - Principle of good conduct, truthfulness, nonviolence, love, chastity and non-possession.
2. *Niyam* - Practice of discipline, punctuality and cleanliness.
3. *Asan* - Sitting in a relaxed posture, firm, motionless, erect, holding of the spinal column, neck and head in a straight line.
4. *Pranayam* - Breathing rhythmically, slow, while in *asana*.
5. *Pratyadhar* - Detachment of mind from sense organs.
6. *Dharna* - Concentration of thought on a fixed object - continuous and sustained.
7. *Dhyan* - Meditation, continuous of only one thought.
8. *Samadhi* - Further stage complete identification of mind with the matter, reaching the status of union between the mind and the consciousness, that is, all mental functions are blocked - a state of 'eternal bliss'.

Yoga is thus a practical systematic albeit rigorous discipline to attain perfection in the control of sensual experiences and psychological states. It is not a mere metaphysical, supernatural or mystical discourse as some may assume. Yoga is a science of the higher functioning of consciousness (super-consciousness). Recent studies⁷ have indicated remarkable physiological changes following practice of yoga: reduction in oxygen consumption and respiratory rate, relaxation of skeletal muscles, increase in skin resistance, EEG summation, coherence of alpha and theta frequencies. There are also biochemical alterations, e.g., reduction in blood lactate level and hormonal changes, lowering of corticosteroids. Optimization of response to stress, improvement in cognitive function, perceptual ability and better emotional behavioural integration have been observed in subjects who adopt the practice of yoga.

In our laboratories¹, we have conducted studies on volunteers who have been practising transcendental meditation over varying time intervals of two months to two years. The main objective was to establish whether such individuals when subjected to stress (in experiments designed by chemical changes) while in the process of meditation underwent alterations in the hormonal profile. The following Table summarises data on blood glucose and cortisol:

	Recent meditators	Meditators intermediate duration	Meditators of long duration
(Insulin 0.1 u/Kg response)			
Blood glucose mg/dl	81.6→48.7	80.0→58.3	85.0→67.0
Cortisol μg/dl	26.6→45.0	28.6→38.3	17.6→19.3

From this study, it was possible to establish that in those who practised meditation for over two months, cortisol response was obviated in stress, implying that such hormonal changes upgraded the body's biochemical responses so that the individual is better optimized for the stress. Earlier reported work has only focused on the neuronal changes and spectral coherence in EEG and shift in activity of

autonomic nervous system towards parasympathetic dominance which favours energy conservation and relaxation of body.

Our present data also bring into consideration that in integrated response to transcendental meditation, hormones also have a significant role.

In the same perspective, there is now more recent information on the brain peptides, resembling opiates, which extends the hypothesis of integration of neuronal and hormonal functions through paracrines.

Pro-opio-cortin is the precursor for ACTH and lipoprotein (molecular weight 31,000) and is present in the brain as well as at sites other than anterior pituitary. It is conceded that CNS processing is directed towards generation of peptide fragments that are neurally active over short distances whereas in anterior pituitary such processes yield other fragments that are destined for peripheral export to subserve metabolic functions and other uncharacterised functions.

A number of peptide fragments generated from β LPH possess various degrees of opiate-like activity. Their receptors are as well recognised as μ and δ receptors, μ receptors being involved in analgesic responses whereas δ receptors are involved in eliciting seizure activity and certain behaviour responses. Some of the effects may be mediated through adenylate cyclase. All three peptides ACTH, β LPH and β endorphins are secreted in response to stress possibly to serve as adaptive functions with β endorphins aiding pain relief. Naloxone, an opiate antagonist, is capable of completely blocking the analgesic effects of exogenously administered narcotics. Sandman et al⁸ infused a hepta-peptide derived from the 4-10 amino acids in ACTH molecule into normal volunteers. A series of detailed psychological tests were performed and the results indicated that the peptide raised the perceptual threshold for detection of visual stimuli but facilitated perceptual integration and patterned information. An improved ability to discriminate between relevant and irrelevant information was observed.

Epilogue

In the world of tomorrow in which scientific discoveries will possess the power to alter the gene, create new species and synthesise novel biological materials or inhabit new planets or cosmos, it is imperative that human beings learn new adaptations otherwise humanisation of the future will not be feasible. The accelerated new social order in the external world imbues our lives with a transience, a sense of unreality and materialism, forcing a faster and faster pace of daily life demanding a new level of adaptability which is a challenge to truism at a higher conscious level.

In concluding this, it may be worth recalling some excerpts from Jonathan Livingston Seagull³. At the moment Seagull is exorted from the flock, the narration is "How much more there is now to living?"

"Instead of our dark slogging forth and back to the fishing boats, there is a reason to life!"

"We can lift ourselves out of ignorance, we can find ourselves as creatures of excellence and intelligence and skill, we can be free! We can learn to fly!"

In the closing pages, Seagull while in conversation with the Elder, ... "Well, what happens from here? Where are we going? Is there no such place as heaven?"

"No, Jonathan, there is no such place. Heaven is not a place, and it is not a time. Heaven is being perfect". He was silent for a moment. "You are a very fast flier, are you not?"

"I I enjoy speed", Jonathan said, tall aback but proud that the Elder had noticed.

"You will begin to touch heaven, Jonathan, the moment that you touch perfect speed. And that is not flying a thousand miles an hour or a million flying at the speed of light. Because any number is a limit and perfection does not have limits. Perfect speed, my son, is being there".

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