Establishing the Scientific Validity of *Tridosha*

Part 1: *Doshas, Subdoshas* and *Dosha Prakritis*

***Alex Hankey PhD**

ABSTRACT

*In traditional Ayurveda, basic concepts such as Tridosha are introduced didactically. Students of Ayurveda learn to appreciate their practical value through clinical experience; their validity is **empirical**. In an age where validity of concepts is judged by their **scientific** relevance, establishing the scientific validity of Tridosha is a program of significance. It requires translating concept and practical application into the idiom of modern biology and medicine. Four different complementary approaches have been proposed to do so: factor analysis of human physiology; systems analysis of organism function; correlation of Dosha and genomic variations - Ayugenomics; and correlation of Dosha and cellular function. Together these four independent approaches present compelling evidence that the family of Dosha based, Ayurveda fundamental concepts - the three Doshas, their fifteen subdoshas, innate Dosha balance in the individual (prakriti), and Dosha imbalances (vikriti) are **scientifically** valid. This paper concerns the first three. (1) The systems approach shows how Tridosha applies to every living organism from the first cells, and how it is inherited and diversified in the history of life. (2) Ayugenomics confirms Dosha's inheritance. (3) Each Dosha is responsible for regulating an essential aspect of organism function, connected to a recognised definition of life: Vata, Input/Output (homeostasis); Pitta, Turnover (negative entropy production); Kapha, Storage (inheritable structure).*

INTRODUCTION

Appreciation of Vedic culture and all its sciences, including Ayurveda and closely associated Yoga practices, are beginning to be given the world-wide appreciation they deserve developing over the past quarter century. His Holiness Maharishi Mahesh Yogi[1,2] established a world-wide program of Ayurvedic clinics in the 1980's, and instigating fundamental research. Ayurveda has a long history of successful practice[3,4], interrupted only by intrusions of foreign cultures into the land of the Veda. It is slowly returning to normality, following repression in the 19th century. Ayurveda represents a treasury of some of the world's greatest and deepest insights into the nature of life (5), the structure of the human physiology, and the possibility of extending the human life-span.

Since 1986 Ayurvedic *Panchakarma* treatments have been offered extensively throughout the developed world. The success of such practice was obviously based on the precision of this unique knowledge, and led many scientists to wish to establish its bona fides in terms of western science. At that time, Maharishi Mahesh Yogi popularized the idea of research on Ayurveda. Bodeker, in particular, stimulated much early research in the US on its preparations and treatments, such as that by Schneider (6-8), and Sharma (9-11), and others (12), and continues to make major contributions (13), and with colleagues such as Patwardhan (14).

When a House of Lords Report (15), though favorable to Maharishi Ayurveda, was hostile to, and uninformed about Ayurveda (16), it was countered by large numbers of papers by authors such as those mentioned (17-20). For that reason, scientific understanding of Ayurvedic concepts began to be recognized as holding a key (13,21). If they could be expressed in scientific form, and so be seen to be part of the canon of biology and physiology, they could then be used in support of campaigns to bring Ayurveda's advantages to larger fractions of the world's population, through government health care systems (22). Even in the UK, with its traditional hostility to Ayurveda, government scientists had to acknowledge the high quality of research (23) that had already been done (24).

n the United States, Ayurveda was seen as a flagship of excellence in research on complementary medicine. Thanks to previous awards totaling many millions of US dollars by the National Institutes of Health to Maharishi University of Management (MUM), Maharishi College of Vedic Medicine in Fairfield, Iowa, was made the first N.I.H. Center of Excellence in research by the newly created National Center for Complementary and Alternative Medicine, NCCAM. Schneider's achievement in winning this for Ayurveda in front of other systems of CAM, and other medical schools in the U.S., including the nation's best, such as Harvard Medical School and Johns Hopkins Medicine, cannot be understated. It was as much an endorsement of the therapeutic efficacy of Ayurveda and Yoga medicine (Transcendental Meditation), and the accuracy of their systems of assessment and diagnosis, as it was of the scientists and doctors concerned.

*Dean, Academic studies, Institute of Ayurveda Integrative Medicine, Bangalore.
Executive Editor , Journal of Ayurveda and Integrative Medicine, Bangalore.
Professor of Yoga and Physical science, SVYASA, Bangalore.

Even in the 1980's, the effectiveness of Ayurveda's practical wisdom was clear to all who saw it at first hand. To those, interested in scientific mysteries, one obvious question came persistently:

'*If Tridosha is valid, then why should the three Doshas exist, and how, in scientific terms, do they work*?'

First answers were given in a seminar at Maharishi University of Management (25). This led to a first, invited, publication (21), and subsequent refinements (26,27). However, details of *Dosha* dynamics were sketchy, much needed to be added. The present pair of papers summarizes that basic theory, and further development to this date. It has been facilitated by Mashelkar's vision of a 'Golden Triangle' in his Chitrakoot Declaration (28), and the resulting large scale Ayurveda research initiative in India. The torch so lit will shine forever, a tribute to the Vedas' ancient wisdom, and their eternal relevance to the happiness of man, whatever the age.

CURRENT RESEARCH ON AYURVEDA BASIC CONCEPTS

Among current scientific research projects on Ayurveda, three develop this scientific understanding of Ayurvedic theory significantly further: that undertaken by Dr R.R. Joshi (29) at the Indian Institute of Technology in Mumbai; the Ayugenomics programme of Patwardhan, Joshi and Chopra (14,30) at the University of Pune, recently amplified by Brahmachari (31); and work on the electro-physiology of *Doshas* undertaken by Polisetty (32). All concern the Ayurvedic concept of '*Prakriti*', the innate balance of *Doshas* and *subdoshas* as expressed in individual differences in each person's physiology.

Dr Joshi has undertaken statistical analysis of questionnaires used to determine patients' *Prakritis* in Ayurvedic consultations. Such questionnaires are designed to determine 'individual differences' in a patient's physiology. That is really what the various possible *Prakritis* constitute. For some reason, although the idea of 'individual differences' pervades western psychology (33), and forms a huge body of research in that subject (34), to this author's knowledge no corresponding study has been attempted on the level of physiology. Similar individual differences must exist, as is obvious from looking at the varieties of shapes, sizes and dispositions of humanity. Modern genomic studies concern tendencies towards specific diseases, but there is nothing of the simple, practical nature, pervading Ayurveda: the combination of '*Prakriti*' and specific *Dosha* aggravations, allowing the physician to tell what each patient should or should not be instructed to do. The reasons for this are probably similar to those underlying western pathology, outlined in Part 2: reductionist scientists of the 19th century tried to avoid anything that might smack of a 'subjective' influence, so that aspects of patient individuality were removed. Hence, age old considerations of patients' humors were eliminated in favor of a supposedly objective approach and at a costly price, as Part 2 recounts.

To explain this by analogy: scales of individual differences in psychology are established by procedures closely related to Dr Joshi's. Statistical analysis of questionnaires decides the number of *statistically independent* scales that exist, and what they refer to. This is done by 'factor analysis': specially designed questionnaires are administered to thousands of people, and statistical correlations between answers to various questions measured. Analysis of correlations reveals the number of independent degrees of freedom in a given set of questions; that number equals the 'dimension' of that set of questions, considered as a vector, in the same way that the maximum number of linearly independent vectors in a vector space equals its dimensionality d. The *maximum* number of degrees of freedom found for any set of questions whatsoever will equal the number of possible independent scales that can be measured. In psychology, the number so identified over the years has increased from two to three in the 1960's, to today's 'Big Five'.

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In the case of *Dosha prakriti*, *Doshas* provide a theory that remains to be fully verified. Dr Joshi's first paper (29) has begun to test *Dosha* theory through a related application of factor analysis. The importance of this cannot be underestimated: if the program confirms Ayurveda and indications are that in the end it will, two major goals will have been achieved: first, the raw *Tridosha* concept as it occurs in the *Prakriti* will have been empirically verified; and second, the best questions to ask to determine the various scales in *Prakriti* questionnaires will have been identified. Moreover, the correlations between questions on each scale for a given population will also be known, so that optimal *Prakriti* questionnaires will be easy to design optimal in the sense of providing even spacing in each scale of measurement.

When complete, Dr Joshi's programme will enable us to say, '*Tridosha is a valid concept in human physiology*, it has been empirically verified by factor analysis. It can be used to decide what aspects of patient physiology are vulnerable with respect to different kinds of environmental challenge, and which kinds of adaptive pressure are most likely to start the disease process unfolding. It will do so in terms that all western scientists will understand and respect, and will establish *Tridosha* as a valid means of physiological classification and etiological analysis, *independent of Ayurveda's teachings on the subject*. Completing this programme is of the highest importance to persuade the scientific community of the direct *empirical* validity of the pure *Tridosha* concept.

The Ayugenomics approach to verifying *Tridosha* is that of molecular genetics: to verify its basis in the human genome. The power of genomics is to explain variations of properties of different members of the same species in terms of different manifestations of particular genes. One person has sickle cell anemia, another does not. Why? A single base in a single codon in a single gene encoding a particular amino acid for a particular protein is different: the result is fatal. According to this approach*, Tridosha* and the *Prakriti* concept can be verified by showing that different *Prakritis* correspond to different variations of particular parts of different genes: the challenge is to select appropriate genes to test for corresponding *Prakritis*.

The first investigation (30) used the two insights that, (a) variations in HLA genes encoding the immune response produce differing susceptibilities to rheumatoid arthritis, and (b) that different Ayurvedic Prakritis are known to have differing RA susceptibility. It therefore hypothesized a correlation between HLA allele frequencies and different *prakritis*. It is fair to say, however, that modern studies of genome regulation are revealing such rich inheritable possibilities, that future Ayugenomics studies should also attempt to observe correlations between the *Prakriti* and the *epigenome*, particularly as this may indicate how the *Prakriti'*s well-known variation with age may occur. The Ayugenomics initiative began to establish a *biological basis* for *Tridosha*. The truly scientific nature of Ayurveda theory was beginning to be clearly delineated (26).

The first paper on Ayugenomics (30) was subject to the criticism that the function chosen had little to do with the fundamental biology of individual *prakritis*. Its result, though momentous, was only a correlation with a peripheral interaction with the external world, and not with internal function. Patwardhan's group has since published a second related discovery, that the CYP2C19 loci, coding for drug metabolizing enzymes, also show systematic variations with *Dosha prakriti* (35). This time, the variations can be intuitively understood from basic understanding of *Doshas: Pitta prakriti* types, traditionally associated with greater energy and heat production, and thus strong metabolic systems, are faster drug metabolizers, while the colder and less active *Kapha* types are associated with genes making them weaker drug metabolizers, and requiring smaller drug dosages.

One problem these first Ayugenomics studies have faced is defining and obtaining supposedly 'pure' *Prakriti* types with which to experiment. This has raised considerable controversy. *Prakriti* is partly measured by questionnaires which estimate the percentage of each *Dosha* in each subject. Both studies approximate quite wide variations of *Prakriti* percentage's as supposedly 'pure' *Prakritis*, a potential source of significant inaccuracy. It is to be hoped that future studies will have enough subjects to justify full multivariate MANCOVA analyses to be carried out.
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Another paper, published in 2008, has expanded the range of effects expected to be associated with different *prakritis* from genomics to epigenomics. Work at CSIR under its Director-General, S.K. Brahmachari (31), has found that genetic expression differs systematically in different *prakritis*. There are systematic variations in *epigenetic* expressions of genes in different *prakritis,* as well as different alleles in the genome. The implications of this important result will be discussed in Part 2.
More recent work by Polisetty (32) has profound implications for understanding the general structure and disposition of different Dosha *Prakriti* physiologies and personalities, and how they may be rooted in different genomic variations. It is briefly outlined in the appendix.

ESTABLISHING A THEORETICAL BASIS FOR THE EXISTENCE OF *TRIDOSHA*

That brings us to the question, 'if Tridosha *exists empirically*, manifesting in individual differences in human physiology, the *Prakriti*, and if those variations in *Prakriti* have *a substantial genomic basis*, then *why should Tridosha exist in the first place*? What theoretical reasons justify it's existence? And if it does exist, to what organisms does it apply? Humans ? Primates ? Mammals? Vertebrates? Chordates? The animal kingdom? All of life?

The answer, as I shall attempt to explain, seems to be this: understood widely enough, *Tridosha* refers to fundamental functions of any organism; it applies to every living cell, and every organism on the planet; indeed, potentially, to any living organism anywhere in the universe. This section explains how to arrive at this conclusion.

A general approach to scientific problems is through systems theory, a fundamental property of which is that, "every *open* system has functions of *input/output*, *turnover* and *storage*" (Figure 1). Since every living organism *is* an *open* system, the three *Doshas* might be related to these three. This seems the kernel of a possible solution to the problem, for if some aspect of these functions can be equated with *Vata, Pitta* and *Kapha Doshas*, their *necessary* existence in living organisms will be obvious. To carry the approach through in detail requires many further insights.

Our first hypothesis is simple*: Vata* relates to input/output, *Pitta* to turnover, and *Kapha* to storage. Let us start simply: *Apana Vata*, held to be the chief *Vata subdosha,* is responsible for colon and kidney function. In the colon water and nutrients are absorbed a basic *input* and solid wastes are passed out *output* and in the kidneys, water and other wastes are removed from the bloodstream a second, important *output*. Secondly, the lungs, under *Udhana Vata*, are responsible for input of oxygen and output of carbon dioxide, so this seems OK. *Pitta* is responsible for heat production metabolism on the cellular level, a form of *turnover*. Its chief *subdoshas*, *Pachaka* and *Ranjaka Pitta*, are responsible for major digestion processes the 'processing' part of the digestive canal, the main organ system for *turnover* of food *p*assing through the system, equating '*turnover*' with '*throughput*'. *Kapha*, on the other hand is more subtle; *Shleshaka Kapha* is an important *subdosha*

Responsible for synovial fluid: *'Shlesha'* has a word root meaning to cling, and is often translated as 'cohesion', but it is better left at 'lubrication'. Lubrication is the concern of other *Kapha subdoshas*, *Bodhaka Kapha* in saliva, and other mucous membranes in the head, and *Kledaka Kapha* for mucous function in the stomach. Mucous is an oligosaccharide, and polysaccharides are used for the *storage of energy* in the eukaryotic cells of higher organisms like plants and animals. Further, *Kapha* is aggravated by fats, and lipids are also important *energy storage* molecules.

These functions seem to fit the hypothesis well (see Table 1). But the question remains, how do the rest of the *subdosha* functions of *Vata, Pitta* and *Kapha* fit into this line of thinking? The answer is that deductions to this stage tell a story: firstly, only a few *subdoshas* fit this line of reasoning when applied to the whole organism; but, secondly, in *Pitta they seem to apply to processes in single cells* as well as to the organism, and, thirdly, in the case of *Kapha*, *they seem to apply at a biochemical level*, and one *Dosha* would appear to govern a number of functions *with the same biochemistry*.

FIGURE 1

THE THREE NECESSARY FUNCTIONS OF ANY NON-TRIVIAL OPEN SYSTEM

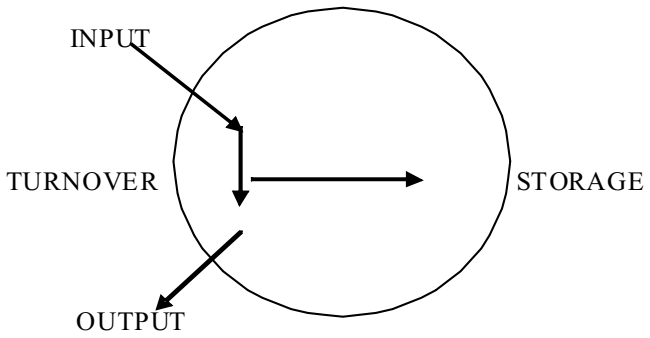

Figure 1: Any open system has input and output. However

If what goes in comes out unchanged, it is a trivial system.
For it to be non- trivial, there must be processing – turnover.
Finally, for growth, materials must be free to be taken off
the production line – for storage or to create new structure.

Armed with these three clues, let us look at the rest of the subdoshas. Table 2 shows how these clues provide explanations for the functions of all the subdoshas of each *Dosha.*

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A. *Vata subdoshas* all are connected to input/output functions either at cellular or organism levels. For *Prana Vata* responsible for sensation, and all nervous system functions, these work through input/output gating mechanisms in the cell membrane: action potentials are entirely driven by them. More subtle processes of *Prana Vata* flowing through the system of *Nadis* and regulating feelings in the body, such as bliss, pain, and internal sensory awareness, are, according to acupuncture theory, a result of transmembrane potentials of every cell in the body again driven by cellular input/output processes. *Udhana* and *Samana Vayu* also depend on membrane processes for their functioning: *Samana* through the smooth muscle action driving peristalsis, and *Udhana* in two ways: first, O_2 transfer through alveoli in the lungs is a very subtle input/output process for the whole organism, depending on specialized membrane properties of lung cells; second, the action of *Udhana Vata* in clearing the lungs and trachea of dust and particles is effected by the action of cilia, again dependent on membrane functions. Finally, *Vyana Vata* is responsible for functions like opening and closing pores in the skin, so sweating can occur, connected to input/output for the whole organism.

B. *Pitta subdoshas*: all are concerned with *energy turnover* processes. *Alochaka Pitta* with energy reception in the sense of sight, and *Bhrajaka Pitta* with energy balance in the skin. Only *Sadhaka Pitta* remains, and it is easy to locate its 'energy' function: without the 'light' that comes from fullness of heart and devotion, humans becomes miserable and depressed. All subjective experience of 'energy' and all sense of motivation depend on a combination of *Sadhaka Pitta*, and *Prana Vata*. The all important quality of 'enthusiasm' is a well appreciated function of *Vata Dosha*. Ultimately, its healthy function depends on *Sadhaka Pitta*, promoting optimal flow of *Prana* through the *Nadis*.

lC. *Kapha subdoshas*: *Avalambhaka* concerns lipid tissue, energy storage, and polyglycans polysaccharide functions. Similarly, *Bodhaka, Kledaka* and *Shleshmaka Kaphas* all concern polyglycans, carbohydrate molecules used in lubrication. *Tarpaka Kapha* provides nutrient and lubrication in the spinal cord, probably in all chordates, also fitting the classification.

TABLE 1

***SUBDOSHAS* CONCERNED WITH INPUT/OUTPUT, TURNOVER AND STORAGE**

FUNCTION	*SUBDOSHA*
INPUT/OUTPUT	*Samana* and *Apana Vata* for Nutrient Input/Output *Prana* and *Udhana Vata* for O2/CO2 Input/Output *Vyana Vata* for Sweat Excretion
TURNOVER	(*Ranjaka Pitta*) Digestive Functions are (*Pachaka Pitta*) Key to Nutrient Turnover
STORAGE	(*Bhodhaka Kapha*) Mucous function uses energy (*Kledaka Kapha*) rich polysaccharide molecules (*Avalambhaka Kapha*) Adipose Tissue is a means of energy storage

TABLE 2

HOW ALL THE *SUBDOSHAS* RELATE TO THE FUNCTIONS INPUT/OUTPUT, TURNOVER AND STORAGE

FUNCTION	*SUBDOSHA*
INPUT/OUTPUT	*Prana Vata* membrane transport
Vata Subdoshas	*Udhana Vata* O_2 input / CO_2 output & membrane cilia
	Samana Vata membrane transport
	Apana Vata nutrients and water, membrane transport
	Vyana Vata input/output regulation at the epidermis
TURNOVER / PROCESSING	*Pachaka Pitta* food processing
Pitta Subdoshas	*Ranjaka Pitta* digestive enzyme production
	Sadhaka Pitta sense of 'energy' – fullness
	Alochaka Pitta energy processing in the eyes
	Bhrajaka Pitta energy turnover in the epidermis
STORAGE	*Kledaka Kapha* polysaccharide production for lubrication
Kapha Subdoshas	*Bodhaka Kapha* same and replenishment of lost storage
	Avalambaka Kapha mucous membranes in lungs etc. adipose tissue, lymph etc.
	Tarpaka Kapha Spinal fluid
	Shleshmaka Kapha Synovial fluid

n order for these properties to hold so widely, *Dosha* functions must have been precisely inherited from organism to organism throughout biological history; they must have altered mildly in the details of their expression as species evolved into different species; and with radical changes of expression as different phyla evolved in the animal kingdom, introducing new organ systems. These suppositions are reasonable because the *Doshas* have been identified as general functions, requiring appropriate regulation in every organism.

These observations lead to the following hypotheses, which we make in order to develop a full theory of *why Tridosha* should exist with its five *subdoshas* for each *Dosha*:

1. The three *Doshas Vata, Pitta* and *Kapha*, are responsible for the three identified systems functions.
2. In particular, they apply to single cells as well as whole organisms.
3. Each is responsible for particular classes of biochemical, molecular function in any system: *Vata* for membrane function; *Pitta* for turnover on energy production processes and other biochemical pathways; and *Kapha* for energy storage molecules, starting in individual cells, and later developing to the whole organism.

Let us apply this to single cells (Figure 2): *input/output* is the function of the cell membrane with its receptor proteins, and active transport mechanisms in gated channels; *turnover* of ingested material, particularly energy rich foods, is carried out by enzyme catalysts on biochemical pathways; *storage* is the function of energy rich molecules in the cell membrane.

These *Dosha* functions in single cells, logically deduced from the first hypothesis, agree with those proposed from considering the role of the *subdoshas*, with a transfer from polysaccharides to carbo-hydrates for *Kapha* (presumably because in the animal kingdom carbohydrates form primary energy reserves, and lipids a secondary one).

IAnother point to note is that, in single cells, energy storage and membrane transport functions are mutually exclusive properties of the cell membrane. These complementary functions make cell design highly efficient: the only 'organ' in prokaryotic and other primitive cells is the membrane, which can now be seen to play a double role, functioning as both boundary separating inside from outside (*Vata*), and storage repository for energy reserves (*Kapha*).

If this overall picture is correct, it means that the polarity between *Vata* and *Kapha*, as expressed for example in the opposite ways they relate to the six tastes, *Shadrasa*, dates back to the earliest times of biological history; possibly a reflection of the fact that *Vata's* action of closing the gates to regulate membrane transport, is the opposite of *Kapha's* requirement to keep the gates open for food molecules to enter.

This development points to the idea that the functions, *Vata, Pitta* and *Kapha* have been inherited over biological history, undergoing appropriate changes of expression at an organism level from species to species and from phylum to phylum, while their expression at the level of single cells remained unchanged or 'invariant'. This idea can be tested at a biochemical level, by considering the biochemical pathway for lipid synthesis and catabolism that has to occur in all cells since all have to be able to create membrane in order to reproduce, as well as to store energy reserves. The universal occurrence of coenzyme A in all known cells is a confirmation of the strategic role of the pathway, and the need for its precise regulation (27). No single gene mutation can substitute both the function and its regulation, so the pathway has never been replaced. This can be interpreted as confirmation that the role of the pathway is fundamental at a *systems* level of cell function, rather than just biochemically for membrane synthesis (27).

TRIDOSHA AS A FUNDAMENTAL, ALL INCLUSIVE DEFINITION OF LIFE

That the functions of *Vata, Pitta* and *Kapha* identified by systems theory are fundamental is confirmed by the fact that each represents one of modern biology's independent definitio*ns* of 'Life'. *Vata's* membrane transport governs homeostasis, the ability of cells to regulate their environment, maintaining it constant enough to make enzyme function reliable, and far-from-equilibrium with the outer environment. *Pitta* governs energy production: only by producing energy rich molecules like ATP to drive cellular metabolism can organizing power, known in thermodynamics as negative entropy, be made available to keep the organism far-from-equilibrium. *Kapha* is responsible for lubrication, and thus maintains structure. These three, homeostasis, the ongoing production of 'negative entropy', and inheritable structure, have all been used as definitions of life. Comprising all three makes *Tridosha* the most powerful definition of life ever formulated!

FIGURE 2

THE THREE FUNCTIONS IN SINGLE CELLS – THE SIMPLEST ORGANISMS

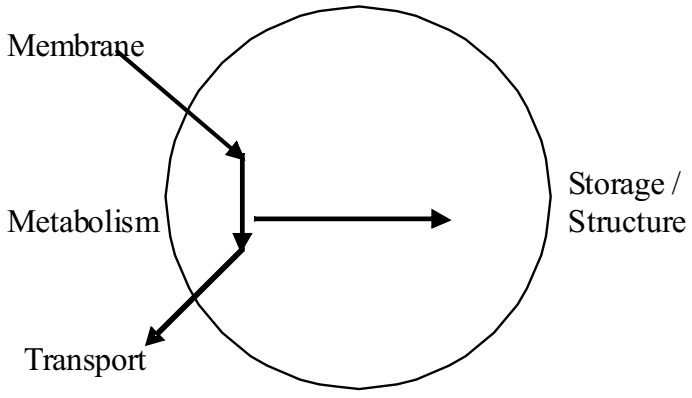

Figure 2: In a single cell, regulation of Input/Output is responsible for homeostasis. Turnover is conducted by metabolism , which generates the 'free energy' needed to run the cell. Storage of excess materials eventually creates new cell structure and growth.

Based on systems theory, *Tridosha* biology would also apply to life forms other than those found on earth. On other planets, reproducing structures based on similar chemical principles might have developed, but with other kinds of specific chemical: possibly using different nucleic acid bases, or different codons for different amino acids, or not based on DNA or RNA, or not based on carbon chemistry at all ... The possibilities for speculation are endless. Whatever chemical basis for its reproducing forms, each organism in such a system of life would have to possess the inheritable systems functions named. Their regulation would justifiably be identified as *'Vata, Pitta* and *Kapha'*.

SUBDOSHA FUNCTIONS

To complete the first stage of this scientific theory of *Tridosha*, we must consider the question of how *subdosha* functions arose, for *subdoshas* are an important concept. A clue to how to tackle the question comes from the observation that *subdoshas* apply to different parts or regions of the human organism, where they have specialized functions in particular organs.

In physiological terms, as one moves from the whole to the parts, the level after 'whole organism' is organ subsystems after that come organs, tissues and cells. It is therefore instructive to see how the various *subdoshas* of each *Dosha* relate to the body's organ subsystems (see Table 3). Comparing its three columns reveals something remarkable: each *Dosha's subdoshas* are distributed the same way among organ subsystems: two for the digestive system, one for the cardiovascular system, one for the central nervous system, and one for epithelia (*shleshmaka kapha* requiring more explanation).

n the case of the *shleshmaka*, it pertains not to the skin, but to the joints, part of the musculo skeletal system. However, this is said to originate in epithelial tissue of the nervous system, so the common concept for *Vyana, Bhrajaka* and *Shleshmaka* is the Epithelia.

Table 3 now suggests that *subdoshas also come in triplets*, *each triplet relating to a particular organ subsystem*. This means that two *subdosha* triplets are assigned to the digestive system, one to the cardiovascular system, one to the central nervous system, and one to epithelia, as in Table 4. To be applied in detail, some of this understanding of *subdoshas* needs careful qualification. Certain subdosha functions in man, such as *Tarpaka Kapha*, which includes spinal fluid, cannot have that particular function when the (central) nervous system first appears, for there is no chord of nerves to protect, lubricate and nourish, only a network of nerve cells. *Tarpaka* must refine to its present function at a stage of evolution subsequent to the first introduction of the organ system in which it first occurs in this case the central nervous system. Similarly, for *pachaka* and *ranjaka pitta*, *avalambaka kapha* etc.: their particular functions relate to the organ in which each is found in the human body, but must have evolved through similar functions in that organ system during earlier stages of development.

Table 4 raises the question: why should there be two triplets for the digestive system? The answer turns out to be simple: organ subsystems arise at successive stages of biological evolution, giving rise to new phyla as they do so. The digestive system, however, arises in two stages: first, the 'mouth' and 'stomach' in Ctenophora and Cnidaria (coelenterates), and then the full gut passing from mouth to anus in Nematoda. This would suggest that the digestive system *subdosha* triplets arise in two s*tep*s, the first to govern the functions of Ctenophora, and the second to govern the subsystem's new functionality in Nematoda.

In coelenterates, the first triplet of digestive system subdoshas must include functions of *Apana Vata* for absorption and excretion, *Ranjaka Pitta* for protein digestion, and *Bodhaka Kapha* to activate 'taste' sensation and so help regulate the 'mouth'. In Nematoda, the second *subdosha* triplet of digestive functions must include the peristaltic action of *Samana Vata* to move the food along the gut (its present function), the acidification function of *Pachaka Pitta* to create conditions for a more effective and prolonged digestive process, and the lubrication of *Kledaka Kapha* to enable the chyme (mixed with particles of earth in the original nematodes) to move through the bowel without injuring its epithelia, now mucous membranes. Table 4's digestive system *subdosha* triplets have therefore been set out as (*Apana, Ranjaka, Bhodaka*), and (*Samana, Pachaka, Kledaka*), ordering the triplets as they would have arisen down the main line of evolution in the animal kingdom from protozoa to chordates and vertebrates with the organ subsystems arising in the order: epidermis (skin), digestive system I, digestive system II, circulatory/cardiovascular system, and finally central nervous system though Nematoda like *C. elegans* also have a neural net. This scheme presents a coherent picture of how the fifteen *subdoshas* arose in the course of biological evolution: they did so in triplets, an idea not contained anywhere in the Ayurvedic *Shastras*, to my knowledge possibly a contribution of modern science to understanding the structure of *Ayurveda*.

TABLE 3

ASSIGNATION OF *SUBDOSHAS* TO ORGAN SYSTEMS

VATA SUBDOSHAS		*PITTA SUBDOSHAS*		*KAPHA SUBDOSHAS*	
Prana	CNS	*Pachaka*	DgS	*Kledaka*	DgS
Udhana	CVS	*Ranjaka*	DgS	*Bodhaka*	DgS
Samana	DgS	*Sadhaka*	CVS	*Avalambhaka*	CVS
Apana	DgS	*Alochaka*	CNS	*Tarpaka*	CNS
Vyana	EpiD	*Bhrajaka*	EpiD	*Shleshmaka*	Musculoskeletal

THE NEW *SUBDOSHA* PROPERTIES

The above analysis brings out properties of *subdoshas* that are not just surprising, but gratifying because of the consistency of their implications. There is nothing in the Ayurvedic texts that gives any hint that this might be the case. The significance of these *subdosha* properties lies not just in their being unexpected, but in pointing to their having such systematic and simple origins. They are like laws, which the five sets of *subdoshas*, seemingly serendipitously, turn out to obey.

1. All the *subdoshas* of each *Dosha* pertain to the same major function in single cells:

Vata	Membrane Transport processes
Pitta	Energy Regulation Processes and Metabolism
Kapha	Processes involving Lipids and Carbohydrates, Energy Storage Processes

2. The same number of *Subdoshas* of each *Dosha* pertain to each organ subsystem. All *subdosha* sets contain one for epithelia, one for the cardiovascular system, one for the central nervous system, and two for the digestive system.

These unexpected facts about the *subdoshas* are clear and undeniable. They have clear implications: *Dosha* function is inherited and diversified as evolution, speciation and phylogenesis take place. They have implications for comparative genomics: genes responsible for related *subdosha* functions should have more closely related DNA sequences, than those for functions belonging to different subdoshas. They also imply a third statement this time a more tentative

TABLE 4

ORGAN SYSTEMS AND THEIR *SUBDOSHA* TRIPLETS

ORGAN SYSTEM	*VATA SUBDOSHA*	*PITTA SUBDOSHA*	*KAPHA SUBDOSHA*
Epithelia	*Vyana*	*Bhrajaka*	*Shleshmaka*
Digestive System I	*Apana*	*Ranjaka*	*Bodhaka*
Digestive System II	*Samana*	*Pachaka*	*Kledaka*
Cardiovascular System	*Udhana*	*Sadhaka*	*Avalambhaka*
Central Nervous System	*Prana*	*Alochaka*	*Tarpaka*

Table 4: Each of today's *subdoshas* can be traced back to its first form, when the relevant subsystem was first created, since the *subdoshas* seem to have arisen in triplets during biological evolution. All have generalized since that time, the location of *Vyana* is no longer restricted to the skin, though it's first function was to generalize *Vata's* location in the cell membrane to the epidermis of the new multicellular organism; similarly for *Shleshaka.* The names are only an indication of the present *subdosha* with the greatest connection to the primordial one.

3. *Subdoshas* for different *Doshas* can be combined in triplets.

The novelty of this proposal cannot be adequately emphasized. Ayurvedic texts (36, 37) introduce *subdoshas* in lists of five under their parent *Dosha* with no hint of relationships between them. That there are the same numbers of each is surprising in itself. "Why should that be?", one might ask. After all, *doshas* have different numbers of qualities; *subdoshas* govern different numbers of organs and functions. Why should there be equal numbers of subdoshas for each *Dosha*? Association of *subdoshas* into triplets, with one *subdosha* of each type in each triplet begins to explain it.

This proposal may be testable by means of comparative genomics: genes associated with the functioning of the same *subdosha* may be associated more closely with each other, than with those governing other *subdosha* functions in the same triplet.
associated more closely with each other, than with those governing other *subdosha* functions in the same triplet.

The next observation, that the gastrointestinal tract arises in two major stages, with two distinct phyla being needed to develop it, provides the final clue to a fourth major statement. Once again this is given in the form of a hypothesis that may become testable.

4. When a major new organism subsystem develops, a new *Subdosha* triplet is introduced.

The five subsystems, epidermis, mouth and stomach, gut and anus, circulatory system and central nervous system all seem to have required the introduction of a new *subdosha* triplet, as processes of phylogenesis occur. Development seems to have limited itself to five *subdosha* triplets. Why further *subdoshas* are not required is not clear e.g. for sense organs. Further development has taken place by diversifying the properties of individual subdoshas e.g. *Apana Vata* between the colon, the kidneys and the genitalia.

Nor is the reason for the introduction of a *subdosha triplet* obvious at this stage. Is it because all three kinds of function are needed to coordinate subsystem function with that of other subsystems, and integrate it into the functioning of the whole organism? Is it because genes of every type may be needed to create and regulate the new subsystem's function: cell membrane receptors (*Vata*) to receive instructions from endo-, exo-, and para- crine activities; various specific enzymes (*Pitta*) to create the new biochemical pathways required for the new cell types to carry out their functions? Or is it something to do with way that phylogenesis itself must occur, with many new genes having to be created in a silent state, and then switched on simultaneously, for something as complex as a new stage of morphogenesis to take place?

We do not know the answers to these questions, nor do we have clues to their answers. But it is clear that comparative genomics may provide hints, once we begin to see which genes are involved in which organ subsystems, and how those of various subdoshas are related to each other.

EXPLAINING MAJOR PROPERTIES OF THE *DOSHAS*

One advantage of the emerging point of view that whole organism levels of *subdosha* function arise at distinct stages of evolution is that it becomes possible to explain some of the major properties of *Tridosha* named in the Ayurvedic texts, the 'principal location of each *Dosha'*, and their sequence in the *Dosha's* 'diurnal biorhythm'. The principal locations are given as follows. *Vata*: the lower abdomen the region of *Apana Vata;* of *Pitta*, the middle abdomen the region of *Pachaka* and *Ranjaka Pittas*; and of *Kapha*, the head and upper thorax the region of *Bhodaka Kapha*. These are precisely the three *subdoshas* of digestive system I in the locations they have to adopt in Nematode worms: *Bhodaka* must be placed at the mouth, for taste and to supply initial lubrication (in man, for the esophagus); the digestive functions of *Pachaka* and *Ranjaka Pittas* must be placed next, while the absorption / excretion functions of *Apana Vata* must, to be effective, come last.

It cannot be other than this order. Lubrication (*Kapha*) must come first; without lubrication, sharp ingested particles would rip epithelial cells in the GIT to pieces. Absorption (*Vata*) cannot be placed before digestion (*Pitta*), if it were, there would be nothing to absorb. The 'principal locations' of *Dosha* function, *Kapha* at the mouth, *Pitta* in the middle, and finally *Vata*, must have applied to all organisms ever since Nematoda first appeared a very long time!

A similar line of reasoning applies to the order in which *Doshas* become active during the Diurnal Biorhythm: *Kapha, Pitta, Vata*. A well known property of neural nets is that they possess the ability to learn. In even the simplest Nematodes like *C. elegans* a network of neurons coordinates activity. One of its roles is to learn to model, and then control, the activity of the whole organism. What does it first learn to model? The order of activation of *Dosha* functions in the body of the *"*Nematode*"* *Kapha* in the 'mouth', *Pitta* as digestive enzymes are produced, and *Vata* as absorption begins to take place. It would appear that the order of *Dosha* activation, *Kapha-Pitta-Vata*, has been locked into animal nervous systems ever since neural nets first appeared.

DISCUSSION

The analysis of *Dosha* function presented here confirms the experience of every practicing *Vaidya*: *Tridosha* is a simple and profound way to understand human physiological function, providing an accurate explanation for it, including means of regulation of all the major organ subsystems and their principal organs. One of the most powerful aspects of *Tridosha* is that it presents physiological function from a *holistic* perspective. The sequence *Tridosha-Dosha-Subdosha-*organ *Dosha* traverses a sequence of levels from whole to parts:

1. *Tridosha* coordination and integration of wholeness of organism functioning.
2. *Dosha* regulation of the three major aspects of open system function, for the whole organism.
3. *Subdosha* regulation and coordination of activity of major organ subsystems.
4. Organ *Dosha* aspect of *subdosha* which regulates a particular organ in an organ subsystem.

That it maintains wholeness and integration even when dealing with each component part, reveals *Tridosha's* sophistication in regulating physiological function. From the perspective of the organism itself, 'the organism as a whole' is primary; the functioning of parts is secondary. Wholeness of organism functioning can only be maintained by coordinated regulation of each successive level of parts. In *Tridosha*, Ayurveda enables the human organism to maintain wholeness of functioning (health), and, when compromised, to restore it. *It establishes the ground for both maintenance and restoration of health* i.e. prevention of ill health on one hand, and its cure on the other. This is the topic of Part 2 of this paper.

Viewed from the perspective of systems theory, Ayurveda's explanation of physiological function in terms of *doshas* makes perfect sense. *Tridosha* is responsible for the main physiological functions of any organism regarded as an open system. Each *dosha* governs one of the three major functions, which any non-trivial open system must possess. That is why there are *three Doshas*.

Input/Output <=>*Vata Dosha* Turnover <=> *Pitta Dosha* Storage <=>*Kapha Dosha*

In single cells (Figure 2), these functions correspond to homeostasis, metabolic energy production to maintain the organism far from equilibrium, and maintenance of inheritable structure, all defining properties of life.

Understood in this way, 'Tridosha' comprises an all inclusive functional ***definition of life****: it is completely fundamental, applying to the whole of biology.*

From the systems perspective, *subdoshas* and their functions similarly appear to arise in triplets. The ancient texts do not comment on the fact that there are an equal number of *subdoshas* for each *Dosha*. The triplet concept is new: each triplet of *subdoshas* provides overall regulatory functions for a major organ subsystem; arising at the stage of biological evolution when that subsystem develops, ensuring its successful function.

Just as the triplet of Doshas, Tridosha, regulates a whole organism, triplets of subdoshas are responsible for successful function of major organ subsystems.

IThese intermediary steps make it possible to trace the development of *Doshas* and their functions throughout biological history. Each *Dosha* has diversified from a single function in the earliest cells, to a multiplicity today.

Each has gained five *subdoshas* governing subsidiary areas of function in chordates. Each of those now has several, 'daughter' functions in different organs. *Dosha* continuity can be traced by considering how it functions in all intermediary organisms. The same functions merit the same name. Continuity through various stages of development justifies naming their functions, including in single cells, *'Vata', 'Pitta'* and *'Kapha'*.

CONCLUSIONS

Even at this stage, we can see how the systems approach to understanding *Tridosha*, combined with the work of Joshi (29), Patwardhan (30) and Polisetty(35), will indubitably establish the concept of *Dosha* as scientifically valid. First, the '*Prakriti*' concept is shown to be an empirical fact in terms of individual differences in human *physiology*. The systems approach then gives irrefutable justification for the existence of inherited *Doshas* and *subdoshas*, as named in the Ayurvedic texts. The proof's final nail is Ayugenomics, which establishes that variations between different people's '*Prakriti*' has its basis in differences in their genome i.e. Dosha function has its basis in molecular biology as systems theory implies. Ayugenomics should soon validate the relationship between *Prakriti* and biological function that Ayurveda states in the texts, and confirms from experience.

When these bodies of work are complete, they will show how individual differences in *Prakriti* originate in fundamental systems functions shared by all forms of life, and are implemented by genes responsible for relevant cellular functions: there will be no scope for doubt about the validity of the *Tridosha* description of physiological function, nor for doubt about its scientific basis.

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REFERENCES

1. Maharishi Mahesh Yogi. Science of Being and Art of Living. MUM Press, 2004.
2. Maharishi Mahesh Yogi. On the Bhagavad Gita: a new translation and commentary. Penguin, 1967.
3. Sharma H, Clark C. Contemporary Ayurveda. Philadelphia: Churchill Livingstone. 1998.
4. http://en.wikipedia.org/wiki/Ayurveda# History
5. Valiathan M.S. The Legacy of Caraka, Orient Longman, 2003.
6. Schneider RH, Kavanaugh KL, Kasture HS, Rothenburg S, Averbach R, Robinson D, Wallace RK. Health promotion with a traditional system of natural health care: Maharishi Ayur-Veda. Journal of Social Behavior and Personality, 1990, 5, 3: 1-27.
7. Schneider RH, Alexander CN, Wallace RK. In search of an optimal behavioral treatment for hypertension: a review and focus on Transcendental Meditation. From Johnson EH, Gentry WD, & Julius S. (eds), Personality, Elevated Blood Pressure, & Essential Hypertension, 1992, 291-312. Hemishere Publishing Corp, Washington DC.
8. Schneider RH, Staggers F, Alexander CN, Shepard W, Rainforth M, Kondwani K, Smith S, King CG. A randomised controlled trial of stress reduction for hypertension in older African Americans. Hypertension, 1995, 26: 820-827.
9. Sharma HM. et al/ Pharmacol. Biochem. Behav. 1990; 35: 767-773.
10. Sharma HM. et al/ Jour. Res. Edu Ind. Med. 1991; 10: 1-8.
11. Sharma HM. Freedom from Disease. Publishing. 1993.
12. Niwa Y. Effect of Maharishi 4 [MAK-4] and Maharishi 5 [MAK-5] on Inflammatory Mediators With special Reference to Their Free Radical Scavenging Effect. Indian Journal of Clinical Practice, 1991, 1, 8: 23-27.
13. Bodeker G. Second World Ayurveda Congress Symposium on Globalisation and Traditional Medicine. Pune, 2006
14. Bodeker GC & Patwardhan B, Ayurvedic Genomics: Establishing a Genetic Basis for Mind-Body Typologies, J Altern Complement Med 2008; 14: 571-576.
15. House of Lords Select Committee on Science and Technology. Complementary and Alternative Medicine. 2000. Session 1999-2000 6th Report. The Stationary Office Ltd., London. ISBN 0 10 483 100 6 Order from: The Stationary Office, P.O. Box 29, Norwich NR3 1GN, UK [also available at http://www.ukstate.com]
16. McIntyre MA, The House of Lords Select Committee's Report on CAM. J Altern Complement Med 2001; 7: 9-11.
17. Janssen G. Maharishi Ayur-Ved in the treatment of ten common chronic disorders -- a pilot study. Nederlands Tijdschrift voor Integrale Geneeskunde, 1989, 5: 586-594.
18. Herron RE, Schneider RH, Mandarino GV, Alexander CN, Walton KG. Cost-effective hypertension management: comparison of drug therapies with an alternative program. American Journal of Managed Care, 1996, 2: 427-437.
19. Alexander CN, Schneider RH, Staggers F, Shepard W, Clayborne BM, Rainforth M, Salerno J, Kondwani K, Smith S, Walton KG, Egon G. Trial of stress reduction in older African Americans II -- Sex and risk subgroup analysis, Hypertension, 1996, 28: 228-237.
20. Maharishi Ayur-Ved: Summary of Research Findings. 1998, Maharishi Ayur-Ved Products International Inc. P.O. Box 49667, Colorado Springs CO 80949.

21.Hankey A, Ayurvedic physiology and etiology: Ayurvedo Amritanam. The doshas and their functioning in terms of contemporary biology and physical chemistry. J Altern Complement Med 2001; 7: 388-396.
22. Hankey A. CAM can stimulate advances in theoretical biology. Evid. Based Comp. Alternative Med. (eCAM) 2005; 2: 5-12.
23.Holgate S. Private communication, 1999.
24.Hankey A. Response to the Call for Evidence on behalf of Maharishi Ayurveda. Submitted to the Lord Walton's House of Lords Subcommittee, 1999.
25.Hankey A. The Ayurvedic Doshas and Subdoshas and modern biological sciences. Maharishi University of Management Seminar, 5 May 1993.
26.Hankey A. Response to the Call for Evidence on behalf of Maharishi Ayurveda. Submitted to the Lord Walton's House of Lords Subcommittee, 1999.
25.Hankey A. The Ayurvedic Doshas and Subdoshas and modern biological sciences. Maharishi University of Management Seminar, 5 May 1993.
26.Hankey A. The scientific value of Ayurveda. J Altern Complement Med.2005; 11, 221 - 225.
27. Hankey A. A test of the systems theory underlying the scientific theory of Ayurveda's Tridosha. J Alterns Complement Med. 2005; 12, 385 - 390.
28.Mashelkar R.A. Building a Golden Triangle between Traditional Medicine, Modern Medicine and Modern Science. http://www.csir.res.in/external/heads/aboutcsir/leaders%5Cdirector-general.htm.
29.Joshi R. A Biostatistical approach to Ayurveda: quantifying the Tridosha. J Altern Comp Med 2004; 10: 879-889.
30.Patwardhan Bh. Joshi K. Chopra A.. Classification of human population based on Ayurvedic concept of Prakriti. J Altern. Complement. Med. 2005; 11: 349-353.
31. Prasher B, Negi S, Aggarwal S, Mandal AK, Sethi TP, Deshmukh SR, Purohit SG, Sengupta S, Khanna S, Mohammad F, Garg G, Brahmachari SK; Indian Genome Variation Consortium, Mukerji M. Whole genome expression and biochemical correlates of extreme constitutional types defined in Ayurveda. J Transl Med. 2008 Sep 9;6:48.
32.Polisetty R. Lecture to IAD Conference, Kasaragod, Kerala, February 2008.
33.Jonassen DH, Grabowski BK. Handbook of individual differences, learning and instruction. New Jersey, Erlbaum. 1993.
34.Eysenck HJ. Fact and Fiction in Psychology. Penguin, London, 1965.
35.Ghodke Y. Joshi K. Patwardhan B. Traditional Medicine to Modern Pharmacogenomics: Ayurveda *Prakriti* Type and CYP2C10 Polymorphism Associated with the Metabolic Variability. Accepted by Evid. Based Comp. Altern. Med. (eCAM) 2009; 6:
36. Sharma R.K. Das B. (trs.) Charaka Samhita Vols. 1-5. Chowkambha Sanskrit Series Office, Varanasi, India: 2006.
37. Bhishgratna K.L. (Trans.) Sushruta Samhita Vols. 1-3. Chowkambha Sanskrit Series Office, Varanasi, India: 1963.

APPENDIX: MEMBRANE POTENTIALS AND *PRAKRITIS*

Recently, Professor Ravishankar Polisetty, an Indian Cardiac Surgeon working at the University of Moscow, has announced his discovery of a new aspect of *Tridosha* (33): *Dosha* dependent resting membrane potentials in certain cell types. According to Polisetty, mean resting potentials are lower in *Vata Prakriti* types, higher in *Kapha Prakriti* types, and normal 96 mV in *Pitta Prakritis*. Cellular discharge occurs when cells' resting membrane potential decreases to 65 mV or so, so this means that discharges are more common in *Vata Prakritis*, and less so in *Kapha Prakritis*.

So, so this means that discharges are more common in *Vata Prakritis*, and less so in *Kapha Prakritis*.

In *Vata*, normal cellular function would thus entail more membrane transport processes, and incur more energy expenditure. The opposite would be true of *Kapha*. This might account for why *Vata* tend to be thinner, and more highly strung, while *Kapha* tend to be more heavily set, and more placid. Comparative learning abilities are also explained, since *Vata* would have more active neural nets, and *Kapha* less active ones. Similar remarks would apply to tendencies to anxiety, emotionality, obsessive/compulsive behavior, etc.

Polisetty's discovery is potentially of supreme significance to Ayurveda, since:

(1) it offers possible explanations for a more, apparently unrelated material concerning *Vata, Pitta* and *Kapha*, particularly that *Vata* is strongly coupled to membrane transport processes,

(2) it suggests how to look for specific genes, which will co-vary strongly with *Dosha Prakritis*, and (3) it would further confirm that *Vata, Pitta* and *Kapha* are valid concepts, from yet another perspective..