

# If systems approach is the way forward, what can the ayurvedic theory of *tridosha* teach us?

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*With a shift in focus from genes to cells, systems approach is not only revolutionizing cell biology, but is also providing impetus for clinical medicine to shift from a reductionistic to a holistic approach for efficient disease management. This inevitably brings into focus one of the longest unbroken healthcare systems in the world, namely ayurveda, the medical system indigenous to Indian subcontinent. A distinctive feature of ayurveda is its systems approach to health and disease. Through the theoretical framework of vata, pitta and kapha, ayurveda offers a new paradigm for understanding the human system as a networked functional entity wherein system properties are integral components. An open-minded dialogue between the cell-centric systems biology and organism-centric ayurveda can open new exciting vistas for research beneficial to both sciences, which could leave a major imprint on clinical practice.*

**Keywords:** Ayurveda, *kapha*, *pitta*, systems approach, *tridosha*, *vata*.

It is now widely acknowledged that systems biology holds great promise for the future of healthcare and clinical medicine<sup>1</sup>. Data from the ‘omics’ technologies is re-defining the understanding of cell as a system rather than as sum of its components. This has not only revolutionized the emerging field of systems biology but has also fuelled growing interest in applying systems theory to clinical medicine<sup>2-5</sup>. As these advances continue to broaden our understanding of human complexity and provide methodologies for patient-centric systems approach, it is pertinent to have a relook at the Indian medical system of ayurveda known to have an integrated approach to health and disease. The answer to how ayurveda deals with human complexity lies in its theoretical underpinnings.

Ayurveda has perhaps the longest unbroken health tradition in the world and for long been the major healthcare system in Indian subcontinent<sup>6</sup>. The principles and methodologies of Indian schools of thought such as *Sāṅkhya*, *Nyāya*, *Vaiśeṣika* and *Mīmāṃsā* applied to the vast empirical data collected and documented over centuries have resulted in the unique theoretical framework of ayurveda<sup>7-9</sup>. Despite such conceptual development, very little is understood of the science underlying ayurveda, especially in the context of contemporary science. That it has a theoretical framework, is even less known and appreciated.

There are many nuances and essentials in the foundations of the knowledge embodied in ayurveda. However,

this article focuses on *tridosha* (*vata*, *pitta* and *kapha*), the concept which not only runs as an undercurrent to the ayurvedic understanding of health and disease but also is the basis of clinical approaches in ayurveda. The explanation sheds contemporary light on the theory of *tridosha* and its relevance in systems medicine that ayurveda is. Though theoretical interpretations of *tridosha* have been put forth<sup>10-12</sup>, the one presented here is unique since it is based on information from classical ayurvedic texts reflecting the clinical use of *tridosha*. The explanation given has not been reported till date and more importantly does not digress from the essentials of ayurvedic principles. At the same time, contemporary terminologies have been used, creating space for new paradigms.

## Functional perspective of ayurveda

Ayurveda views the human system from a predominantly functional standpoint, for which it has identified three key functions namely, movement, metabolic transformation, and growth and support. These are referred to respectively as *Vata* (V), *Pitta* (P) and *Kapha* (K) in Sanskrit, the language of ayurveda<sup>13,14</sup>. The functions associated with V, P and K exist at all levels of biological organization. For example, movement exists at the level of cell (e.g. cell motility), organ (pumping of heart), entire system (walking), and also mind (movement of thoughts).

Although ayurveda also has a tissue [*dhatu* – *rasa* (extra- and intracellular fluids), *rakta* (blood), *mamsa* (muscle), *medas* (fat), *asthi* (bone), *majja* (bone-marrow), *shukra* (reproductive fluids)]-based perspective, the functional concept of VPK is at the very core of ayurveda’s

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approach to health and ill-health<sup>13,14</sup>. Being the endpoint of underlying complex processes, these functions are emergent properties of several contributing factors and are irreducible. Implicit in ayurveda's functional viewpoint, therefore, is absence of hierarchy. This is in contrast to the conventional stance of modern biology and medicine, which is based on structural hierarchy that has atom as the fundamental component and entire organism at the highest level, with the intermediary levels comprising of cells, organelles, tissues, organs, etc.

### What are we referring to when we talk about V, P and K?

In addition to functions, ayurveda mentions ten pairs of opposing properties, i.e. twenty factors (*Vimśati guna*)<sup>15</sup>: (1,2) heavy (*guru*) and light (*laghu*); (3,4) cold (*sheeta*) and hot (*ushna*); (5,6) oiliness (*snigdha*), dryness (*ruksha*); (7,8) slow/dull (*manda*), sharp (*tikshna*); (9,10) immobility (*sthira*), mobility (*sara*); (11,12) soft (*mrudu*), hard (*kathina*); (13,14) adhesive/sticky (*pichchila*), non-slimy/non-adhesive (*vishada*); (15,16) smooth (*shlakshna*), rough (*khara*); (17,18) minuteness (*sukshma*), gross (*sthula*); (19,20) viscosity (*sandra*), diffusivity/fluidity (*drava*). These properties at the opposite ends of a continuum are inherent to material bodies and used in ayurveda to understand the human system. These properties refer not only to the bio-physical properties of substances but also their effect on the body. For instance, heavy substances are difficult to digest and hot materials produce heat in the body.

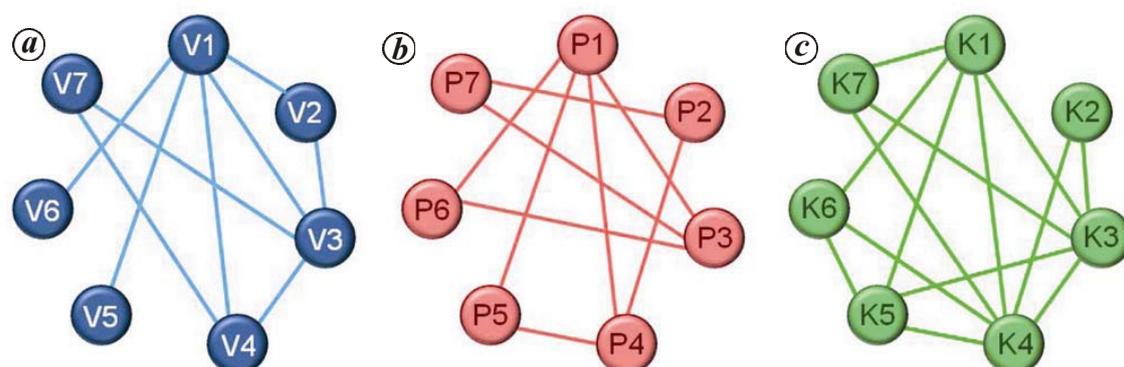
Some of the above mentioned properties, which impact the core functions associated with V, P and K define *tridosha*: V by V1–V7, P by P1–P7 and K by K1–K7 (see legend of Figure 1 for the list of parameters). *Dosha* are defined by their *guna* (property). For instance, the classi-

cal ayurvedic text of *Caraka Samhita*, while defining *tridosha*, mentions seven properties each for V and P, and eight properties for K<sup>16</sup>. In order to focus on bio-physical and physico-chemical properties, the 8th property of taste (sweet) in K has not been included in the list. These properties are part of the *vimśati guna* mentioned in the previous paragraph. Parameters like dryness (V1) and weight (V4) influence movement (V), whereas physiological factors like temperature (P1) and pH (P4) have predominant influence on metabolism (P). K on the other hand, includes properties like viscosity (K4) and adhesion (K7), which are associated with stability. Without undermining the actual meaning of ayurvedic terminologies<sup>15,16</sup>, carefully curated list of synonyms has been used, e.g. pH for acidity, adhesion for stickiness, lubrication for oiliness, etc.

The parameters under the same category (cofactors), namely, V1–V7 in V, P1–P7 in P, and K1–K7 in K influence the function associated with the corresponding group. Majority of the factors in VPK occur in pairs – some opposing and some enhancing. For instance, cold in V (V2) and K (K5) augment each other, whereas dryness in V (V1) and oiliness in K (K3) are mutually contradictory. Many of the properties under V and K are diametrically opposite, yet they co-exist and carry out their functions.

### Clinical relevance of the properties associated with V, P and K

Although the association between temperature, pH and metabolism is well known<sup>17</sup>, no precedent exists in modern biology or medicine for using properties like dryness and viscosity to describe physiological functions. Nevertheless, these parameters are well studied for their association with non-physiological functions in other subject



**Figure 1.** Functional modules of (a) *Vata*, (b) *Pitta* and (c) *Kapha* represented as networks. The circles correspond to nodes representing system properties and the lines between nodes to links indicating association between properties. V1, Dryness; V2, Temperature (cold); V3, Mobility; V4, Weight (light); V5, Roughness; V6, Non-adhesive; V7, Minuteness; P1, Temperature (heat); P2, Penetrative power; P3, Fluidity; P4, pH; P5, Acrid; P6, Causing movement; P7, Lubrication (mild); K1, Stability; K2, Smoothness; K3, Lubrication; K4, Viscosity; K5, Temperature (cold); K6, Weight (heavy); K7, Adhesion.

areas. For example, dryness plays a dominant role in surface friction, an important characteristic affecting movement and discussed in great detail in subjects such as fluid dynamics and engineering mechanics<sup>18</sup>. Friction is an universally influencing factor affecting motion of objects in contact, be it in mechanical or biological systems. In the latter, all movements in an organism from subtle (cellular movement) to gross (walking) are also influenced by friction, which in turn is affected by dryness. For example, friction between two joints will affect movement. This indicates the relevance of dryness in biology. Interestingly, many of these properties such as dryness, viscosity and adhesion used in ayurveda are increasingly being studied for their physiological roles and clinical relevance<sup>19–30</sup>.

Just as the functions associated with VPK, these parameters (V1–V7, P1–P7, K1–K7) also exist at all levels of biological organization. For example, dryness is present from cell up to the level of organism. Dryness at cellular level causes changes in cell motility, shape, adhesion, and osmosis, all of which have physiological and clinical implications<sup>20–24</sup>. Recent studies have shown that change in cell shape is associated with malignant transformation of normal cells<sup>24</sup>. Pathologic dryness at system level is referred as ‘medical dryness’ in conventional medicine, e.g. keratoconjunctivitis sicca, xerostomia, atrophic vaginitis and xeroderma<sup>25–29</sup>. For instance, Ozturk *et al.*<sup>29</sup> have reported dryness as a causative factor for increased oral mucosal friction resulting in chronic cough. Other parameters such as lubrication (K3) and viscosity (K4) also have clinical implications. As working examples, consider the following: viscosity of cellular cytoplasm acting on the hydrodynamic forces and affecting macromolecular as well as cellular motion leading to functional changes; viscosity of blood affecting bloodflow; viscoelasticity of synovial fluid in joints influencing movement at the system level<sup>19,20,30</sup>.

### System properties associated with V, P and K as biomarkers

The parameters defined by VPK impact functions at various levels and can be considered biomarkers for system properties, which are not only physiologically relevant but are also tangible parameters<sup>31</sup>. The same properties which play a role in health cause diseases when they become pathological. Although several underlying complex processes are responsible for the functions and properties<sup>32</sup>, the framework of VPK allows describing these without focusing on the individual components involved in the processes. This perspective of VPK provides a seamless view of functional endpoints and system properties across different levels of organization and offers a broader scope to understand health and disease.

### Network of V, P and K

Ayurveda perceives the human system as a network of V, P and K. The discussion on VPK in *Ashtānga Sangraha*, one of the classical text in ayurveda, explains how V undergoes increase when K is decreased and *vice versa*<sup>33</sup>. It goes on to discuss instances when V is increased due to a decrease in P and reduced K due to an increase in P. There is also detailed explanation about the individual behaviour of V, P and K when each of them is in normal state. It is pointed out that variations in V, P and K refer to changes in the parameters associated with them. The interdependency of V, P and K can also be inferred from treatment strategies<sup>33</sup>. For example, management of increased V (e.g. osteoarthritis) includes medicines which decrease dryness (V1) and increase lubrication (K3). Interventions for increased P will include medicines with bitter ingredients, which will decrease both P and K and increase V. On the other hand, treatment for aggravated K will include dryness inducing drugs, which will cause increase in V.

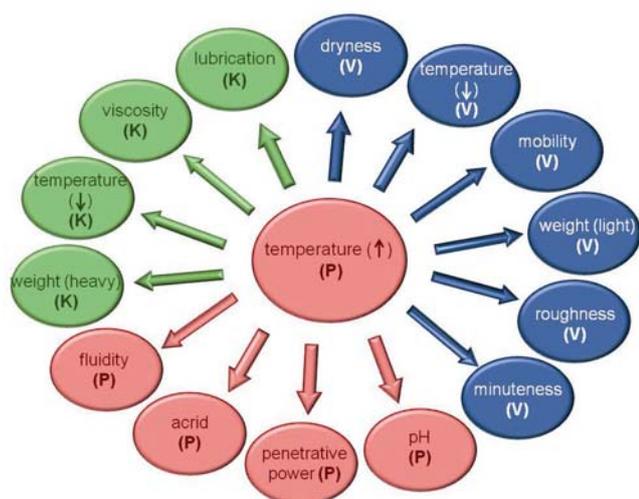
#### *Intraconnections within V, P and K*

V, P and K can each be considered as modules with functional endpoints. For example, movement is the functional endpoint of V. The parameters (V1–V7) impacting movement form components of the module and are intra-connected. In graph theory, associations are represented as networks, where parameters are denoted by nodes and connections by links or edges<sup>34</sup>. V, P and K can also be represented as networks of nodes and edges (Figure 1 a–c). The nodes are represented by system properties indicated by circles in the figures. It is seen that there are some nodes with more links (edges) than the rest. Such a topology is considered a partially connected mesh network and the number of edges incident on a node is known as degree ( $\nu$ ). The node with the highest degree is considered to play a pivotal role in the network<sup>34</sup>. Extrapolating this to the modules of VPK (Figure 1), V1 ( $\nu = 5$ ), P1 ( $\nu = 4$ ) and K4 ( $\nu = 6$ ), the nodes with maximum links should have pivotal roles in their respective modules. In fact, ayurveda also assigns significant roles for V1 (dryness), P1 (increased temperature) and K4 (viscosity) in V, P and K, respectively<sup>13,16</sup>.

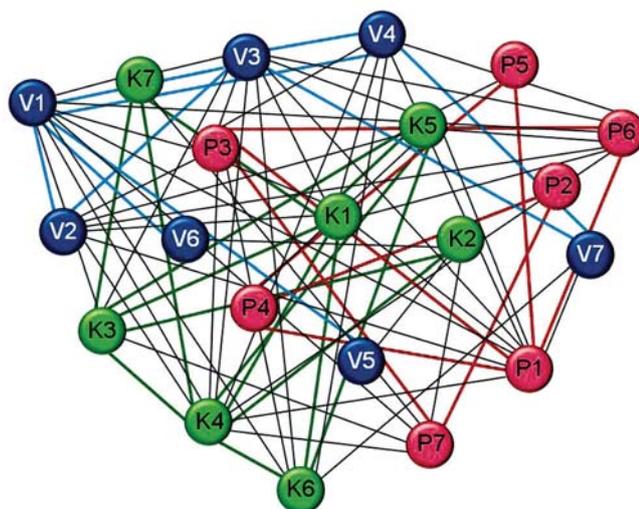
#### *Interconnections between V, P and K*

The ten pairs of parameters, which are two ends of a continuum, have built-in association within a pair. Since these properties are also distributed among *tridosha*, VPK are not independent modules but interconnected forming a larger network. Figure 2 illustrates with the example of P1 (increased temperature), the intra- and interconnections within and between V, P and K. The diagram

shows how P1 is intraconnected with its cofactors in P and interconnected with those of V and K. An increase in temperature (P1) therefore, is likely to effect changes in several other associated parameters. Figure 3 shows all the intra- and inter-connections between the various parameters of V, P and K. The information documented in ayurveda has been used to construct this network, define its components and their linkages<sup>15,16,33</sup>. It is interesting to note the similarity of the network shown in Figure 3 to the ones in systems biology<sup>2</sup>.



**Figure 2.** An illustrative example of intra- and inter-connections between parameters of *Vata* (V), *Pitta* (P) and *Kapha* (K). The associations between a factor of P (temperature) with its co-factors, and those of V and K are shown. (↑, Increase; ↓, Decrease).



**Figure 3.** Topology of the connections between the various system properties associated with *Vata* (V), *Pitta* (P) and *Kapha* (K). Parameters (indicated by circles) of V (V1–V7), P (P1–P7) and K (K1–K7) are coloured differently. The associations between cofactors (intraconnections) are shown in thicker lines with the colour of the corresponding category. The interconnections are shown by dark grey lines. Refer to caption of Figure 1 for the description of V1–V7, P1–P7 and K1–K7.

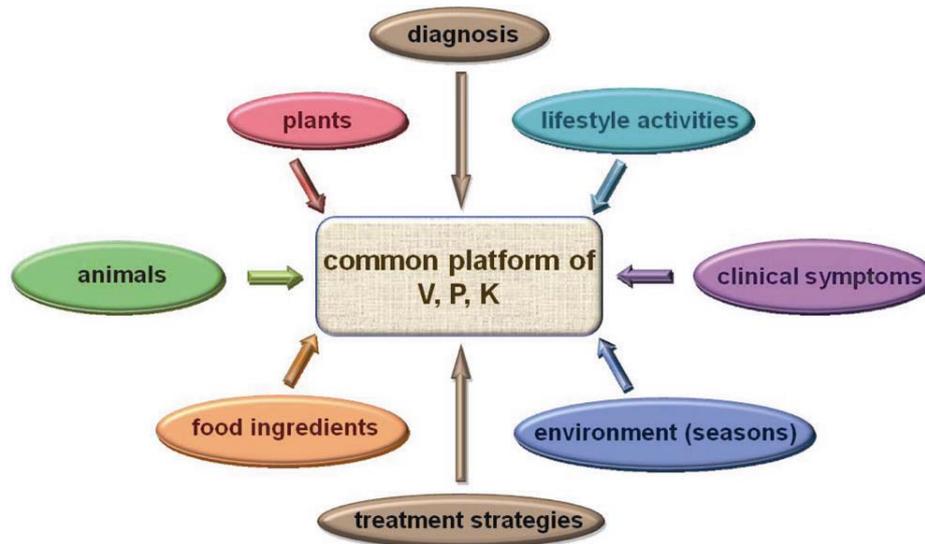
The associations shown in Figure 3 have also been corroborated further: (i) using information from current scientific studies, e.g. correlation between dryness and mobility<sup>18,21,27,28</sup>, temperature and viscosity<sup>35</sup>, pH and temperature<sup>36</sup>, dryness and viscoelastic properties<sup>37</sup>; (ii) using analogical reasoning – e.g. correlation between heaviness and stability, weight and mobility, lightness and fluidity, mobility and fluidity. Many of the parameters (nodes) in the network are connected to more than one factor (node) as in a scale-free network<sup>34,38</sup>.

With majority of the factors having multiple connections, the essential feature of this network of VPK (Figure 3) is non-linear interdependency. For instance, consider a change in dryness (V1), which could occur at any level of organization. An increase in dryness will affect lubrication (K3) and fluidity (P3), which in turn will affect other interconnected parameters. At the same time, change in V1 will also affect its cofactors such as weight (V4) and roughness (V5). In a nutshell, an alteration in V1 will cause changes in P1, P3, P6, P7, K3, K4, K5, K6 and K7, and its cofactors V2, V3, V4, V5 and V6. These changes will lead to disturbances both at the level where dryness had initially increased and at other interacting planes. Variation in one level will have a downward or upward effect over the course of physiological events in other levels, leading to a cascade of changes. The effect of a single parametrical change does not therefore remain isolated, but spreads through the network causing multiple changes, some gross and some subtle.

This can be explained further with an example. Liver disease is often associated with other symptoms like portal hypertension, increased blood pressure and dryness, characterized by dry skin, lower rate of salivation, dry eyes, etc.<sup>39–41</sup>. From the stance of ayurveda, if the liver disease is caused by *vata*, there would also be systemic increase in dryness (V1) resulting in dry skin, lower rate of salivation and dry eyes (all observed in liver disease). In addition, there will also be other symptoms due to changes in the P and K factors interconnected with V1. For instance, by virtue of the association between V1 and P3 (fluidity), blood flow would be altered. At the same time, stiffness and narrowing would be created in arterial walls by the link between V1 with K3 (lubrication). Put together, all these changes can cause increased blood pressure, an associated clinical symptom in liver diseases. The other connections between the parameters of V, P and K will cause other associated clinical symptoms. In other words, deranged *vata* can lead to symptoms of disturbed *pitta* and *kapha* or vice versa. This is just a case in point to demonstrate how diseases and clinical symptoms can be explained in terms of V, P and K.

### Disease is a system perturbation in ayurveda

Health in ayurveda is a balanced interplay of parameters defining VPK. Key to health is maintaining the stability



**Figure 4.** *Vata* (V), *Pitta* (P) and *Kapha* (K) provide a common interface for biotic (plants and animals) and abiotic (seasons, clinical symptoms, lifestyle activities) factors, which play a role in health and disease management. By classifying them in terms of V, P and K, these factors are brought under one common denominator.

of these factors and the network<sup>42</sup>, the balance of which depends on its response to internal and external factors (biotic and abiotic). The network responds to perturbations in a complex manner that cannot be explained by considering its components in isolation. Identity of individual factors is lost in the orchestrated changes. Deviation beyond a point in any of the parameters disturbs the network, disrupts the functions and drives the system towards instability and disease state. Since disease is viewed as a system perturbation culminating in functional failure<sup>42,43</sup>, ayurvedic treatments look beyond the behaviour of individual components and attempt to rebalance the system<sup>33</sup>. This is achieved by targeting the function associated system properties. Ayurveda uses these properties and their associations to identify the functional state of an individual not only for diagnosis but also for therapeutic management<sup>33,44,45</sup>.

### Theory to clinical applications

Ayurveda has incorporated the theory of VPK in an ingenious way into its diagnosis and therapeutic management. All biotic (plants, animals, food components), abiotic (activities, seasons) and clinical (symptoms) factors having a role in disease are classified and understood in terms of V, P and K<sup>44-46</sup>. For instance, wheat (food component) increases *kapha* and hence classified under K. Exercise (activity) increases V and *pitta* increases in all biological organisms during autumn making this season P related. Examples of classification of clinical symptoms are: cough – dry cough is V related and wet cough is of K origin; skin disorders – dryness involves V, burning sensation indicates involvement of P, and a K

associated symptom is pruritus. VPK thus provides theoretical and practical frameworks within which all clinical symptoms can be classified and interpreted. No clinical symptoms lie outside the purview of this classification.

V, P and K thus offer a common platform for all factors involved in a disease (Figure 4). From a clinical stance, VPK provides an interface facilitating easy conversion of all diagnostically and therapeutically relevant parameters to a common denominator, enabling VPK-based diagnosis and treatment. Ayurvedic therapeutic strategy is therefore comprehensive, addressing all biotic and abiotic causative factors and incorporating all therapeutically relevant parameters such as medicines, diet, activities, etc. in the treatment protocol. A brief example of how the theory of VPK is translated to clinical practice is given below.

### Therapeutics targeting properties

Taking the example of osteoarthritis (OA) – OA may be interpreted as a disorder where lubrication (K3) between joints is reduced and dryness (V1) has increased. The latter affects viscosity (K4) of the lubricating fluid between joints. Conventional medicine also opines the same, albeit using different terminologies. It says that alteration of viscoelastic properties of synovial fluid is a possible causative factor for friction between joints resulting in their degeneration<sup>30</sup>. It is pertinent to note that viscoelastic property comes under the ambit of *kapha*.

According to ayurveda, there is a systemic increase in dryness (the causative factor) in OA but the clinical manifestation is through the patient's vulnerable part, i.e. the joint. The choice of treatment, therefore, would

involve such *vata*-reducing medicines, diet and lifestyle regimens that would also be appropriate for the state of K and P in each individual. The treatment for OA therefore addresses dryness, both locally and systemically. While the latter prevents the subsequent involvement of other joints and organs, local treatment with medicated oils addresses dryness and tackles the already manifested clinical symptoms. Avoiding diet and activities known to increase V form an integral part of the treatment. Ayurvedic therapeutic strategies target system properties and are not organ specific but context-dependent. Although treatment for OA in ayurveda has been validated and documented over centuries of practice, recent clinical studies have also confirmed using scientific methodologies, the efficacy of ayurvedic treatments for arthritis<sup>47,48</sup>.

## Conclusion

Clinical medicine has entered an era of systemic approach<sup>1-5</sup>. In this context, ayurveda has much to offer. Although disease management serves as a common point of interest for both conventional medicine and ayurveda, there are also fundamental differences in their approaches. While conventional medicine simplifies complexity by reductionism, ayurveda manages human complexity by systems approach using broad based theories. The conceptual framework of V, P and K offers a different perspective of health and disease. By networking system properties, ayurveda provides a new and comprehensive paradigm for managing health in an integrated manner. From a contemporary scientific viewpoint, the concept of network of system properties applicable at multiple scales in the organism offers a novel approach to understand a biological system. It provides new biomarkers for diagnosis, treatment and prevention.

A central feature of modern medicine is addressing disease at the molecular level. Ayurveda, on the other hand, understands and addresses disease at the level of organism using system properties. In this sense, ayurveda is systems biology at a higher level, in comparison to the current cellular-centric approach. All these raise interesting possibilities of dialogue between systems biology and ayurveda, adding new dimensions for understanding human complexity and variability. It can give rise to formerly unthought-of models and parameters for systems research in medicine benefiting both systems. The prospects are truly exciting.

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