

Conceptual analysis of Physiology of vision in Ayurveda

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ABSTRACT

The process by which the world outside is seen is termed as visual process or physiology of vision. There are three phases in this visual process: phase of refraction of light, phase of conversion of light energy into electrical impulse and finally peripheral and central neurophysiology. With the advent of modern instruments step by step biochemical changes occurring at each level of the visual process has been deciphered. Many investigations have emerged to track these changes and helping to diagnose the exact nature of the disease. Ayurveda has described this physiology of vision based on the functions of *vata* and *pitta*. Philosophical textbook of ayurveda, *Tarka Sangraha*, gives certain basics facts of visual process. This article discusses the second and third phase of visual process. Step by step analysis of the visual process through the spectacles of ayurveda amalgamated with the basics of philosophy from *Tarka Sangraha* has been analyzed critically to generate a concrete idea regarding the physiology and hence thereby interpret the pathology on the grounds of ayurveda based on the investigative reports.

Key words: *Ayurveda*, physiology of vision, visual process

INTRODUCTION

The series of actions that takes place during visual perception is termed as visual process. There are three phases for this process: First, phase of refraction of light; second, phase of photo-chemical reaction and; finally, neural functions of the retina and the phase of central neurophysiology. During the first phase, light rays from the outside world are focused on the retina. In the second phase, these light rays are converted into electrical impulse through some chemical reactions. During the last phase, these impulses are transmitted through the optic nerve to reach visual cortex and are then interpreted to produce the sensation of vision.

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In authoritative textbooks of *Ayurveda*, terms like *darshana* and *drik* are used to describe the visual process. It has been described as the function of two *doshas* namely *vata* and *pitta*. *Vata* is the key factor for *aksha patavam* (*aksha* means *drik*. *Patavam* means clarity)^[1] and *pitta dosha* for *darshana* (vision);^[2] specifically by *alocaka pitta* (one among the 5 types of *pitta*).^[3] This *pitta* is of two types: *Chakshur vaisheshika* and *buddhir vaisheshika*. The former one helps in visual perception and latter helps in interpretation and recollection of the memory regarding an object.^[4]

Among these two *doshas*, *vata* has an inseparable role in each and every phase of *darshana karma* and hence *timira* (blurred vision or blindness)^[5] is mentioned as a *Vataja nanatmaja vyadhi* (various *vata* disorders).^[6]

Scientific data from other sciences can be merged with *Ayurveda*, if required.^[7] In light of this, few basics of visual process described in the Indian philosophical textbook *tarka sangraha* are amalgamated at appropriate places with the *tridosha* theory to make the explanation of visual process complete.

CONCEPT OF LIGHT

Before starting to describe the visual process, it is essential to narrate the concept of light energy in *Ayurveda*. The Sanskrit term *prakash* is used to denote light.^[8] It is the function of *agni mahabhoota*.^[9] Hence, the properties of light can be explained

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on the basis of *gunas* (properties) of *agni mahabhoota*. It is *ushna* (hot), *teekshna* (penetrating) and *sookshma* (miniscule) and is the foundation stone for visual process.^[10]

CONCEPT OF BRIGHT LIGHT AND DIM LIGHT

In *tarka sangraha*, there is description of two concepts *bhasvara shukla* and *abhasvara shukla*.^[11] The term *shukla* means white.^[12] A color can be perceived as white only in the presence of light. Absence of light makes every object look black or grey. This is termed as Purkinje shift. Hence, presence of light can be indirectly called as *shukla*. The Sanskrit term *bhasvara* means shining or bright.^[13] It relates to the intensity of light. Increase in the intensity of light makes it appears as white. Hence, light of higher intensity can be termed as *bhasvara shukla* (comparable to bright light or day light) and that of lesser intensity as *abhasvara shukla* (comparable to dim light or twilight).

Bhasvara shukla darshana (vision in bright light) is accomplished by *agni and prithvi mahabhoota*.^[11] *Pitta* is composed of *agni mahabhoota*.^[14] Hence, it can be inferred that *bhasvara shukla darshana* is the function of *pitta dosha*. *Abhasvara shukla darshana* (vision in dim light) is the function of *prithvi* and *jala mahabhoota*.^[11] *Prithvi* and *jala mahabhoota* constitutes *kapha dosha*.^[14] Hence, *abhasvara shukla darshana* is the function of *kapha dosha*. *Prithvi* is the *adhara bhoota* for *kapha*.^[14] Hence, it can be concluded that *abhasvara shukla darshana* is purely *kaphaja* and *bhasvara shukla darshana* is *pitta pradhana kapha anubandha*. Vision in bright light is termed as photopic vision and in dim light as scotopic vision. Thus, photopic vision is termed as *bhasvara shukla darshana* and scotopic vision as *abhasvara shukla darshana* [Figure 1].

Hamarlophia (day blindness) and nyctalopia (night blindness)

This concept proves the cause of *hamarlophia* (day blindness) and *nyctalopia* (night blindness) in *pitta vidagdha drishti* and *kapha vidagdha drishti* respectively. When the

vitiated *pitta* reaches the third *patala* of eye, it results in *hamarlophia*. Hence, *dosha* predominance in a case of *hamarlophia* is *pitta* and *kapha* and hence the choice of treatment is *virechana*.

When *kapha* gets vitiated and reaches the third *patala* of eye, it results in *nyctalopia*. Hence, *dosha* predominance in a case of *nyctalopia* is *kapha* and hence *kapha shamana upakrama* is the choice of treatment.

FUNCTIONAL ANATOMY OF EYE

Retina is the inner most coat of the eye that transforms light energy to electrical impulse. The two photo-receptors of retina, rods and cones, convert light energy into electrical energy. The light-sensitive photo-chemicals, rhodopsin (in rods) and color pigments (in cones), are actually responsible for this bio-conversion.

SECOND PHASE OF VISUAL PROCESS

The light reaches the layer of rods and cones in the retina after passing all the layers in front of it. When it reaches retina the phase of photo-transduction begins.

Prakasha is having *sookshma guna* (minuscule property).^[15] The property that makes any substance to pass easily through different materials is termed as *sookshma*. The term *sookshma* also means minute or that which cannot be seen.^[15] In this context, the former meaning is taken into consideration. Hence this *guna* (property) of *prakasha* makes it possible to reach till the photo-receptors in retina traversing various layers in front of it.

PHOTO-TRANSDUCTION

Photo-transduction is the process of conversion of light energy into electrical energy. When light falls on retina the light sensitive photo-receptors, photo-chemicals in them undergo certain biochemical reactions to facilitate this process. It comprises of two essential reactions: photo-chemical and electrical. Discussion in this paper is focused on the photochemistry of rhodopsin, but the same principles can be applied even to the cone pigments.

Photo-chemical phase

Rhodopsin is the photo-chemical present in rods. It consists of a protein called as scotopsin and pigment retinal. This retinal is a particular type termed as 11-cis-retinal. This cis form of retinal is important because only this form can bind with scotopsin to synthesis rhodopsin.

CONCEPT OF LIGHT ENERGY IN AYURVEDA

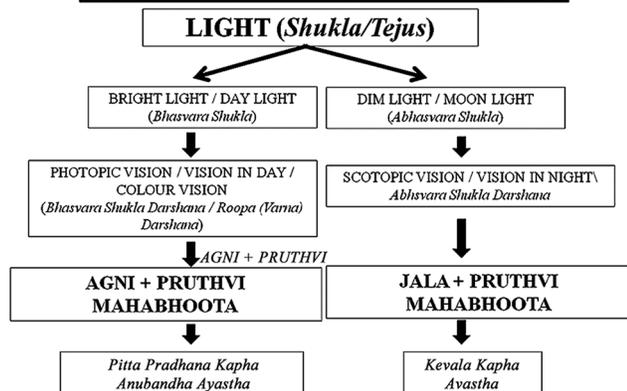


Figure 1: Concept of light energy in *Ayurveda*

When light energy falls on rods, it is absorbed and begins to decompose within fraction of a second. The cause of this is photo-activation of electrons which leads to instantaneous change of the cis form of retinal into an all-trans form. It then triggers a cascade of complex biochemical reactions in these photo-chemicals which finally ends up in separating it into scotopsin and all-trans retinal as described in Figure 2. This process of separation of the pigment from the protein part is called as photo decomposition and rhodopsin is said to be bleached by the action of light. During these reactions, metarhodopsin II, termed as photo-activated rhodopsin, when triggered causes electric potential.

After this decomposition rhodopsin is again re-formed without much delay as shown in Figure 2. The rhodopsin so formed then remains stable until its decomposition is again triggered by absorption of light energy. All-trans retinal, also by a second chemical route, gets converted into all-trans retinol, which is a form of vitamin A. This is finally converted into rhodopsin [Figure 2]. The whole process of reformation of rhodopsin by the union of dissociated pigment and protein is termed as rhodopsin regeneration.^[16-18]

Activation is termed as *prerana* or *chalana* and is done by *chala guna* of *vata*.^[19] Inactivation or loss of movement is termed as *stambhana*^[20] and is performed by *sheeta guna* of *vata*.^[21] Therefore, its opposite *chalana* is performed by *ushna guna*^[21] of *pitta*. Thus, it can be interpreted that *chala guna* of *vata* is required for any making any inanimate object move or to alter the movement of a previously moving object and *ushna guna* of *pitta* intensifies or accelerate the *chalana* (movement).

Electrons are always in a state of motion. Therefore, they are always having *chala guna* in them. When light falls on them, their intensity of motion increases and this phenomenon is said to be photo-activation, i.e. when *ushna*

guna of *prakasha* falls on them their *chalana* gets intensified. This photo-activation results in altering of cis form of retinal into trans form. This alteration of pre-existing state, of cis to trans, is done by the *chala guna* of *vata*. Hence, the *dosha* involved in the phase of photo-activation is *pitta pradhaba vata anubandha*. *Pitta* is given importance because photo-activation occurs due to *pitta*. It is only after this phase that *vata* plays its role in altering the form.

The structural unit that imparts function is termed as *dhātu*.^[22] As retina is the structural unit that imparts the function of vision, it can be considered as a *dhātu*. There are 7 *dhātu* namely *rasa, rakta, mamsa, medas, asthi, majja* and *shukra*.^[23] Retina as a whole can be explained on the basis of all these *dhātu*, based on different functions; but explanation here is limited to the *dhātu* that aid directly in the visual process, i.e. *rakta dhātu*.

The function of *rakta dhātu* is *jeevanam*.^[24] The term *jeevanam* means sustenance of function or life.^[25] A structure can perform its function only in the presence of life. It is quiet natural that loss of life will lead to total loss of function. The photo receptors situated in the retina are the primary cause for visual process. Destruction of these receptors leads to loss of vision and hence they can be considered as *rakta dhātu*. The term *rakta dhātu* here does not imply blood, but the structure that aids the functional aspect of vision.

Ranjana is the term given to the impartment of color to an object.^[26] In human body, it the *pitta, ranjaka pitta* in specific, that does the act of coloring.^[27] It is the color pigments in these photo-chemicals that result in coloring of the photo-receptors. Hence they can be considered as *ranjaka pitta*, i.e. 11-cis-retinal (in rods) and color pigments (in cones) can be compared to *ranjaka pitta*.

These pigments combine with protein counterpart resulting in the production of the photo-chemicals. *Ranjaka pitta* combines with *rasa dhātu* to impart color to it.^[27] Hence the protein part is comparable to *rasa dhātu*. In other words, scotopsin (in rods) and photopsin (in cones) is comparable to *rasa dhātu*.

Transformation or processing happening to any substance is termed as *paka*.^[28] and is done by *teekshna guna* of *pitta*.^[29] During the transformation process new bonds between the molecules are either formed or existing ones are broken. Based upon the stability of these bonds, *paka* can be of two types: *sthira paka* (permanent transformation), where the bond between the molecules are strong and hence they do not further breakup and *asthira paka* (temporary transformation), where the bond between the molecules are weak and hence can be broken. According to authoritative textbooks of *Ayurveda, rakta dhātu* is produced when *rasa*

PHOTO CHEMICAL REACTION – AYURVEDA VIEW

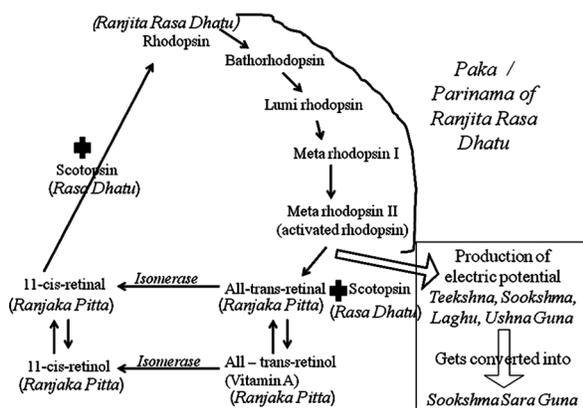


Figure 2: Photo-chemical reaction-Ayurveda view

dhātu undergoes *paka*.^[30] This is a *sthira paka* as *rakta dhātu* cannot be converted back to *rasa dhātu*.

Combination of pigment part (*ranjaka pitta*) with protein part (*rasa dhātu*) produces photo-chemical. The bond in the photo-chemical can always be broken and rejoined easily by the action of light. This implies that the bond between the protein part and the pigment is as a result of an *asthira paka*. The photo-receptors are stable and do not get converted into any other form when light falls on them. Hence, they can be aptly called as *rakta dhātu* and photo-chemicals in them as *ranjita rasa dhātu*.

When *prakasha* falls on the *rakta dhātu*, by its *teekshna guna*, *parinama* occurs to the *ranjita rasa dhātu* and not to the *rakta dhātu*. This *paka*, is the series of bio-chemical reactions occurring photo-chemicals which finally leads to separation of *ranjaka pitta* from the *rasa dhātu*. This takes out of its color. Since, they are located in the *rakta dhātu*, it appears as the loss of coloring of *rakta dhātu*. This is manifested as retinal bleaching which can be termed as *pandutra* of retina. This *paka* occurs only in the presence of *prakasha*. Later *rakta varna* is re-obtained when the separated *ranjaka pitta* and *rasa dhātu* combines together to form the *ranjita rasa dhātu*. For this regeneration to happen *prakasha* is not required, but *rasa dhātu* is a must [Figure 2].

Hence, the *dosha* involved in the *avastha* of photo bleaching is *pitta* (by virtue of presence of *prakasha* and it is *ushna*) and regeneration is *kapha* (regeneration occurs even in the absence of *prakasha* or in other words absence of *ushna* which is *sheeta*).

Blackouts in excess fasting

It is quiet observable that people who fast for a long time will get episodes of blackouts. *Ahara* (food) is converted into *rasa dhātu*, by the action of *agni*. When food is not taken, production of *rasa dhātu* is decreased. This *rasa kshaya* results in delayed photo-transduction process which results in black outs.

Vitamin A deficiency

Chronic deficiency of vitamin A in foods and drinks results in a spectrum of symptoms. Main symptoms include dryness of conjunctiva (*rookshata*), softening of cornea (*bala nasha*) and dryness of skin (*rookshata*). *Pitta* is *sasnigdha* which means of little moisture. *Rooksha* (dryness) is seen in vitamin A deficiency, which happens when there is chronic deficiency of *snigdha guna*. This *rookshata* is manifested in the form of dryness of conjunctiva and skin. *Snigdha* is the property that provides *bala* (strength) to a tissue. Since *snigdha guna* has decreased, *bala* of organ will decrease which is manifested in the form of softening of cornea. *Bala* is also the resistance of a person to diseases.

Hence chronic deficiency of *snigdha guna* will lead to immune deficiency further inviting other diseases. Hence treatment protocol in vitamin A deficiency is to provide *snigdha guna dravya*. Formulations made out of *ghrita* (ghee) would be the drug of choice as *ghrita* is *snigdha* and *bala vardhaka*.

Production of electric potential

The photo-activated rhodopsin (metarhodopsin II) stimulates some biochemical reactions by which sodium ions continue to be pumped outward through the membrane creating an electric potential. The term *savana* is used to denote flow^[29] and is done by *teekshna guna*^[29] of *pitta*. This *guna* of *prakasha* is responsible for flow of Na outside the cell membrane which leadings to generation of electric potential.

Electric energy can never be seen, i.e. it is having *sookshma guna*^[15] of *vata*. Electricity can only flow through a streamlined fashion in a unidirectional path like the flow of water from a tap. It cannot move to any other direction instantly without any provocation, like the movement of air. Therefore, electric energy can be said to have *sara guna* of *pitta* (unidirectional flow, like water) and not *chala guna* of *vata* (random movements, like air). Hence, electric energy is *sookshma-sara*. The *avastha* is *vata pradhana pitta nubandha*. *Vata* is given importance because of *sookshma guna*.

Treatment principle of *vata vyadhi* (disorders of *vata*)

The term *sara* itself means *anulomana*. Electric potential is *sookshma-sara*, i.e. it means that it is *sookshma* and *anulomana*. This explains why, the treatment principle of all the disorders of *vata* is mainly *anulomana*. Whenever there is conduction defect in the nerve fibers, leading to paresis or palsy, the conduction has to be re-established by using *anulomana* drugs. Providing *anulomana* drugs will remove any sort of obstruction if present and induce *saratva* of electric potential thereby bringing back the normal conduction in the nerve fiber which is responsible for the movement of various muscle groups.

Photo-transduction is thus conversion of *teekshna*, *sookshma* and *ushna guna* of *prakasha* into *sookshma-sara guna*. Since the light energy is transformed into electric energy it can said that *prakasha* has underwent *paka* in retina. Hence this *avastha* of photo-transduction is *pitta pradhana vata anubandha avastha* getting transformed to *vata pradhana pitta anubandha avastha*.

THIRD PHASE OF VISION

The third phase comprises of processing and transmission of visual sensation and visual perception.

PROCESSING AND TRANSMISSION OF VISUAL IMPULSE

The electrical impulse thus generated is processed in a complicated step and is then transmitted via the horizontal, amacrine and ganglion cells of retina to the optic nerve. They are then transmitted to optic chiasma, neurons of lateral geniculate body and finally to the primary visual cortex.^[16-18]

The processing of the electrical impulse can be compared with *paka*^[28] done by *teekshna guna* of *pitta*^[29] specifically by *chakshur vaisheshika pitta*. Anything can be transmitted or moved only when there is a *srotas* (channel or way). The electrical potential generated in the photo-receptors flows through the *srotas* termed as *roopa vaha dhamaani*^[31] (~ structures of visual pathway) to the visual cortex. Hence, *avastha* of processing is *paittika* and transmission is *vata pradhana pitta anubandha*.

IMAGE FORMATION – FUNCTION OF MANAS AND BUDDHI

The electrical impulses from both eyes need to be interpreted together in the visual cortex for visual perception. When an *indriyarth* (sense object) comes in contact with its *indriya* (sense organ), knowledge regarding the object termed as *pratyaksha jnanam* (sense of perception) occurs^[32] in the presence of *manas* (mind).^[33] The *pratyaksha jnanam* regarding an object comprises its *lakshana* (characteristics), *samsthana* (shape and size) and *varna* (color).

When an object is seen for the first time *chakshur vaisheshika pitta* captures this information regarding the object is interpreted and stored into memory with the help of *buddhir vaisheshika pitta*.^[4] Next time when a person sees an object of same *pratyaksha jnana* by the action of *chakshur vaisheshika pitta*, *buddhir vaisheshika pitta* helps in recollection and proper identification of the object. Hence *buddhir vaisheshika pitta* has the role of interpretation of the sense of visual perception, memorizing it and its recollection while *chakshur vaisheshika pitta* has always only one role: sense of visual perception.

According to *tarka sangraha*, *pratyaksha jnanam* obtained can be classified into two: *savikalpaka jnanam* (definitive perception) and *nirvikalpaka jnanam* (non-definitive perception).^[32]

Visual perception of every object in this world has two phases: Perception for the first time, where the *pratyaksha guna* (*lakshana*, *samsthana* and *varna*) of an object is perceived but has not been attributed any identity; and perception for the next time, where the *pratyaksha guna* is attributed an identity. The first phase where, objects are perceived without providing an identity is termed as *nirvikalpaka jnanam* (*Nir* means without and *vikalpa* means differentiation). The same object, when attributed an identity and is perceived for the next time, becomes *savikalpaka jnana* (*sa* means with and *vikalpa* means differentiation).^[32]

A person sees three different red large fruits for the first time; hence cannot differentiate them from one another. This knowledge of the objects without differentiation is termed as *nirvikalpaka jnanam*. Later he adds adjectives to the *pratyaksha guna* of the individual fruits for making its identification. Next time when he sees these three fruits, he will be able to differentiate them from one another by memorizing the previously interpreted individual adjectives. This knowledge of differential interpretation is termed as *savikalpaka jnanam*. This differentiation of adjectives of objects which resemble similar in *pratyaksha guna* is the function of *buddhi* which is maintained by *prana vata* and *pitta*.^[34,35]

Thus, *pratyaksha jnanam* is the function of *prana vayu* and *pitta*. It is four types: Form sense, color sense, contrast sense and light sense.

The form sense

This sense is the faculty that enables us to discriminate between the *lakshana* (characteristic), *samsthana* (size) and *akruti* (shape) of different objects. This is termed as visual acuity. The same is termed as *aksha patana* (clarity of vision) in authoritative textbooks of *Ayurveda*. Cones are responsible for acuity of vision.

The color sense

It is the ability of eye to discriminate between different colors. *Roopa* or *varna* is the term given for color.^[36] It is a property which can only be perceived by the eyes,^[11] i.e. color sense can be perceived only through eyes. It is the function of *prithvi* and *agni mahabhoota*.^[11] As mentioned earlier, color of an object can be appreciated only in *bhasvara shukla*. Hence, *avastha* during color vision is *pitta pradhana kapha anubandha*. Based on the intensity of combination of these *mahabhootas* seven types of colors are recognized: *Shukla* (white), *Rakta* (red), *Harita* (green), *Neela* (blue), *Peeta* (yellow), *Kapisha* (brown) and *Chitra* (colorful).^[11]

Analysis of color sense begins from the eyes (specifically in the cones) and is not entirely a function of *buddhi*. There exist three kinds of cones, each containing a different photo pigment, which is maximally sensitive to one of the three primary colors viz., *Rakta* (red), *Harita* (green) and *Neela* (blue). This is termed as the trichromatic theory of color vision also called as Young-Helmholtz theory. The signals from these receptor levels are recorded into the opponent process form, appropriately computed at higher levels of neural system of color vision processing and creates the sensation of color.^[16-18] Hence, *chakshur vaisheshika pitta*, with reference to color sense, works at the level of cones to capture the three basic colors and *buddhir vaisheshika pitta* computes these signals into the rest four. Hence *paka* by *chakshur vaisheshika pitta* is comparable to the trichromatic theory and by *buddhir vaisheshika pitta* to the opponent theory of Hering.

The contrast sense

It is the ability of eye to perceive slight changes in the luminance between regions which are not separated by definite borders. Luminance is the intensity of light per unit surface area.

The term *roopa* can also be used to denote the sense of contrast. Increase in luminance will lead to whitening while decrease leads to blackening of objects. Thus, increased luminance is comparable to *shukla varna* (white color) and decreased one to *krishna varna* (black color). *Krishna varna* is the mere absence of *shukla* (whiteness). Hence *shukla varna* can be considered as luminance or sense of contrast which is one among the seven *roopa*. This is again the function of cones.

Hence, it can be concluded that interpretation of signals from the cones, by the action of *prana vata* and *pitta*, is the root cause for the form sense (*aksha patava*), color sense (*roopa* or *varna*) and contrast sense (*roopa* or *varna*).

The light sense

It is the sense of awareness of light. This faculty permits us to perceive light, but does not give finer details. This type of sense usually occurs during twilight or in the area of field beyond the central 10° of vision (which is the macular area). Thus rods are the ones which are responsible for the light sense. There are two aspects for light sense: Dark adaptation and light adaptation.

Dark adaptation

It is the ability of eyes to adapt itself to decreasing illumination. When a person moves from *bhasvara shukla*

to *abhasvara shukla* place, he cannot perceive the objects around him until sometime has elapsed termed as “dark adaptation time.” This is because the low threshold light sensitive pigments are fully transformed into their respective components in bright light. It takes a few minutes to regenerate these bleached pigments. As already mentioned *bhasvara shukla* is function of *agni mahabhoota* while *abhasvara shukla* is that of *jala*. *Jala* being *sandra* (dense) takes a little time to appear replacing the *tejo mahabhoota*. Hence, the time for dark adaptation is a little more.

Light adaptation

When one passes suddenly from a dim to a brightly illuminated room light seems to be intense and even uncomfortable until it gets adapted. This is termed as light adaptation. This is because the low threshold light sensitive pigment rhodopsin is formed in excess to perform the vision in dark. When subjected to bright light, these pigments take a little time to decompose and adjust to the high intensity. *Agni* is *laghu* (light in mass) and *teekshna* and hence conversion of *jala mahabhoota* into *agni mahabhoota* takes place at a faster pace. Hence, light adaptation is faster than dark adaptation.

CONCLUSION

The entire visual process has been described in *Ayurveda* on the basis of *vata* and *pitta*. By the advancement in modern technology biochemical changes happening in each and every phase of the visual process has been deciphered. An elaborate interpretation of modern physiology through the spectacles of *Ayurveda* as summarized in Figure 3 will give

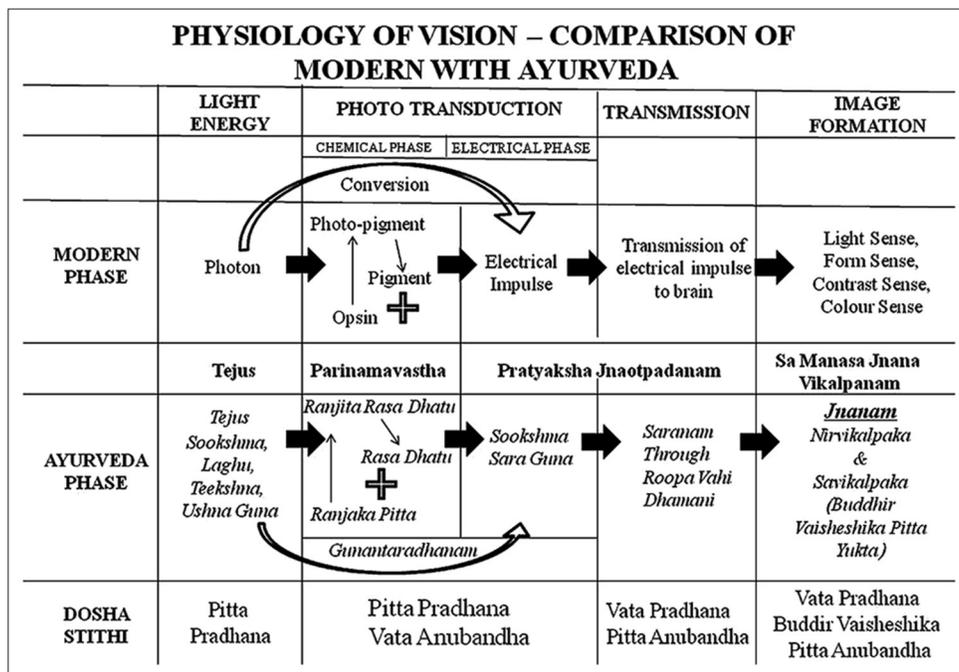


Figure 3: Physiology of vision-comparison of modern with *Ayurveda*

a better and clearer analysis of various phases of vision which will help to provide a better understanding of the pathologies in relation to these phases.

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REFERENCES

1. Sadashiva HS, editor. Astanga Hrudaya of Vagbhata, Sootra Sthana; Doshadi Vijnaneeyam. 1st ed. Ch. 11. Verse 1-2. Varanasi: Chaukhambha Sanskrit Sansthan; 2011. p. 182.
2. Sadashiva HS, editor. Astanga Hrudaya of Vagbhata, Sootra Sthana; Doshadi Vijnaneeyam. 1st ed., Ch. 11. Verse 2. Varanasi: Chaukhambha Sanskrit Sansthan; 2011. p. 182.
3. Sadashiva HS, editor. Astanga Hrudaya of Vagbhata, Sootra Sthana; Doshabhedeyam. 1st ed., Ch. 12. Verse 13-14. Varanasi: Chaukhambha Sanskrit Sansthan; 2011. p. 194.
4. Srinivasa R, editor. Bhela samhita of Bhela, Sarira Sthana; Purusha Nicayam Shareeram. 1st ed., Ch. 4. Verse 4-5. Varanasi: Choukhambha Krishnadas Academy; 2010. p. 133.
5. Monier Williams M A, Sanskrit English Dictionary. Timira. 1st ed. Reprint. New Delhi: Motilal Banarasidass Publishers; 2007. p. 447.
6. Shivaprasad S, editor. Astanga Samgraha of Vagbhata, Sootra Sthana; Dosha Bhedeeyam. 3rd ed. Ch. 20. Verse 25. Varanasi: Choukhambha Sanskrit Series Office; 2012. p. 158.
7. Trikamji J, Ram N, editors. Susruta Samhita of Susruta, Sootra Sthana; Prabhashaneeyam Adhyayam. 1st ed., Ch. 4. Verse 6. Varanasi: Chaukhambha Sanskrit Sansthan; 2010. p. 18.
8. Monier Williams M. A Sanskrit English Dictionary. Prakasha. 1st ed. Reprint. New Delhi: Motilal Banarasidass Publishers; 2007. p. 653.
9. Trikamji J, Ram N, editors. Susruta Samhita of Susruta, Sootra Sthana; Dravya Visheshha Vijnaneeyam. 1st ed., Ch. 41. Verse 3. Varanasi: Chaukhambha Sanskrit Sansthan; 2010. p. 181.
10. Sadashiva HS, editor. Astanga Hrudaya of Vagbhata, Sootra Sthana; Dravyadi Vijnaneeyam. 1st ed., Ch. 9. Verse 7. Varanasi: Chaukhambha Sanskrit Sansthan; 2011. p. 166.
11. Virupakshananda. Tarka sangraha, Characteristic Mark of Qualities. 2nd ed. Sect. III, Verse 1. Chennai: Sri Ramakishna Math; 2004. p. 54.
12. Monier Williams M A Sanskrit English Dictionary. Shukla. 1st ed. Reprint. New Delhi: Motilal Banarasidass Publishers; 2007. p. 1080.
13. Monier Williams M A Sanskrit English Dictionary. Bhasvara. 1st ed. Reprint. New Delhi: Motilal Banarasidass Publishers; 2007. p. 756.
14. Sharma S, editor. Astanga Sangraha of Vagbhata, Sootra Sthana; Doshabhedeyam. 3rd ed. Ch. 20. Verse 2. Varanasi: Chaukhambha Sanskrit Series Office; 2012. p. 156.
15. Trikamji J, Ram N, editors. Susruta Samhita of Susruta, Sootra Sthana; Annapaana Vidhi. 1st ed., Ch. 46. Verse 524. Varanasi: Chaukhambha Sanskrit Sansthan; 2010. p. 252.
16. Hall JE. Receptor and neural functions of retina. In: Guyton and Hall Textbook of Medical Physiology. 11th ed. Uttar Pradesh: Elsevier Publications; 2011. p. 626-38.
17. Khurana AK. Physiology of eye and vision. In: Comprehensive Ophthalmology. 4th ed. New Delhi: New Age International Limited; 2007. p. 14-8.
18. Sihota R, Tandon R, editors. Physiology of vision. In: Parson's Diseases of the Eye. 21st ed. Uttar Pradesh: Elsevier Publications; 2011. p. 22-6.
19. Sadashiva HS, editor. Commentary Saravanga Sundara of Arunadutta on Ashtanga Hrudaya of Vagbhata, Sootra Sthana; Ayushkameeyam. 1st ed., Ch. 1, Verse 18. Varanasi: Chaukhambha Sanskrit Sansthan; 2011. p. 12.
20. Monier Williams MA Sanskrit English Dictionary. Stambhana. 1st ed. Reprint. New Delhi: Motilal Banarasidass Publishers; 2007. p. 1258.
21. Trikamji J, Ram N, editors. Susruta Samhita of Susruta, Sootra Sthana; Annapaana Vidhi. 1st ed., Ch. 46. Verse 515. Varanasi: Chaukhambha Sanskrit Sansthan; 2010. p. 252.
22. Sadashiva HS, editor. Commentary Saravanga Sundara of Arunadutta on Ashtanga Hrudaya of Vagbhata, Sootra Sthana; Ayushkameeyam. 1st ed., Ch. 1. Verse 13. Varanasi: Chaukhambha Sanskrit Sansthan; 2011. p. 10.
23. Sadashiva HS, editor. Astanga Hrudaya of Vagbhata, Sootra Sthana; Ayushkameeyam. 1st ed., Ch. 1. Verse 13. Varanasi: Chaukhambha Sanskrit Sansthan; 2011. p. 10.
24. Sadashiva HS, editor. Astanga Hrudaya of Vagbhata, Sootra Sthana; Ayushkameeyam. 1st ed., Ch. 11, Verse 4. Varanasi: Chaukhambha Sanskrit Sansthan; 2011. p. 183.
25. Sadashiva HS, editor. Commentary Ayurveda Rasayana of Hemadri on Ashtanga Hrudaya of Vagbhata, Sootra Sthana; Doshadi Vijnaneeyam. 1st ed., Ch. 11, Verse 4. Varanasi: Chaukhambha Sanskrit Sansthan; 2011. p. 183.
26. Monier Williams MA Sanskrit English Dictionary. Ranj. 1st ed. Reprint. New Delhi: Motilal Banarasidass Publishers; 2007. p. 861.
27. Trikamji J, Ram N, editors. Commentary Nibandha Sangraha of Delhana on Susruta Samhita of Susruta, Sootra Sthana; Dosha Dhatu Mala Kshaya Vruddhi Vijnaneeyam. 1st ed., Ch. 15, Verse 2. Varanasi: Chaukhambha Sanskrit Sansthan; 2010. p. 67.
28. Monier Williams M A Sanskrit English Dictionary. Paka. 1st ed. Reprint. New Delhi: Motilal Banarasidass Publishers; 2007. p. 613.
29. Trikamji J, Ram N, editors. Susruta Samhita of Susruta, Sootra Sthana; Annapana Vidhi. 1st ed., Ch. 46, Verse 518. Varanasi: Chaukhambha Sanskrit Sansthan; 2010. p. 252.
30. Trikamji J, editor. Commentary Ayurveda Dipika of Chakrapanidutta on Charaka Samhita of Charaka, Cikitsa Sthana; Grahani Dosha Cikitsam. 1st ed., Ch. 16. Verse 16. Varanasi: Chaukhambha Surbharati Prakashan; 2011. p. 514.
31. Trikamji J, Ram N, editors. Susruta Samhita of Susruta, Sootra Sthana; Dhamani Vyakaranam Shareeram. 1st ed., Ch. 9. Verse 5. Varanasi: Chaukhambha Sanskrit Sansthan; 2010. p. 384.
32. Virupakshananda. Tarka sangraha, The Nyaya Vaisheshika Theory of Epistemology. 2nd ed., Sect. IV, Verse 32. Chennai: Sri Ramakishna Math; 2004. p. 79.
33. Trikamji J, editor. Caraka Samhita of Caraka, Shareera Sthana; Katidhaapurushheeyam. 1st ed., Ch. 1. Verse 22. Varanasi: Chaukhambha Orientalia; 2011. p. 289.
34. Sadashiva HS, editor. Astanga Hrudaya of Vagbhata, Sootra Sthana; Doshabhedeyam. 1st ed., Ch. 12. Verse 4. Varanasi: Chaukhambha Sanskrit Sansthan; 2011. p. 193.
35. Sadashiva HS, editor. Astanga Hrudaya of Vagbhata, Sootra Sthana; Doshabhedeyam. 1st ed., Ch. 12. Verse 13. Varanasi: Chaukhambha Sanskrit Sansthan; 2011. p. 194.
36. Monier Williams MA Sanskrit English Dictionary. Varna. 1st ed. Reprint. New Delhi: Motilal Banarasidass Publishers; 2007. p. 924.

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