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Sharira-Kriya Vijnan

A TEXT BOOK OF

Sharira-Kriya Vijnan

(According to the Syllabus of CCIM, New Delhi)

Dr. Prof. Subhash Ranade
Dr. Prof. R.R. Deshpande
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A TEXT BOOK OF

Sharira-kriya Vijnan

(According to the Syllabus of CCIM, New Delhi)

[PART - 2]

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PREFACE

Sharira-kriya is the fundamental subject for the study of Ayurveda. This subject explains all the basic concepts starting from Triguna, Panchamahabhuta, Tridosha & their sub-types, Dhatu, Upadhatu, Mala, Prakriti, Agni, Dietetics, Digestion, Nutrition, Respiration and Circulation. The subject also deals with the fundamental concepts of Embrylogy and the formation of fetus.

If the concept of Sharira-kriya is understood correctly, all other subjects, which depends on this subject like Vikriti Vijnana and Kayachikitsa are also understood in proper way. Many important concepts in Kayachikitsa like how basti acts on Vata dosha, how basti treatment is effective in joint disorders, why Sāma Pitta is digested by herbs and minerals having good smell are all based on the concepts in Sahrira-kriya.

We have taken great care to include all the necessary references from various classical texts like Charaka Samhita, Sushruta Samhita, Ashtanga Sangraha and Ashtanga Hridaya with their explanations. These explanations are according to the references and wherever necessary, we have made them easier to understand by adding examples from day to day life also. Syllabus of Sharir kriya has an excellant blend of treasure of Ayurvedic knowledge, supplemented by essential concepts from Modern physiology (like cardiac cycle, ECG, Lung function tests, Digestion etc.). This matter has been included properly. So Students will not need to refer any other book for modern physiology.

We have also taken care to include line diagrams at proper places to explain the points mentioned in the text, so that the students will understand the subject better. The entire book has been written as per the syllabus of CCIM, New Delhi and like our other text books, we are sure that students and teachers will appreciate our work.

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❖

Chapter 1

Introduction

In Paper One of Sharira-kriya Vijnan we have discussed the physiological aspect of Doshas. The main components of human body are - Dosha, Dhatu & Mala. Now in this Paper Two, we will learn about the remaining components e.g. Dhatu & Mala.

Human physiology depends on balanced state of dosha, dhatu & mala. Doshas are the main bio-energies which are responsible for the physiological activities. These activities take place through the media of dhatu & mala. Dhatus or tissues can be called as the stabilizing pillars of the body ('धारणात् धातवः'). Malas are excretory products formed during metabolic activity of the body.

There are seven types of dhatus such as

1] Rasa	2] Rakta	3] Mamsa	4] Meda
5] Asthi	6] Majja	7] Shukra	

To understand the concept of health & disease, one should first understand the concept of dhatu.

Etymology of the word dhatu is 'धृ - धारयति' which means dharana, or to support the body. Dhatus are those constituents which support the body. Well nourished dhatus give strength to body & maintain health & immunity. Dhatus of weak quality are prone to diseases. Immunity & strength of dhatu can be improved by rasayana chikitsa.

Dhatus & its Relation to Health

'शीर्यते इति शरीरम्' ।

The human body continuously undergo wear & tear process.

Formation of new dhatus & destruction of old one is a continuous process. During childhood rate of tissue formation (anabolism) is rapid while in old age rate of tissue deterioration (catabolism) is more.

Tissues are replenished by food, air & water. Ingested food undergoes transformation. The process of transformation of food is called as Pachana (Digestion). Digestion in annavaha srotas is called as **sthoola pachana** (Primary phase of digestion).

Sthula pachana is divided into three stages according to predominance of rasas (tastes) in food. Madhura avasthapaka, amla avasthapaka, katu avasthapaka are the three phases of sthoola pachana. During this process ahara rasa is formed from the ingested food, under the influence of samana vayu & Agni. This ahara rasa gets absorbed from grahani (small intestine) & is brought to the heart. Ahara rasa consists of nutrients of seven dhatus. Dhatu receives ahara rasa, which is pumped & propelled from heart to various channels. Nutrients of each dhatu undergo further transformation. In secondary phase of digestion, stable tissues or sthayi dhatus are formed.

Dhatu-agni or tissue fire, ranjaka pitta and vyana vayu are essential for the tissue formation during sukshma pachana.

For the formation of each dhatu a separate dhatu-agni or dhatvgni is required. There are seven dhatu-agnis for seven dhatus.

Agni located in each dhatu is called dhatu-agni. Hypo-activity or hyperactivity of dhatu-agni results in excess or depletion of tissue respectively.

'स्वस्थानस्थस्य कायाग्नेरंशाः धातुषु संश्रिताः ।
तेषां सादातिदीप्तिभ्यां धातुवृद्धिक्षयोद्भवः' ॥ (A.Hr.Su. 11/34)

The above verse also explains inter-relationship between

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jatharagni & dhatu-agni. The normal state of dhatu-agni is essential for proper nourishment & formation of dhatu.

Following table indicates types of Agni in the body:

1. Jatharagni	1
2. Dhatvagni	7
3. Panchabhautik agni	5

Formation of Ahara rasa is a result of Sthula pachana. Ahara rasa consists of nutrients of seven dhatus. Sukshma pachana involves formation of sthayi dhatus (stable tissues) from the poshaka dhatus (unstable tissues or nutrients) present in ahara rasa.

Dhatu-poshana Nyayas

(Theories of tissue formation)

1) Kshira-dadhi nyaya - Theory of total transformation
2) Kedari-kulya nyaya - Theory of irrigation
3) Khale-kapota nyaya - Theory of selectivity.

We have already seen the detailed information of these three theories in the first volume of Sharira kriya vijnana. Proper formation of dhatu depends on balanced state of dhatu-agni & also on well functioning of srotasas because,

'यथास्वेनोष्मणा पाकं शारीरा यान्ति धातवः ।
स्रोतसा च यथास्वेन धातुः पुष्यति धातुतः' ॥ (Cha.Chi. 8/39)

Poshaka dhatus (nutrients) are acted upon by their respective dhatu-agnis in the respective srotasas and from that poshya dhatus or stable tissues are formed. (Cha. Chi. 8) This verse explains importance of dhatu-agni as well as srotasas. Deranged state of srotas also leads to malnutrition & malformation of dhatus.

Concept of Srotas

The term 'srotas' means channel or system in which some tissue or other material is formed, secreted or transported.

Nirukti (Etymology) of Srotas

'स्रु स्रवणः' ।

The word srotas is derived from the Sanskrit dhatu - 'sru'. Meaning of 'sru' is to secrete, to permeate, to flow. The structure through which substance is either secreted or circulated or transported is called as srotas.

Srotasas are innumerable but grossly there are 16 srotasas in the body as follows:

1) Prana vaha srotas
2) Anna vaha srotas
3) Udaka vaha srotas
4) Rasa vaha srotas
5) Rakta vaha srotas
6) Mamsa vaha srota
7) Medo vaha srotas
8) Asthi vaha srotas
9) Majja vaha srotas
10) Shukra vaha srotas
11) Purish vaha srotas
12) Mutra vaha srotas
13) Sweda vaha srotas
14) Artava vaha srotas
15) Stanya vaha srotas and
16) Mano vaha srotas.

The following verses give information about colour, shape & structure of srotas.

'खानि स्रोतांसि' । (Dalhan on Su.Sha. 9/10)

Those structures having 'kha' (cavity or space) are called as srotas.

'स्वधातुसमवर्णानि वृत्तस्थूलान्यणूनि च ।
स्रोतांसि दीर्घाण्याकृत्या प्रतानसदृशानि च' ॥ (Cha.Vi. 5/25)

Colour of srotasas is similar to that of dhatus they carry. Srotasas can be straight or tubular in shape, some are very small in size or some are be large in size.

Definition of Srotas

'मूलात्खादन्तरं देहे प्रसृतं त्वभिवाहि यत् ।
स्रोतस्तदिति विज्ञेयं सिराधमनिवर्जितम्' ॥ (Su.Sha. 9/13)

Srotas can be defined as a structure whose moolasthana (root) has 'kha' (cavity) in it & it is different than that of sira & dhamanis.

Functions of Srotasas

1) Formation of dhatu takes place in srotas.
2) Transportation of nutrients takes place in srotas.
3) Transformation or metabolism occurs in srotas.
4) Excretion of waste products is the main functions of srotas.

Roots of Srotasas

(Moola sthana of srotasas)

Moola sthanas (roots) of srotas are the controlling organs of srotas.

Moola sthanas are the sites of utpatti (formation) or vahana (transportation) of a particular substance to which the srotas belongs. They can also be the easiest sites for the examination of that srotas. Moolasthana of srotas controls all other organs related to that channel. Some time the root of channel is the easiest one for its examination. Hence examination of the moolasthana is important for clinical examination.

From the above description, it is clear that jatharagni (digestive fire), dhatu-agni (tissue fire) and srotasas are the important factors on which proper formation of dhatus depends. Along with doshas, dhatus & malas, srotasas also

play important role in maintaining health. Unobstructed srotasas allow manufacture of new tissues and proper flow of nutrients & waste materials. Impaired functions of srotas leads to stagnation of doshas, dhatus & malas in the srotasas, hence they must be kept clean to maintain health.

The following table indicates mula-sthana - controlling organs - of every dhatu:

No.	*Dhatu*	*Moola sthana*
1	Rasa vaha srotas	Hriday, Sira
2	Rakta vaha srotas	Yakrit, pleeha, rakta vaha sira
3	Mamsa vaha srotas	Snayu, twacha
4	Medo vaha srotas	Vrikka, vapavahana
5	Asthi vaha srotas	Medo dhatu, jaghana
6	Majja vaha srotas	Asthi dhatu, sandhi
7	Shukra vaha srotas	Vrishana, shephas

Concept of Kala

Definition of kala is stated in the following verse :

'धात्वाशयान्तरमर्यादा:' । (Su.Sha. 4/5)

Internal lining of the different dhatus, organs is called as 'kala'.

Kala can be compared with mucous membrane or the membrane that produces particular substance.

Formation of Kala

Kala is formed in the intra uterine life.

'धात्वाशयान्तरक्लेदो विपक्वा: स्वं स्वमूष्मणा ।
श्लेष्मस्नाय्वपराच्छन्न: कलाख्य: काष्ठसारवत्' ॥ (A.Hr. Sha. 3/9)

Kleda (moisture) is present inside the dhatus & ashayas or organs. Due to heat, kleda inside the dhatu & ashayas get converted into kalas.

Seven kalas & their location are shown in the following table:

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No.	*Kala*	*Location*
1	Mamsa-dhara kala	Sira, snayu, srotas.
2	Rakta-dhara kala	Yakrit, pleeha, dhamani.
3	Medo-dhara kala	Udara, anu asthi (small bones)
4	Shleshma-dhara kala	Sandhi
5	Purisha-dhara kala	Pakvashaya (colon)
6	Pitta-dhara kala	Grahani (small intestine)
7	Shukra-dhara kala	Sarva shareera (whole body)

Time Required for Dhatu Formation

'सन्तत्या भोज्यधातूनां परिवृत्तिस्तु चक्रवत्' । (Cha.Chi. 15/21)

Formation of dhatu is a continuous process. Charaka has compared dhatu formation to fetching of water with pulley from well. Charaka further elaborates that dhatu formation depends on activity of dhatu-agni.

Due to hyperactivity of dhatu-agni, the process of dhatu formation becomes rapid. On other hand dhatu formation will slow down if there is hypoactivity of dhatu-agni.

According to Charaka Samhita in one week all seven dhatus are formed. Rasa dhatu is formed on first day after ingestion of food & shukra dhatu is formed on the 7th day.

Sushruta has expressed different opinion about time factor regarding dhatu formation. According to Sushruta after formation of ahara rasa every dhatu is formed serially on every 5th day. Rasa dhatu is formed on 1st day of ingestion of food & on every 5th day, other new dhatu is formed. Hence shukra dhatu is formed on 30th day.

Dhatu	*Formation according to Charka samhita*	*Formation according to Sushruta Samhita*
Rasa	1st day	1st day
Rakta	2nd day	5th day
Mamsa	3rd day	10th day
Meda	4th day	15th day

Dhatu	*Formation according to Charka samhita*	*Formation according to Sushruta Samhita*
Asthi	5th day	20th day
Majja	6th day	25th day
Shukra	7th day	30th day

Time taken for dhatu formation is important to understand duration & effect of chikitsa (treatment) of particular dhatu. For e.g. effect of haematinic medicines on rakta dhatu can be observed only after five days from the onset of chikitsa because rakta dhatu is formed on 5th day. Twenty one days are required for healing of the fractured bone, as asthi dhatu is formed on 20th day.

Main Functions of Dhatus

'प्रीणनं जीवनं लेपः स्नेहो धारणपूरणे ।
गर्भोत्पादश्च धातूनां श्रेष्ठ कर्म क्रमात् स्मृतम्' ॥ (A.Hr.Su. 11/4)

No.	*Dhatu*	*Function*
1	Rasa	Preenana (Gratification)
2	Rakta	Jeevana (Maintenance of life)
3	Mamsa	Lepana (To cover various organs)
4	Meda	Snehana (Lubrication)
5	Asthi	Dharana (To support)
6	Majja	Purana (To fill the bony cavity)
7	Shukra	Garbhotpadana (Reproduction)

Tissue Excellence

(Dhatu Sarata)

Tissue excellence or dhatu sarata is a quality assessment of seven dhatus. Examination of dhatu sarata is done at physical & psychological level. Detailed symptoms of dhatu sarata are explained in the concerned chapters.

Definition of Dhatu-sarata

'विशुद्धतरः धातुः सारः उच्यते' । (C.Vi. 8/102, Chakrapani)

Vishuddhatara dhatu is called as Sara dhatu. This means dhatu with excellent or optimal qualities.

Types of Dhatu-sarata

Sarata of seven dhatus & the eighth Sattva sarata (optimal quality of mind) have been explained as follows:

1) Uttam Sara dhatu - Best quality
2) Madhya Sara dhatu - Medium quality
3) Asara Sara dhatu - Low quality

Clinical Importance of Dhatu-sarata

Quantitative assessment of dhatus must be done.

1) To assess the strength of each dhatu, and
2) To assess immunity of dhatu

Uttama Sara - best dhatu sarata has good strength & good immunity. Asara dhatus are tissues with poor quality and they are very weak. Hence they are prone to diseases. Asara dhatus can be strengthened by rasayana chikitsa.

Upadhatus (Secondary Tissues)

Secondary tissues are byproducts of tissues hence called as secondary tissues.

'रसात् स्तन्यो ततो रक्तमसृजः कण्डराः सिराः ।
मांसाद्वसा त्वचः षट् च मेदसः स्नायुसम्भवः' ॥ (Cha.Chi. 15/7)

'स्तन्यं रजश्च नारीणां काले भवति गच्छति ।
शुद्धमांसभवः स्नेहः सा वसा परिकीर्तिता ॥
स्वेदो दन्तास्तथा केशास्तथैवोजश्च सप्तमम् ।
इति धातुभवा ज्ञेया एते सप्तोपधातवः' ॥

(Sharngadhar. 1/5/16-17)

Table showing dhatus & their respective upadhatu:

No.	*Dhatu*	*Upa dhatu*
1	Rasa	i) Stanya - breast milk ii) Raja -menstrual fluid

No.	*Dhatu*	*Upa dhatu*
2	Rakta	i) Sira - blood vessels ii) Kandara - tendons
3	Mamsa	i) Vasa - fat in the muscle ii) Twacha - skin
4	Meda	Snayu - flat muscle
5	*Asthi	Danta - teeth
6	*Majja	Kesha - hair
7	Shukra	Ojas

*According Sharngadhara Samhita danta & kesha are upadhatu of asthi & majja dhatu respectively, while according to Sushruta Samhita, Ojas is the secondary tissue of shukra dhatu.

Upadhatu or sub tissues are byproducts of dhatus. They do not support the life like dhatus. When damaged secondary tissues takes longer time for healing than the main tissues. Generally main tissues except shukra, do not leave the body, while upadhatu can leave the body without giving harming the body. (If the tissues leave the body then it can create serious condition). Upa dhatus do not follow the chain of nourishment like dhatus.

Dhatu Mala (Waste Products of Dhatu)

Dhatu mala is formed during metabolism of dhatu.

'कफः पित्तं मलाः खेषु प्रस्वेदो नखरोम च ।
स्नेहोऽक्षित्वग्विशामोजो धातूनां क्रमशो मलाः' ॥ (A.Hr.Sha 3/63)

'किट्टमन्नस्य विण्मूत्रं, रसस्य च कफोऽसृजः ।
पित्तं, मांसस्य खमला, मलः स्वेदस्तु मेदसः ॥
स्यात् किट्टं केशलोमास्थ्नो, मज्ज्ञः स्नेहोऽक्षिविट्त्वचाम्' ।
(Cha.Chi. 15/18-19)

Dhatus & their respective waste products :

No.	*Dhatu*	*Dhatu mala*
1	Rasa	Kapha
2	Rakta	Pitta

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No.	*Dhatu*	*Dhatu mala*
3	Mamsa	Kha-mala
4	Meda	Sweat
5	Asthi	Hair, nails
6	Majja	Akshi-vit, sneha
7	Shukra	Ojas

According to Ashtang Sangraha Ojas is a waste product of shukra dhatu.

Symptoms of Dhatu Vriddhi & Kshaya

(Symptoms of increased & decreased dhatu)

Symptoms of dhatu vriddhi & kshaya are explained in the concerned chapters. These symptoms are the applied study of every dhatu, so one should learn the symptoms & causes of dhatu vriddhi & kshaya.

Anjali-pramana

Anjali pramana is a measure to assess quantity of various constituents of body. One anjali is the unit equal to one handful of a person.

'तदुदकं दशाञ्जलिप्रमाणं; नवाञ्जलयः पूर्वस्याहारपरिणामधातोः यं 'रस' इत्याचक्षते; अष्टौ शोणितस्य, सप्त पुरीषस्य; षट् श्लेष्मणः, पञ्च पित्तस्य, चत्वारो मूत्रस्य, त्रयो वसायाः, द्वौ मेदसः, एको मज्जायाः, मस्तिष्कस्यार्धाञ्जलिः शुक्रस्य तावदेव प्रमाणं, तावदेव श्लैष्मिकस्योजस इति'। (Cha.Sha. 7/15)

Table showing Anjali pramana of various body constituents.

Body Constituents	*Anjali pramana*
Udaka	10
Rasa	9
Rakta	8
Faeces	7
Kapha	6
Pitta	5
Urine	4

Body Constituents	*Anjali pramana*
Vasa (fat in muscles)	3
Meda	2
Majja	1
Mastishka (brain)	½
Shukra	½

Embryological Development of Organs

Dhatus participate in the embryological development of various organs.

Sushruta in Sharira sthana has mentioned embryological development of organs.

'गर्भस्य यकृत्प्लीहानौ शोणितजौ, शोणितफेनप्रभवः फुफ्फुस, शोणित-किट्टप्रभव उण्डुकः' ।

'असृजः श्लेष्मणश्चापि यः प्रसादः परो मतः ।
तं पच्यमानं पित्तेन वायुश्चाप्यनुधावति ॥
ततोऽस्यान्त्राणि जायन्ते गुदं बस्तिश्च देहिनः ।
उदरे पच्यमानानामाध्मानाद् रूक्मसारवत् ॥
कफशोणितमांसानां साराज्जिह्वा प्रजायते' । (Su.Sha. 4/26-28)

'रक्तमेदःप्रसादाद् वृक्कौ; मांसासृक्कफमेदः प्रसादाद् वृषणौ; शोणितकफप्रसादजं हृदयम्' । (Su.Sha. 4/31)

Guda, unduka (anal canal), antra (intestine) & basti (bladder) are developed from rakta dhatu & tridoshas. Vrikka (kidneys) are developed from medo dhatu. Sira & snayus (vessels and tendons) are developed from meda & rakta dhatu. Vrishana (testes) are developed from meda dhatu & kapha dosha. Jivha (tongue) is developed from rakta, mamsa dhatu & kapha dosha. Heart is developed from rakta dhatu & kapha dosha. Phupphusa (lungs) are developed from shonita-phena.

Outline for Study of Dhatu

For the systematic study of dhatu one should follow the specific pattern which is as follows :

1] Nirukti of dhatu (Etymology)
3] Metabolism of dhatu
4] Functions of dhatu
5] Properties of dhatu
6] Anjali pramana of dhatu
7] Upadhatu & mala of dhatu
8] Symptoms of dhatu Vriddhi & dhatu kshaya

Chapter 2

Ahara Rasa

Concept of Ahara-rasa

Living body is continuously subjected to wear & tear process. Dhatus needs constant nourishment. Nourishment of the body or dhatu depends upon the quality of food. Food is converted to body constituents by the process of digestion. Panchabhautika food which consists of all six rasas is able to nourish Panchabhautik body.

'तत्र पाञ्चभौतिकस्य चतुर्विधस्य षड्रसस्य द्विविधवीर्यस्य अष्टविधवीर्यस्य वा अनेकगुणस्य उपयुक्तस्य आहारस्य सम्यक्परिणतस्य यः तेजोभूतः सारः परमसूक्ष्मः स रस इति उच्यते'। (Su.Su. 14/3)

The Panchabhautika, shadrasatmaka (sweat, salty, sour, bitter, pungent, astringent tastes) food undergoes the process of digestion & sara, sukshma (subtle), tejobhuta ahara rasa is formed.

Absorption of Ahara-rasa

'जाठराग्निना विपक्वः सारभूतः आहाररसः ग्रहणीतः समानमरुतेः इरितः सिराभिः हृदयं गच्छति'। (Sharngadhar)

'रसस्तु हृदयं याति समानमरुतेरितः। (Sharngadhar)

Due to action of jatharagni, ahara rasa containing all the nutrients (sarabhuta) is formed in grahani, due to action of samana vayu, ahara rasa is absorbed from grahani & brought to the heart. From here it is circulated throughout the body to all the cells.

Circulation & Formation of Ahara-rasa

'स हृदयात् चतुर्विंशतिः धमनीः अनुप्रविश्य ऊर्ध्वगाः दश, दश च अधोगामिन्यः च चतस्रः च तिर्यग्गाः कृत्स्नं शरीरम् अहः अहः तर्पयति वर्धयति धारयति यापयति च अदृष्टहेतुकेन कर्मण'। (Su.Su. 14/3)

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Ahara-rasa which is brought to heart enters the twenty four dhamanis arising from heart & set into circulation. There are twenty four dhamanis emerging from the heart, out of which ten branch off in upward direction, ten branch off inferiorly & four branch off laterally. Ahara rasa which has entered heart & its dhamanis is circulated through these dhamanis in superior, inferior and lateral directions.

Tarpana (nourishment), vardhana (growth), dharana (to support), preservation (yapana) are the functions of ahara rasa.

'वर्धयति इति बालं, धारयति इति सम्पूर्णधातुत्वात्। यापयति इति वृद्धं क्षीयमाणदेहत्वात्'। (Su.Sha. 14/3, Dalhan)

According to Dalhana, functions of ahara rasa vary at different stages of life. Tarpana & vardhana are predominant in children while in old age ahara rasa maintains the physiological activities which are called as 'yapana'. In middle age body is fully developed & dharana (support) of developed body is the chief function of ahara rasa during middle age.

In this way ahara rasa is formed from food. It consists of nutrients of seven dhatus. Nourishment of dhatu is the important function of ahara rasa. Improper food, behavior, imbalanced agni can affect ahara-rasa, therefore one should have balanced diet, for proper formation of ahara rasa & ultimately for proper nourishment of body.

Chapter 3

Rasa Dhatu

Rasa dhatu is the First dhatu in the body being nourished from ahara-rasa.

'तत्र रसगतौ धातुः अहः अहः गच्छति इति अतो रसाः' । (Su.Su. 14/13)

Nirukti (etymology)

Dhatu which is being continuously circulated in the body is called as rasa dhatu.

Synonyms

Soumya dhatu, ahara prasada, dhatu sara, ahara teja, agnisambhava, asrikkara are the synonyms of rasa dhatu.

Site

'तस्य हृदयं स्थानम् । स हृदयात् चतुर्विंशति धमनीः अनुप्रविश्य उर्ध्वगाः दश, दश च अधोगामिन्यः चतस्र तिर्यग्गाः कृत्स्नं शरीरं अहः अहः तर्पयति' ।

(Su.Su. 14/3)

Heart & twenty four dhamanis emerging from heart is the site of rasa dhatu. Rasavaha srotas is the site of rasa dhatu.

Heart & dhamanis arising from heart are the moolasthana of rasavaha srotas.

Panchabhautika Constitution

'.....रसः आप्यः' । (Bhanumati on. Su.Su. 15/8)

Jala mahabhuta is predominantly present in rasa dhatu.

Metabolism

'तेषां रसादीनां मल-स्थूल-अणुभागविशेषेण त्रिविधः परिणामो भवति, तद् यथा—अन्नात् पच्यमानात् विट्-मूत्रं मलः, सारो रसः रसाद् अग्निपक्वाद् मलः कफः स्थूलो भागो रसः; अणुभागो रक्तम्' । (Dalhan on Su.Su. 14/10)

Rasa dhatu is formed from the poshaka rasa (nutrients of rasa dhatu) present in ahara-rasa. Poshya rasa dhatu is formed from the poshaka rasa dhatu. Rasa dhatu is formed in rasavaha srotas. Dhatvagni of rasa dhatu plays vital role in the metabolism of rasa dhatu. Rasa dhatvagni transforms nutrients of rasa dhatu into poshya rasa.

Poshaka Rasa	Rasavaha srotas → Dhatvagni of rasa dhatu	1) Formation of poshya rasa dhatu. 2) Formation of poshaka rakta dhatu 3) Formation of upadhatus, raja & stanya 4) Formation dhatu mala - kapha

Quality of food can affect metabolism of rasa dhatu. Cold, liquid, unctuous food promotes formation of rasa dhatu while dry food, lighter food like toast, popcorn, or fasting leads to malnutrition of rasa dhatu.

Time taken for the formation

'रस: किल एक अहेन एव सम्पद्यते' । (Dalhan on Su.Su. 14/15)

Rasa dhatu is formed in twenty four hours.

Qualities

'रसोऽपि श्लेष्मवत् (वृद्ध:)' । (A. Hr. Su. 11/8)

While describing qualities of rasa dhatu, Vagbhata in Ashtang Hridaya says that rasa dhatu is similar to Kapha dosha.

Liquidity, coldness, unctuousness, dullness are the qualities of rasa dhatu. These qualities help rasa dhatu to make preenana of the body. Colour of rasa dhatu is white like Shleshma.

Quantity

'नव अञ्जलय: पूर्वस्य आहारपरिणामधातो: यं 'रस' इति आचक्षते'।

(Cha.Sha. 7/15)

Quantity of rasa dhatu is 9 anjali. Proper functioning of rasa dhatu, absence of symptoms of rasa vriddhi or rasa-kshaya indicates normal (9 anjali) quantity of rasa dhatu.

Functions

'प्रीणनं जीवनं लेप: स्नेहो धारणपूरणे।
गर्भोत्पाद: च धातूनां श्रेष्ठं कर्म क्रमात् स्मृतम्'॥ (Ash.Hr.Su. 11/4)

'रस: तुष्टिं प्रीणनं रक्तपुष्टिं च करोति'। (Su.Su. 15/51)

Preenana (gratification) & raktapushti (nourishment of rakta dhatu) are the functions of rasa dhatu. Preenana means to provide enough fluids to all the cells in the body. As the dried plant becomes fresh after receiving water, similarly all dhatus become physiologically active due to preenana of rasa dhatu. Therefore in clinical practice oral rehydration therapy or transfusion of intravenous fluids is the line of treatment for the patient of dehydration. Dehydration is rasa kshaya in which rasa dhatu is depleted in the form of vomiting or diarrhea.

Formation & functioning of rasa dhatu affects rakta dhatu because dhatus are interdependent. Therefore proper metabolism of rasa dhatu will lead to rakta pushti or proper formation of rakta.

Symptoms of Rasa-sarata

'तत्र स्निग्धश्लक्ष्णमृदुप्रसन्नसूक्ष्माल्पगम्भीरसुकुमारलोमा सप्रभेव च त्वक्-साराणाम्। सा सारता सुखसौभाग्यैश्वर्योपभोगबुद्धिविद्यारोग्यप्रहर्षणानि आयुष्यत्वं च आचष्टे'। (Cha.Vi. 8/103)

'सुप्रसन्नमृदुत्वग्रोमाणं त्वक्सारं विद्यात्'। (Su.Su. 35/16)

'त्वक्सारं रससारम्.....त्वक्शब्देन त्वक्स्थो रसोऽभिहित:'।

(Dalhan on Su.Su. 35/16)

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Person who is endowed with uttam rasa-sarata has soft, smooth skin. Loma (hair on the skin) of such skin are very fine, sparse & deeply rooted. Person with uttam rasa-sarata is endowed with happiness, intelligence, wealth, health & longevity. He usually does not suffer from any skin disease and if gets inflicted with skin disease, it is easy to cure.

Upadhatus

Stanya (breast milk) & raja (menstrual fluid) are the upadhatus (secondary tissues) of rasa dhatu.

Mala

'रसस्य सारो रक्तं मलः कफो लसिका च' । (S.S.Sha. 6/29)

'व्रणगतं उदकं लसिका' । (A.Hr.Su. 30/45)

Kapha & according to Ashtang Sangraha, lasika are the malas (waste products) of rasa dhatu. Unctous fluid which oozes from the wound is called as lasika

Disorders of Rasa dhatu

Symptom of Rasa-vriddhi

(Symptom of increased rasa dhatu)

Over indulgence of cold, heavy, oily, sweet food, stress can lead to vruddhi of rasa dhatu.

'रसो अतिवृद्धो हृदयं उत्क्लेदं प्रसेकं च आपादयति' । (Su.Su. 15/14)

'रसोऽपि श्लेष्मवत् (वृद्धः)' । (A.Hr.Su. 11/8)

Utkleda (nausea), Praseka (ptylism) are the symptoms of rasa vriddhi.

Langhana (fasting), dry & light food is the line of treatment in rasa vriddhi.

Symptoms of rasa-kshaya

(Symptoms of decreased rasa dhatu)

'रसे रौक्ष्यं श्रमः शोषो ग्लानि शब्द असहिष्णुता रसक्षये हृत् पीडा शून्यता तृष्णा च' । (A.Hr.Su. 11/9)

Dry skin, dyspnoea, emaciation, intolerance of speech thirst are the symptoms of rasa kshaya. Fasting, dry, light food, excretion, traveling, less sleep leads to rasa kshaya.

Brimhana therapy which includes food like wheat, meat, ghee, dairy products and plenty of sweet and sour liquids like fruit juices, meat soup is the line of treatment for rasa kshaya.

Importance of Rasa dhatu

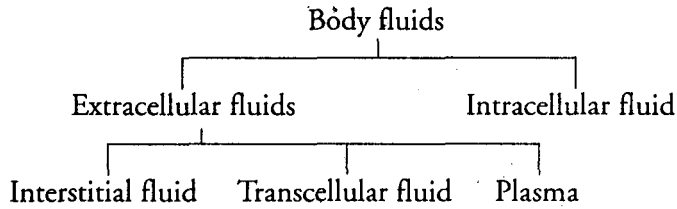
'रसजं पुरुषं विद्यात् रसं रक्षेत् प्रयत्नतः' । (Su.Su. 14/12)

Sushruta advises to protect rasa dhatu by taking nutritious food & with proper regimen.

Body fluids, Plasma and Lymphatics

Water is present in the body in the form of various body fluids.

Distribution of body fluid is as follows:



In the 70 kilogram person, the total body water is 60 percent of the body weight. Fluid which is present in the interstitial spaces of the cells as interstitial fluid.

Interstitial fluid is formed from plasma. It occupies intercellular spaces, and provide nutrition, gases to tissue cells. Cells excrete their metabolites into interstitial fluid. It is a great reservoir of water.

Plasma

When the formed elements are removed from the blood, a straw coloured liquid is left, which is called as plasma.

1) Plasma is also a extracellular fluid which consist of water

and other solid constituents like albumin, globulin, fibrinogen.

Albumin, globulin, fibrinogen are called as plasma proteins.

Albumin is required to maintain osmotic pressure of blood. Various antibodies belong to globuiln. Fibrinogen is required for blood coagulation.

2) Plasma acts as a medium of transport for glucose, amino acids and fatty acids.
3) Plasma conducts respiratory gases.
4) Various enzymes and hormones are present in the plasma.
5) Plasma conduct waste products like urea, uric acid, creatinine to the excretory organs.
6) Electrolytes like Na^{+}, K^{+}, Ca^{2+}, Mg^{2+} are dissolved in plasma.
7) Chlorides, phosphates, Carbonates are also conducted in plasma.

Trancellular Fluids

The special extra cellular fluids are called as transcellular fluids, they are as follows :

1) Cerebrospinal fluid
2) Synovial fluid
3) Intra ocular fluid
4) Pericardial, pleural, peritoneal fluids.
5) Gastro intestinal fluids.

Intracellular Fluid

Fluid which is present within the cell is called as intracelular fluid. Intracellular fluid contains large amount of potassium and phosphate ions.

Intracellular fluid contains very small amount of sodium and chloride ions.

Lymph and lymphatic system

The fluid which is present in the lymphatic system is called as lymph. Lymphatic system consist of :

1) Lymphatic capillaries
2) Lymphatic vessels
3) Lymphatic nodules
4) Lymphatic glands

Lymphatic capillaries are microscopic blind vessels, which are present in the intercellular spaces.

Lymph capillaries join to form lymphatic vessels.

Lymphatic vessels join together to form lymphatic ducts.

Right lymphatic duct opens into subclavian vein, while left throacic duct open into superior vena cava.

Lymphatic vessels contains valves, they have thinner walls.

Lymphatic system is connected with venous system at the opening of thoracic duct and right lymphatic duct. The lymphatic system is a closed system.

Aggregation of lymphatic tissue is called as lymphatic nodules. Lymphatic nodules are present along the pathway of lymph vessels. Tonsils, spleen, thymus are lymph organs, which are the part of lymphatic system.

Formation of lymph

Lymph is a fluid, which is formed from the interstitial fluid.

Lymph is formed in the inter cellular spaces. Fluid and proteins which are not absorbed back in the venous end of the capillaries, enters the lymphatic capillaries, and returns to the blood through lymphatic system. The fluid that enters the lymph capillaries is called as lymph. The proteins which are absorbed in the lymph capillaries are very important and they should be preserved and brought back to circulation through lymph.

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Composition of lymph

Lymph consists of 94% water. It consists of proteins, fats, glucose etc.

Functions of lymph

1) Lymph supplies nutrition and oxygen to the parts where blood cannot reach.
2) It drains away excess interstitial fluid and maintains volume of interstitial fluid.
3) Lymph returns protein to the blood from tissue spaces.
4) Lymph is rich in lymphocytes, which act as defensive cells of the body.
5) The lymphatics remove bacteria from the tissue.
6) Lymph is filtered in the lymphatic nodules.
7) Lymphocytes are produced in lymph nodules and lymphatic organs.

Chapter 4

Rakta Dhatu

Rakta dhatu is the Second dhatu being nourished from Ahara rasa.

Etymology (Nirukti) of Rakta dhatu

The word rakta is derived from the Sanskrit word-

'रज रंजने, तेन रंजन: रागवर्णयुक्त: रागकृत् च धातु: रक्तम् इत्यर्थौ भवति'

The name rakta indicates red colour of this tissue.

Synonyms

Rudhira, shonita, kshataja, asrik, asra, lohita.

Site

'शोणितवहानां स्रोतसां यकृत् मूलं प्लीहा च' । (Cha.Vi. 5/8)

'रक्तवहे द्वे (स्रोतांसि) तयोर्मूलं यकृत्प्लीहानौ रक्तवाहिन्य: च धमन्य:' । (Su.Sha. 9/12)

Liver (yakrit), spleen (pliha) are roots of raktavaha srotas. According to Sushruta, blood vessels supplying rakta to every smallest structure of the body is also a root of raktavaha srotas.

Liver and spleen are sites of formation and vitiation of rakta dhatu. Especially liver is the main organ of examination in the diseases of rakta dhatu.

'द्वितीया रक्तधरा मांसस्य अभ्यन्तरत: तस्यां शोणितं विशेषत: च सिरासु यकृत् प्लीह्नो च भवति' । (Su.Sha. 4/10)

Raktadhara kala is present inside liver, spleen and blood vessels. It is concerned with formation and storage of rakta dhatu.

'आशयास्तु वाताशय:.....रक्ताशय: इति' । (Su.Sha. 5/8)

Liver and spleen are considered as raktashaya (organ where blood is stored) or the controlling organs of this system. These organs are also store-house for rakta dhatu.

'रक्तादिनां तु सर्वशरीरचराणामपि विशेषेण हृदयं स्थानमुक्तम्' ।
(Chakrapanidatta on Cha.Chi. 24/36)

Heart is also the seat of rakta dhatu. Rakta dhatu is circulated throughout the body by heart.

Metabolism

Formation of poshaka rakta dhatu takes place in the raktavaha srotas. Nutritive part homologues to rakta dhatu is converted to rakta dhatu in the raktavaha srotas.

'तेजो रसानां सर्वेषां मनुजानां यदुच्यते ।
पित्तोष्मणः स रागेण रसो रक्तत्वमृच्छति' ॥ (Cha.Chi. 15/18)

According to Charaka, rasa dhatu is colorless & consists of nutrients of seven dhatus. Liquid white colored rasa when enters raktavaha srotas - liver & spleen - gets red colour due to action ranjaka Pitta.

'पुष्यन्ति तु आहाररसात् रसरुधिरमांसमेदोऽस्थिमज्जशुक्रौजांसि' ।
(Cha.Su. 28/4)

'स खलु आप्यो रसः यकृत्प्लीहानौ प्राप्य रागमुपैति' ।
(Su.Su. 14/4)

In Sushruta Samhita, ranjaka pitta is described as ranjaka agni. According to Sushruta, agni & pitta dosha are same so he has used the term agni to five types of pitta dosha. Hence role of ranjaka pitta & rakta dhatvagni is same.

'यत् तु यकृत्प्लीह्नोः पित्तं तस्मिन् रञ्जको अग्निः इति संज्ञा, स रसस्य रागकृत् उक्तः' । (Su.Su. 21/10)

Under the influence of rakta dhatvagni, rakta dhatu is formed in the raktavaha srotas.

According to Kshira-dadhi nyaya, rakta dhatu is formed after rasa dhatu, while according to Kedara-kulya nyaya, rakta

dhatu is formed in the raktavaha srotas after five days from ingestion of food.

Metabolism of Rakta dhatu

Nutrients of rakta dhatu → Raktavaha srotas / Agni of rakta dhatu →
1) formation of poshya rakta dhatu
2) Formation of waste product of rakta dhatu
3) Formation of poshaka mamsa dhatu

In this way on the 5th day rakta dhatu is formed from ahara-rasa.

Constitution of Rakta dhatu

'रक्तं तेजोजलात्मकम्' । (Bhanumati on Su.Su. 15/8)

Every substance is made of five mahabhutas. Hence they are also present in the rakta dhatu, & qualities of rakta dhatu can be explained on the basis of five mahabhutas.

'पाञ्चभौतिकं तु अपरे जीवरक्तम् आहु: आचार्य:' ।
'विस्रता द्रवता राग: स्पन्दनं लघुता तथा' । (Su.Su. 14/8-9)

Five qualities of rakta dhatu	*Element*
Visrata - fleshy odor	Earth (Prithvi)
Dravata - fluidity	Water (Jala)
Raga - red colour	Fire (Teja)
Spandana - pulsation	Ether (Vayu)
Laghuta - lightness	Air (Akasha)

In spite of existence of five mahabhutas, rakta dhatu has dominance of teja & jala mahabhuta.

Qualities

'तपनीय इन्द्रगोपाभं पद्मालक्तकसंन्निभम् ।
गुंजाफलसवर्णं च विशुद्धं विद्धिशोणितम्' ॥ (Cha.Su. 24/22)

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To explain colour of rakta dhatu, it is compared with many red colored substances that exist in nature. Hence blood which oozes from the body is red like red colored insect (indragopa) which is seen mainly in rainy season, blackish red like lac, small bright red fruit (like gunja) or yellowish orange red like gold.

Red color of gunja & lac has been compared with the color of human blood, to study relationship between colour of skin & colour of blood. In darker skin persons the colour of blood is like lac, while in lighter skin persons the color of blood is dark red.

In Vata constitution, colour of skin is dark.

In Pitta & Kapha constitution, the skin color is from light to fair or white.

'रक्तं सर्वशरीरस्थं जीवस्याधारमुत्तमम् ।
स्निग्धं गुरु चलं स्वादु विदग्धं पित्तवद् भवेत्' ॥

(Sharngadhar 1/6/10)

Rakta dhatu which supports the life is sweet, heavy, mobile & sweet in taste.

'अनुष्णशीतं मधुरं स्निग्धं रक्तं च वर्णतः ।
शोणितं गुरु विस्रं स्याद्विदाहश्चास्य पित्तवत्' ॥ (Su.Su. 21/17)

The most important quality mentioned here is that rakta dhatu is a warm dhatu (anushnasheeta). However it has also been said that rakta dhatu is neither hot nor cold, it maintains body temperature.

'इन्द्रगोपप्रतीकाशम् असंहतम् अविवर्णं प्रकृतिस्थं जानीयात्' ।

(Su.Su. 14/22)

When rakta dhatu is in a state of health then it possess the following qualities:

Healthy rakta dhatu is red like an insect called as indragopa (cochineal insect).

Asamhata - Healthy rakta dhatu is neither thin nor thick and it never coagulates while flowing in the blood vessels. When rakta dhatu oozes out of body, then only it clots. This property of non-coagulation in the intact blood vessel is called as asamhata.

Qualities According to Ashtang Sangraha

'...धौतं च विरज्यमानं मधुरमीषल्लवणं स्निग्धं अशीतोष्णं गुरु...' ।

(A.S.Su. 36/5)

1) Sweet & slightly salty in taste,
2) Neither hot nor cold,
3) Do not stain the cloth.

Symptoms of Vishuddha Rakta dhatu

'प्रसन्नवर्णेन्द्रियमिन्द्रियार्थानिच्छन्तव्याहतपक्तृवेगम् ।
सुखान्वितं पुष्टिबलोपपन्नं विशुद्धरक्तं पुरुषं वदन्ति' ॥

(Cha.Su. 24/24)

When rakta dhatu is in the balanced state, then following symptoms should be seen in person having purest form of rakta dhatu:

1) Cheerful healthy complexion,
2) Energetic active sense organs,
3) Proper inclination of sense organs towards their subjects,
4) Good digestion,
5) Unobstructed natural urges, and
6) Healthy nourishment of body.

Anjali Pramana - 8 anjali.

As anjali pramana is a subjective measure, absence of disorders of rakta dhatu indicate normal volume of rakta dhatu.

'अष्टौ (अंजलयः) शोणितस्य' । (Cha.Sha. 7/15)

'दोषधातुमलानां तु परिमाणं न विद्यते' । (Su.Su. 15/37)

Functions of Rakta dhatu

'जीवनं (श्रेष्ठकर्म रक्तस्य)' । (A.Hr.Su. 11/4)

'जीवनं नाम प्राणधारणम्' । (Hemadri on A. Hr.Su. 11/4)

'तत् विशुद्धं हि रुधिरं बलवर्णसुखायुषा ।
युनक्ति प्राणिनं प्राण: शोणितं हि अनुवर्तते' ।। (Cha.Su. 24/4)

1) To support the body is the main function of rakta dhatu
2) To maintain life process is the most important function of rakta dhatu.

Rakta dhatu conducts prana to every dhatu, every cell of body. The air inhaled during the process of inspiration become vital prana (life) for human body. This prana along with rakta dhatu is supplied to every organ, tissue & cell to perform physiological activities.

Prana is an energy without which body will not function.

Body cannot survive without prana, & rakta dhatu is a medium for the conduction of prana, hence life depends on rakta dhatu.

Therefore hemorrhage or obstruction to blood flow can affect life.

'रक्तं वर्णप्रसादं मांसपुष्टिं जीवयति च' । (Su.Su. 15/5)

'धातूनां पूरणं वर्णं स्पर्शज्ञानमसंशयम् ।
स्वा: सिरा: संचरद् रक्तं कुर्याच्चान्यान् गुणानपि' ।।
(Su.Sha. 7/14)

3) Nourishment of dhatu: Rasa & rakta dhatu circulates in the body & supply nutrients to tissues.

4) Nourishment of mamsa dhatu: Proper nourishment of mamsa dhatu depends on proper formation of rakta dhatu. Proper functioning of mamsa dhatu depends on rakta dhatu.

During contraction of mamsa dhatu, it needs more & more prana, which rakta dhatu provides to mamsa dhatu.

Hence disorders of rakta dhatu can affect nourishment & functions of mamsa dhatu.

5) Varnaprasad (Maintenance of skin colour): Cheerful complexion is a symptom of pure rakta dhatu. Healthy rakta dhatu maintains normal colour of skin.

In the decrease of rakta dhatu, skin becomes whitish. In the vitiation of rakta dhatu colour of skin may become red, black or yellowish.

In necrosis colour of skin at particular region changes.

In skin diseases like leukoderma, the color of the skin changes.

6) Sparshajnyana (Sensation of touch): Proper conduction of rakta dhatu is responsible for knowledge of touch.

If skin is properly supplied by rakta, then one can get proper sensation of touch. Obstruction to the blood flow to particular region affects touch sensation.

Vitiation of rakta dhatu can cause tenderness of the skin.

In kushtha, due to vitiation of rakta & Vata dosha there is loss of touch sensation.

Role of Rakta dhatu in the formation of various organs in Intra uterine life

'गर्भस्य यकृत्प्लीहानौ शोणितजौ, शोणितफेनप्रभव; फुफ्फुसः, शोणित-किट्टप्रभव उण्डुकः' । (Su.Sha. 4/25)

'रक्तमेदःप्रसादाद् वृक्कौ, मांसासृक्कफमेदःप्रसादाद् वृषणौ, शोणितकफप्रसादजं हृदयम्' । (Su.Sha. 4/31)

In the embryonic life, rakta dhatu plays important role in the formation of liver, spleen, lungs, colon, kidenys and hearts.

Rakta Dhatu sarata

'कर्णाक्षिमुखजिह्वानासौष्ठपाणिपादतलनखललाटमेहनं च स्निग्धरक्तं श्रीमद्-भ्राजिष्णु रक्तसाराणाम् । सा सारता सुखं उद्धतां मेधां मनःस्वित्वं सौकुमार्यमनतिबलम् अक्लेशसहिष्णुत्वम् उष्णासहिष्णुत्वं चाचष्टे' । (Cha.Vi. 8/106)

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'स्निग्धताम्रनखनयनतालुजिह्वौष्ठपाणिपादतलं रक्तेन' । (Su.Su. 35/16)

Individuals who possess uttama rakta dhatu sarata are endowed with following symptoms:

Ears, eyes, oral cavity, tongue, palms, soles, nail, forehead, penis } Color of these organs is red

These organs are very lustrous, glossy. Such individuals are very attractive, handsome.

They cannot sustain strenuous job or, hot climate. They are endowed with intelligence, happiness and beauty.

Disorders of Rakta dhatu

Symptoms of increased Rakta dhatu
(Rakta vriddhi)

Due to over indulgence of oily, pungent food, due to hot climate, rakta dhatu increases & following symptoms of increases rakta dhatu can be seen:

'रक्तं रक्तांगाक्षिता सिरापूर्णत्वं च' । (Su.Su. 14/16)

Redness of eyes & skin, engorgement of blood vessels.

Symptoms of decreased Rakta dhatu
(Rakta kshaya)

Malnutrition, improper diet causes deficiency of rakta dhatu.

'रक्ते अम्लशिशिरप्रीतिः सिराशैथिल्यरूक्षता' ॥ (A.Hr.Su. 11/17)

Craving for sour, cold food and collapsing of veins are the symptoms of decreased rakta dhatu.

Decreased rakta dhatu results in Vata vriddhi. Craving for sour food reduces vata dosha.

Importance of Rakta dhatu

'देहस्य रुधिरं मूलं रुधिरेणैव धार्यते ।
तस्माद् यत्नेन संरक्ष्यं रक्तं जीव इति स्थितिः' । (Su.Su. 14/44)

Sushruta says that rakta dhatu is a root of living body; it maintains life, so one should take proper care of rakta dhatu by proper diet that gives nourishment to rakta & proper regimen.

BLOOD

Blood is a connective tissue, which is made up of plasma and blood cells. Blood is a red, opaque and slightly alkaline tissue.

Composition of Blood

Blood is composed of plasma and different types of cells. Blood cells remain suspended in the plasma.

Constituents of Blood

1) Water is the main constituent of blood.
2) Inorganic constituents like sodium, potassium, calcium, iron, copper, phosphorus etc.
3) Urea, uric acid, creatine, ammonia etc.
4) Serum albumin, serum globulin, fibrinogen, prothrombin etc.
5) Glucose, fats, amino acids, vitamins.
6) Red blood cells, White blood cells, Platelets.

Functions of Blood

1) Transport of oxygen from the lungs to the tissues and CO_2 from the tissues to the lungs.
2) Transport of glucose, fats and amino acids to the liver and to other tissues.
3) Transport of hormones, vitamins to their places of activity.
4) Blood carries waste products of cellular activity and brings them to kidneys, lungs or intestine.
5) Blood maintains water balance.
6) Blood maintains acid-base equilibrium.

7) Blood regulates body temperature.
8) White blood cells of blood protects body by their phagocytic action.
9) Viscosity of blood helps to maintain blood pressure.

Blood Corpuscles

Blood corpuscles are also called as blood cells. Blood cells are suspended in the plasma.

Types of Blood cells are :

1) Erythocytes (Red blood cells)
2) Leucocytes (White blood cells)
3) Thrombocytes (Platelets)

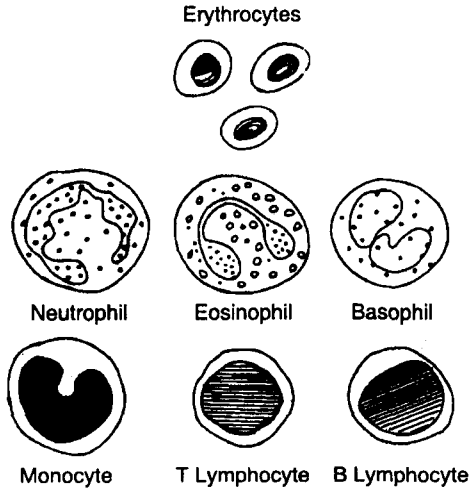

Fig 1 : Blood cells

Erythocytes (Red blood cells)

The mature human red blood cell is a biconcave, non-nucleated disc. The mature R.B.C. is very soft and flexible, so that it can easily squeeze through narrow capillaries. Mean diameter of R.B.C. is 7.2 microns. Red blood cells contain a pigment called as **Haemoglobin**.

Normal count of R.B.C.

In Male - 4.5-5.5 million/cu.mm.
In Female - 3.5 - 4.5 million / cu.mm.
New born baby - 6-7 million / cu.mm.

Physiological variations of red blood cells count

1) Red blood cell count is lowest during sleep and maximum in the evening.
2) Red blood cell count rises during muscular exercise.
3) Red blood cell count rises at higher altitude.
4) Red blood cell count rises at higher temperature.

Functions of red blood cells

1) Carriage of oxygen.
2) Transport of carbon dioxide. Red blood cells contain enzyme called as carbonic unhydrase which removes CO_2 from the blood.

Source of energy of red blood cell

Red blood cells require energy to perform its functions. Red blood cell depend on plasma glucose for its metabolic activities.

Development of Red Blood Cells

1) In early embryonic life, red cells are produced in the yolk sac.
2) During middle trimester of gestation, red cells are produced in the liver and spleen.
3) During later part of gestation and after birth, red cells are produced in red bone marrow. Red bone marrow is present in the cavities of the bones. Red bone marrow is also called as Myeloid tissue.

The process of formation of Erythrocyte or red blood cell is called as **Erythrpoiesis.**

After birth upto age of twenty, red bone marrow of almost all

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bones produce red blood cells. But after the age of twenty, the marrow of long bones become fatty except at the proximal portion of tibia and fibula.

Hence after the age of twenty, red bone marrow of vertebrae, sternum, ribs and ileum produce red blood cells.

Hormones required for Erythrpoiesis are:

1) Erythropoietin (EPO)- This hormone is secreted by kidneys.

2) Thyroxine and Testosterone.

Stages of Erythropoiesis

In red bone marrow, blood cells develops from pluripotential haemocytic stem cells.

Red blood cells, White blood cells and Platelets originates from haemocytic stem cells of red bone marrow.

The early offspring cells orignated from stem cells are called as committed cells.

The different committed cells produce colonies of particualr types of blood cells. The colonies produced from committed cells are called as colony-forming unit CFU.

A committed stem cell that produces red blood cell is called as CFU-erythrocyte, in the same manner, CFU for white blood cells are produced.

Erythroblast is a precursor cell, which develops from CFU-erythrocyte.

Stages of erthropoiesis are shown in the following chart:

Pluripotential stem cells

|

Committed cells

|

CFU - erythrocyte

|

Proerythroblast
|
Early erythroblast
|
Intermeidate erythroblast
|
Late erythroblast
|
Reticulocyte
|
Erythocyte

Time taken for erythropoiesis

It takes 7 days for the formation of mature, non nucleated erythrocyte.

Life span of Red blood cell- 120 days.

Site of fate of Red blood cell- Liver and Spleen.

Fate of red blood cells

1) As the red blood cells grow older, they become fragile, they change their shape and size.

2) Red blood cells burst and hemoglobin is released.

3) Phagocytosis of hemoglobin takes place in liver and spleen.

4) Iron in the hemoglobin is released and reutilised for the formation of new red blood cells or iron is stored in liver in the form of ferritin.

5) The prophyrin part of hemoglobin molecule undergo a series of transformtion, and converted into biliverdin. Biliverdin is reduced to free bilirubin.

6) Free bilirubin is absorbed through the hepatic cells.

7) In the liver free bilirubin conjugates with glucuronic acid, and conjugated bilirubin is formed in the liver.

8) Conjugated bilirubin is excreted into the bile and then into the small intestine.

9) In the intestine half of the conjugated bilirubin is converted to urobilinogen and stercobilinogen.

10) Urobilinogen is absorbed and excreted in the urine.

11) Stercobilinogen is excreted in feces.

Hemoglobin

The red pigment of red blood cell is called as hemoglobin.

Hemoglobin consist of two parts:

1) globin, 2) haem

Globin is a specific simple protein while haem is a metalloporphyrin, where the metal is iron.

Functions of Hemoglobin

1) Carriage of oxygen from the lungs to the tissues.
2) Transport of Carbon dioxide from the tissues to the lungs.
3) Hemoglobin helps to maintain acid-base balance by removing CO_2 in the blood.
4) Bile pigments are formed from the hemoglobin.

Normal value of hemoglobin

Males = 14gms - 16 gms%
Females = 11gms - 14 gms%
New born baby = 23 gms%

Oxygen carriage capacity of haemoglobin

At normal temperature pressure, one gram of haemoglobin combines with 1.34 ml of oxygen.

Factors affecting red blood cell formation and haemoglobin formation are as follows :

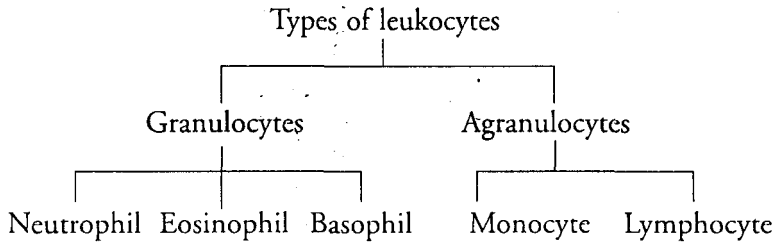
1) Food, rich in proteins is required for erythropoiesis and Hb formation.

2) Vitamin B_{12} & Vitamin C are required for proper formation of red blood cells and Hb.
3) As iron is an important constituent of haemoglobin, diet rich in iron is required for Hb formation. Daily 12 mgm iron is required.

White blood cells (Leukocytes)

Types of leukocytes

Division of leucocytes is done on the basis of granules present in the cytoplasm and number of lobes of the nucleus.



Normal W.B.C. count = 4000-11000/ cu.mm.

The ratio of the total W.B.C. count with the total red cell count is 1:700. For one W.B.C., there are 700 Red blood cells.

Physiological variations of W.B.C. count

1) Diurnal variation - In the morning or after rest, the W.B.C. count is lowest. The W.B.C. count is highest in the evening.

There is no obvious cause for such variations.

2) During muscular exercise, W.B.C. count rises.

3) In new born baby, W.B.C. count is very high. In new born baby, W.B.C. count is 20,000/cu.mn.

Leucopoiesis

Process of formation of white blood cells is called as leucopoiesis. Granulocytes and Monocytes are formed in red

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bone marrow. Lymphocytes and Monocytes are formed in spleen and lymphatic tissue. Monocytes to some extent are formed in red bone marrow.

Development of Granular leucocytes

Granulocytes are developed from the haemocytic stem cells of red bone marrow.

Colony forming unit - CFU for each granulocyte and monocyte originate from the stem cells of red bone marrow and mature granulocytes are developed from their respective colony forming units.

Development of Lymphocytes

Lymphocytes are formed in spleen, tonsils, lymphatic nodules.

In embryo T lymphocytes are processed in thymus, therefore called as T cells, while B cells are produced in bone marrow, then T and B lymphocytes become embedded in lymphoid tissue. The white blood cells are stored in the bone marrow. Lymphocytes are stored in lymphoid tissues.

Life span of Leucocytes

Leucocytes	Life-span
Neutrophils	2-4 days
Eosinophils	8-12 days
Basophils	12-15 days
Lymphocytes	1-2 days
Monocytes	2-3 days

Percentage of White blood cells

Neutrophil = 60 - 70%
Eosinophil = 1 - 6%
Basophil = 0 - 1%
Lymphocyte = 20 - 45%
Monocyte = 2 - 4%

Functions of White blood cells

1) Phagocytosis - The process of engulfing the foreign particles and bacteria and destruction of bacteria is called as phagocytosis.

Stages of phagocytosis are as follows :

- When an infection occurs, neutrophils and monocytes migrate to the site of infection.
- Monocyte enlarges and enlarged monocytes are called as phagocytic macrophages.
- Microphages attach to the surface of micro-organisms.
- Projections are formed from the cell membrane of microphages.
- Projections fuse with each other to form phagocytic vesicles.
- Micro-organisms are trapped in the phagocytic vesicles.
- Digestive enzymes of macrophages digest the trapped micro organisms, and micro-organisms are destructed.

2) Antibody formation is the important function of T lymphocytes.

3) In the process of repair, fibroblast are formed from leucocytes.

4) Basophil secrete 'Heparin', which prevents intravascular clotting.

5) Eosinophil acts against parasites and allergies.

Clinical significance of total W.B.C. count

Whenever there is an infection, W.B.C. count increases.

Leucocytosis - When total W.B.C. count is more than 11,000/cu.mm, the condition is called as leucocytosis.

Leucopenia - The condition in which total W.B.C. count is below 4000/cu.mm then this condition is called as Leucopenia.

Leukemia - is the malignant condition, in which number of white blood cells is greatly increased.

The following table indicates the various condition in which there is increase in the number of white blood cells:

Type of WBC	*Condition*
1) Neutrophilia (Rise in neutrophils)	Pneumonia, Meningitis, Trauma, Appendicitis
2) Eosinophilia	Worms, Filaria, Asthma
3) Basophilia	Chronic myeloid leukemia
4) Lymphocytosis	Tuberculosis, Malaria, Typhoid
5) Monocytosis	Chronic inflammation, Tuberculosis

There are various conditions, which develops leucopenia. In the first weak of typhoid, body develops leucopenia.

Thrombocytes (Platelets)

Thrombocytes are round shaped or oval shaped cells of blood. Thrombocytes are developed in red bone marrow. Platelets are non nucleated cells. In peripheral blood smear, platelets appears in clumps.

The number of platelets = 2,50,000 - 4,50,000 / cubic mm of blood.

Functions of platelets

1) Platelets initiate blood clotting.
2) Platelets repair delicate capillary walls.
3) Speed of clot retraction depends on the number of platelets present.

Decreased platelet count produces haemorrhage under the skin and mucous membrane, this condition is called as purpura.

Haemostasis and blood coagulation

Prevention of blood loss is called as haemostasis.

Steps of haemostasis are :

1) Vascular spasm
2) Platelet plug formation
3) Blood coagulation

Vascular spasm

Contraction of blood vessel immediately after the injury is called as vascular spasm. Vascular spasm reduces blood flow.

Platelet plug formation

Platelets migrate to the injured tissue. When platelets comes in contact with damaged surface, platelets begin to swell, they becomes sticky and adhere to the damaged surface. Adherence of large number of platelets to the damaged tissue is called as platelet plug formation. If the damage is small, platelet plug can stop bleeding. If the tissue damage is not small, then fibrin is required to stop the blood.

Blood Coagulation

Blood coagulation is a third step of haemostasis. This step begins after 15 seconds of injury, if the injury is severe.

Blood coagulation requires various chemicals called as coagulation factors. Coagulation factors are formed in the liver. Vitamin K is required for the formation of coagulation factors. Coagulation factors are present in plasma. There are 13 coagulation factors. These factors become active only after injury to the tissue or blood vessel.

The coagulation factors are as follows:

Coagulation Factors	*Synonym*
I	Fibrinogen
II	Prothrombin
III	Thromboplastin
IV	Calcium ion

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Coagulation Factors	*Synonym*
V	Proaccelerin
VI	Not named
VII	Serum prothrombin Conversion accelerator
VIII	Anti hemophilic factor A
IX	Christmas factor
X	Stuart factor
XI	Antihemophilic factor C
XII	Hageman factor
XIII	Fibrinase

Fibrinogen and prothrombin are protein in nature.

Thromboplastin is present in the plasma as well as on the surface of every tissue.

Thromboplastin present in the plasma is called as intrinsic thromboplastin, and extrinsic thromboplastin is present on tissue surface.

Proaccelerin is required to convert prothrombin into thrombin.

Factor VII accelerates formation of extrinsic thromboplastin.

Antihemophilic factor and christmas factor enhances formation of intrinsic thromboplastin.

Process of formation of fibrin is as follows :

1) With the help of calcium ions, thromboplastin converts prothrombin into thrombin.
Thromboplastin + Prothrombin + Calcium ion = Thrombin

2) Thrombin interacts with fibrinogen to form fibrin. Fibrin is a clot which stops bleeding.
Thrombin + fibrinogen = Fibrin

3) Fibrin or clot seals the damaged walls of blood vessels and bleeding is stopped.

Within one or two weeks, clot is converted into fibrous tissue, or the small clots are removed. Removing of blood clots is called as lyses of blood clots. Plasminogen which is a plasma protein become active and is converted into plasmin. Plasmin digest fibrin and other coagulants and break the clot.

Disorders of coagulation

A condition in which abnormal clot develops in a blood vessel, is called as thrombosis.

Blood Coagulation Tests

Bleeding time, clotting time, prothrombin time are the laboratory tests, which are done to judge the coagulation process in the body.

Normal bleeding time - 2 to 3 minutes
Normal clotting time - 4 to 9 minutes
Normal prothrombin time - 12 seconds.

Blood Groups

Knowledge of blood groups is essential especially during blood transfusion.

The blood of donor must match with the blood of recipient. If blood of donor and recipients are not compatible, then hemolysis of donors corpuscles takes place inthe recipients body, which can cause dangerous effects; so before blood transfusion blood groups must be matched and crossed checked carefully.

Blood group can be identified on the basis of agglutinogen present on the surface of red blood cells.

Three hundred blood group systems exists but the most important systems of blood group are ABO system and Rh system.

ABO system of blood group consist of agglutinogens and

agglutinins. Agglutinogens are present on the surface of red blood cells and agglutinins are present in the plasma. ABO system consist of A and B agglutinogens. Agglutinins of ABO system are called as Anti-A and Anti-B agglutinins.

Individuals having 'A' agglutinogen belong to blood group 'A', person having 'B' agglutinogen on red blood cells has blood group 'B'. Individuals who manufactures 'A' and 'B' agglutinogen belong to blood group 'AB'. In blood group 'O', no agglutinogens are found on the surface of red blood cells.

Agglutinogens and Agglutinins of ABO system is shown in the following table:

Group	*Agglutinogen on RBC*	*Agglutinins present in plasma*
O	Absent	Anti A, Anti B
A	A	Anti B
B	B	Anti A
AB	A and B	Neither Anit A nor Anti B

Rh system of blood group

The agglutinogen of Rh system is called as D agglutinogen. D agglutinogen is also called as D antigen. Rh system does not contain any agglutinin in the plasma.

If D agglutinogens are present on the red blood cells then blood group is called as Rh +ve blood group. If D agglutinogen is absent, then blood group is called as Rh -ve group.

Hazards of Incompatible blood transfusion

1) If blood group of donor and recipient does not match with each other and if such mismatched blood is given to recipient then there is cross reaction between recipient's agglutinins and the agglutinogens of donors blood. Due to cross reaction, blood cels agglutinate and are hemolysed.

2) Recipient suffer from hemolytic jaundice.

3) Renal failure is the hazardous effect of incompatible blood transfusion.

To avoid these hazard, blood groups must be checked and cross match before blood transfusion.

Clinical significance of Rh system

If a Rh -ve female is impregnated by Rh +ve male, and if the fetus is Rh +ve, then during dilivery, while cutting the umbilical cord, some Rh +ve blood cells of baby may escape and enter the maternal blood. Rh -ve blood can make agglutinins against Rh +ve blood cells. Therefore mother's blood prepares Rh agglutinins against Rh +ve agglutinogens. Rh agglutinins circulates in the mothers body and if that female again becomes pregnant, then during the pregnancy, agglutinins cross the placenta and enter the fetal blood. If blood group of fetus is Rh +ve, then fetal blood hemolyses and this results in the hemolytic disease of the new born baby, which is called as erythroblastosis fetalis. To avoid the risk of Rh incompatibility, within 48 hours of dilivery, anti D antibody injection is given to mother, and next pregnancy would be safe.

Significance of blood group

1) Knowledge of blood group is essential before blood transfusion.
2) Blood groups of donor and recipient must be same.
3) Blood groups help in identifying paternity.
4) Detection of blood group of pregnant woman is necessary to avoid Rh incompatibility.
5) Blood group help to identify criminal case.

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Chapter 5

Mamsa Dhatu

Mamsa dhatu is the third dhatu formed and nourished by ahara-rasa.

Synonyms

'पिशितं तरसं मांसं पललं क्रव्यमामिषम्' ।

(Amarakosha. 2/6/63)

Pishita, taras, palala, Kravya, amisha are the synonyms of mamsa dhatu.

Site of Mamsa Dhatu

Channel of mamsa dhatu and mamsa-dhara kala is the seat of mamsa dhatu.

Mamsadhara Kala

'तासां प्रथमा मांसधरा नाम (कला) यस्यां मांसे सिरास्नायुधमनीस्रोतसां प्रताना भवन्ति' । (Su.Sha. 4/8-9)

It is the first kala produced in the body, which is the site of sira, srotas and dhamanis.

'मांसवहानां स्रोतसां स्नायुर्मूलं त्वक् च' । (Cha.Vi. 5/8)

'मांसवहे द्वे, तयोर्मूलं स्नायुत्वचं रक्तवहाश्च धमन्यः' । (Su.Sha. 9/12)

Roots of mamsavaha srotas are snayu and twacha - skin

Movement of skeletal muscles depends on snayu hence snayu is a root of mamsavaha srotas.

Skin is the secondary tissue of mamsa dhatu.

Function of mamsa dhatu and skin is same i.e. to cover or lepana; hence skin is also a root of mamsavaha srotas.

Metabolism of Mamsa Dhatu

'रक्तं·····मांसपुष्टिं (करोति) जीवयति च' । (Su.Su. 15/5)

Poshaka mamsa dhatu is formed during the metabolism of poshya rakta dhatu.

Hence formation of mamsa dhatu depends on rakta dhatu.

रक्ताद् अग्निपक्वान्मल: पित्तं स्थूलभाग: शोणितम् अणुभागस्तु मांसम् इति। ततोऽपि आत्मपावकपच्यमानात् मल: श्रोत्रनासाकर्णाक्षिप्रजननादिस्त्रोतोमल: स्थूलो भाग: मांसम्। (सूक्ष्मो मेद:)। (Dalhan. on Su.Su. 14/10)

Nutrients of mamsa dhatu — Mamsavaha srotas / agni of mamsa

1) Formation of mamsa dhatu
2) Nourishment of upadhatu and mala of mamsa dhatu
3) Formation of poshaka meda dhatu.

Heavy, oily food, sweet food, non vegetarian food nourishes mamsa dhatu.

Mamsa dhatvagni acts on poshaka mamsa dhatu and poshya mamsa dhatu is formed, along with it upadhatus and mala are formed in its srotas.

Time required for formation of mamsa dhatu

'तदनन्तरं (रसानन्तरं) ये षड्धातव: ते प्रत्येकं पंचभि: पंचभि: अहोभि: सम्पद्यन्ते'। (Su.Su. 14/14)

According to Sushruta, mamsa dhatu is formed on 20th day.

Constitution of mamsa dhatu

'मासं पार्थिवम्'। (Bhanumati on Su.Su. 15/8)

Mamsa dhatu predominantly consist of prithvi (earth) mahabhuta.

Qualities

'न अतिशीतगुरुस्निग्धं मांसम् अजम् दोषलम्। शरीरधातुसामान्यादनभिष्यंदि बृंहणम्'। (Cha.Su. 27/59)

Mamsa dhatu is slightly cold, heavy and unctuous.

Quantity

'दोषधातुमलानां तु परिमाणं न विद्यते' । (Su.Su. 15/37)

Functions of mamsa dhatu

Lepana is the most important function of mamsa dhatu.

'(मांसस्य) लेपः (श्रेष्ठं कर्म)' । (A.Hr.Su. 11/4)

Skin is the upadhatu of mamsa dhatu which covers whole body. Skin is an intact sense organs, which protect the body from infection.

'मांसं शरीरपुष्टिं मेदसः च', । (Su.Su. 15/5)

Nourishment of medo dhatu is the important function of mamsa dhatu.

'अनुप्रविश्य पिशितं पेशीर्विभजते तथा' । (Su.Sha. 4/29)

Formation of peshis in the intra-uterine life is the function of mamsa dhatu.

Peshis are formed from mamsa dhatu during fetal life. Vayu divides mamsa dhatu in different types of peshis. To give strength and support to the body is the function of peshis.

Mamsa dhatu is the medium of Vata dosha. Symptoms of vitiated Vata dosha reveal the close relationship between Vata dosha and mamsa dhatu. Tremors (kampa) twitching of muscles, muscle stiffness, joint stiffness (stambha), muscle pain, paralysis, hernia, prolapse these are the few symptoms of vitiated Vata dosha which shows impaired functioning of mamsa dhatu.

Upadhatus (secondary tissue) of mamsa dhatu

'मांसाद् वसा त्वचः षट् च' । (Cha.Chi. 15/7)

Vasa (muscle fat) and twacha are upadhatus of mamsa dhatu.

'मांसस्य खमलो मलः' । (Cha.Chi. 15/18)

Mala (waste product) of mamsa dhatu: Malas which accumulate in the external orifices of the body is called as a khamala which is a mamsa mala.

Symptoms of mamsa-sarata

'शङ्खललाटकृकाटिकाक्षिगण्डहनुग्रीवास्कन्धोदर: कक्षवक्ष: पाणिपादसंधय: गुरुस्थिरमांसोपचिता: मांससाराणाम् । सा सारता क्षमां धृतिम् अलौल्यं वित्तं विद्यां सुखम् आर्जवम् अरोग्यं बलम् आयुश्च दीर्घम् आचष्टे' । (Cha.Vi. 8/104)

'अच्छिद्रगात्रं गूढास्थिसन्धि मांसोपचितं च मांसेन' । (Su.Su. 35/16)

Temples, forehead, nape, eyes, cheek, jaws, neck, shoulder, abdomen, axillae, chest, arms, legs, joints of an individual who is endowed with mamsasara, are firm, heavy, and properly covered with mamsa dhatu. Bony structures are invisible as bones are covered with mamsa dhatu.

Such individuals are endowed with forgiveness, patience, non-greediness, wealth, knowledge, happiness, politeness, simplicity, health, good strength and longevity.

Disorders of Mamsa Dhatu

Symptoms of Mamsa-vriddhi

'मांसं स्फिग्गण्डौष्ठोपस्थोरुबाहुजंघासु वृद्धिं गुरुगात्रता च' । (Su.Su. 15/8)

Heaviness of body, flabbiness of buttocks, cheeks, arms, thighs etc. are the symptoms of Mamsa-vriddhi. Over indulgence of sweet, heavy and oily food, lack of exercise are the causes of Mamsa-vriddhi.

Symptoms of mamsa kshaya

'मांसे अक्षग्लानिगण्डस्फिक् शुष्कता सन्धिवेदना:' ॥ (A.Hr.Su. 11/18)

Over indulgence of dry, light food, over exercise are the causes of Mamsa-kshaya.

Fatigue of the eye muscles, emaciation of cheeks, buttocks, pain in joints (arthralgia) are the symptoms of decrease in mamsa dhatu.

In decreased mamsa dhatu, diet and regimen homologues to mamsa dhatu is advised, for e.g. diet containing wheat, meat of various animals, fish as well as massage with mahanarayan oil, dhanvantara or mahamasha oil is advised.

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ashwagandha, milk and naranyan oil are indicated in mamsa-kshaya.

MUSCLE TISSUE

'Movement' is the important body function.

Muscle tissue is an important connective tissue which is essential for movement of the body.

Special Features of Muscle Tissue

Contraction and relaxation are the two movements of muscles. Due to these movements, muscle can perform following, functions: Motion, maintenance of posture and heat production.

Motion - Walking, running, respiratory movements, cardiac movements etc.

Maintenance of posture - Partial contraction of skeletal muscles maintains posture of body in stationary positions for e.g. standing and sitting.

Heat production - Due to contraction of skeletal muscle, heat is produced in the body.

Muscle tissue forms walls of body cavities and supports the organs in the cavities. Muscles help in respiration, so help in maintenance of acid base balance.

Types of Muscle Tissue

- Skeletal muscle tissue (Striated muscle tissue)
- Cardiac muscle tissue (Striated muscle tissue)
- Visceral muscle tissue (Non striated muscle tissue)

Functional Division of Muscle Tissue

- Voluntary muscle e.g. skeletal muscles
- Involuntary muscles e.g. 1) Smooth muscles 2) Cardiac muscles

Histology of Muscle Tissue

Cells of muscle tissue are called as muscle fibers.

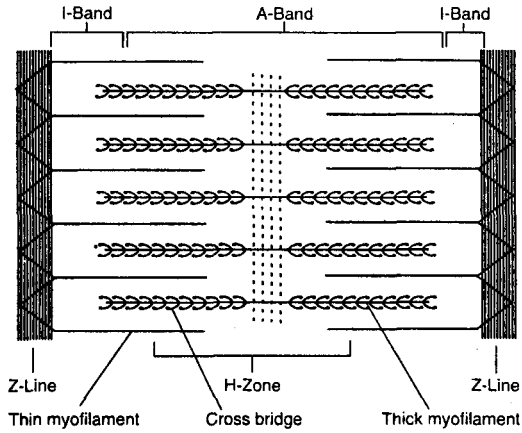

Fig. 2 : Muscle fibre with thick and thin myofilaments

Sarcolemma - It is an outermost covering of muscle fiber.

Sarcoplasm - Cytoplasm in the muscle cell is called as sarcoplasm.

Contents of Sarcoplasm - It consist of many nuclei, sarcoplasmic reticulum and transverse tubules.

Each skeletal muscle fiber consists of thick myofilament and thin myofilament. Thick and thin myofilaments are arranged in compartments called as sarcomer.

In the sarcomer there is alternate arrangement of thick and thin myofilaments which overlap each other.

Alternate arrangement of thick and thin myofilament gives striated appearance to skeletal muscles.

Thick myofilaments are made up of following protein are 1) Actin and 2) Myosin.

Proteins from which thin myofilaments are formed are:

1) Actin
2) Troponin
3) Tropomyosin.

Cross bridges - Projecting heads of myosin are called as cross bridges. They consist of actin and ATP binding sites.

Sarcomers are separated from each other by narrow line called as Z line.

Sarcomers consist of dark area called as 'A' band and light area called as 'I' band.

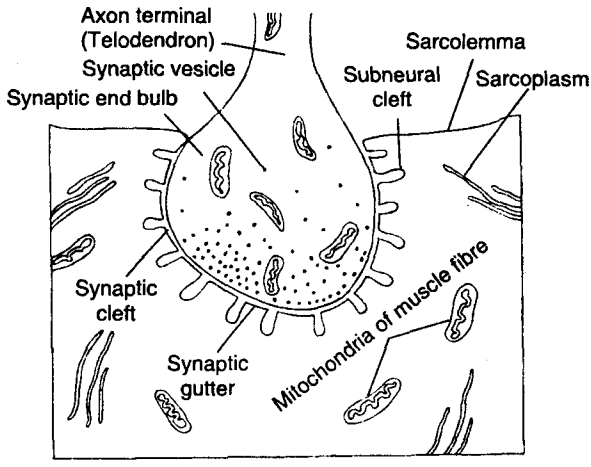

Fig 3 : Neuromuscular Junction

Neuromuscular junction - Contraction and relaxation are two movements of skeletal muscle. Skeletal muscle must receive stimulus for its contraction by a motor neuron. Every muscle fiber receives motor nerve fiber (motor neuron).

Axon is the thread like process of motor neuron which transmits motor stimulates from neuron to muscle fiber.

Axon terminal

When axon of motor nerve reaches surface of muscle fiber, this axon divides into branches. This branching of axon of motor neuron is called as axon terminal.

Motor end plate

The region of sarcolemma of muscle fiber in contact with axon terminal is called as motor end plate.

Neuromuscular junction consists of axon terminal of a motor neuron + motor end plate.

Synaptic end bulb: These are the bulb like structures present at the distal end of axon terminals. Synaptic end bulbs consist of neurotransmitter called as acetylcholine (Ach)

Synoptic cleft - It is a space between axon terminal and sarcolemma.

Synoptic Gutter - The portion of sarcolemma which surrounds axon terminal is called as synaptic gutter.

Physiology of Muscle Contraction

1) Motor neuron conducts stimulus to muscle fibers.

2) Due to nerve action potential, synaptic end bulb releases acetylcholine (Ach).

3) Acetylcholine diffuses across the synaptic cleft of neuro-muscular junction.

4) Due to Ach, muscle action potential develops and that spreads over sarcolemma.

5) Sarcoplasmic reticulum releases calcium ion into sarcolemma.

6) Due to calcium ions, troponin & tropomyosin move and due to this movement, myosin binding sites on actin gets exposed.

7) Muscle needs energy for contraction.

8) ATP is the source of energy for contraction.

9) Due to action potential, energy is obtained from ATP molecules.

10) The energy formed in ATP splits, and activates myosin cross bridges of myosin.

11) Myosin cross bridges combine with myosin binding sites of action.

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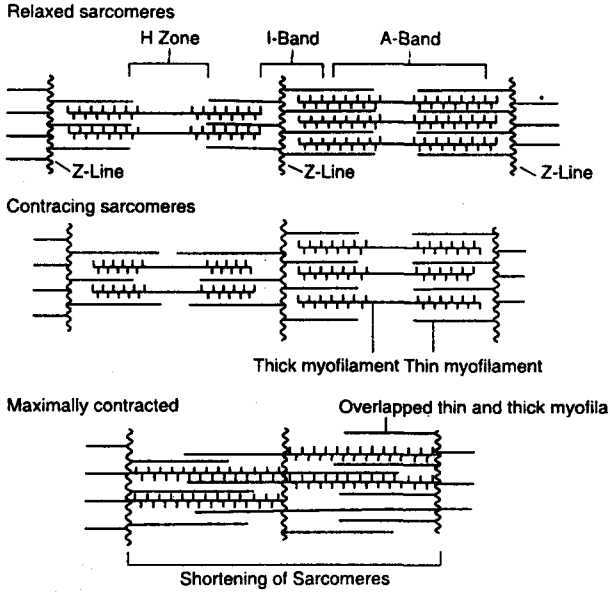

Fig. 4 : Sliding Filament Theory

12) Thin and thick myofilaments slide overlap each other.

13) Due to sliding of filaments, the sarcomeres shorten and muscle fibers contract and contraction of muscle takes place.

14) After contraction Ach become inactive.

15) Calcium ions go back to sarcoplasmic reticulum. Thin and thick myofilaments move to resting position. Sarcomers returns to their resting length and muscle fiber relaxes.

In this way contraction and relaxation of muscle takes place.

Energy Source for Muscle Contraction and Relaxation

1) ATP - It supplies energy for muscle contraction for short duration, i.e. only for 5 to 6 seconds.

2) Phospho-creatine - Phospho-creatine is a high energy molecule. It is a alternative source of energy. When muscles required energy for a longer time then phospho-creatine is

converted to energy. Phosphogen system provides energy for 15 second.

3) Glycogen lactic acid system: In prolonged muscle activity, after phosphogen system, muscles uses glucose for energy.

Glucose is converted to pyruvic acid.

Formation of pyruvic acid doesn't require oxygen so it is called as anerobic respiration.

Conversion of pyruvic acid takes place in the muscle fiber.

Pyruvic acid $\rightarrow$ In presence of oxygen $\rightarrow CO_2+H_2O$

This process needs oxygen, so called as cellular or aerobic respiration.

In absence of oxygen following events takes place:

1) Pyruvic acid in absence of oxygen is converted into lactic acid.

2) Lactic acid produces energy called as glycogen lactic acid system. Some lactic acid may leak in blood. Liver can convert lactic acid into glucose.

3) Glycogen - Lactic acid system provides energy for 30 to 40 seconds of muscular activity.

Clinical application of muscle contraction and energy

Knowledge of muscle contraction, energy supply of muscles is important in sports.

Athletes consume large amount of carbohydrates just before the event, this is called as carbohydrate loading.

Carbohydrate loading supply - additional energy to athletes.

For 100 meter running event, phosphogen system can provide energy.

For 400 meter running event, glycogen lactic acid system provides energy for 30 to 40 seconds.

Types of muscle contractions

Isometric contraction, isotonic contraction, tetanus, treppe and twitch.

Disorders of muscular system

Fibromyalgia, muscular hypertrophy, muscular atrophy, myasthenia gravis, abnormal contractions like spasm, tremors fibrillation.

Chapter 6

Medo Dhatu

Medo dhatu is the Fourth dhatu formed & nourished by ahara rasa.

Etymology (Nirukti)

'मेदयति स्निह्यति अनेन इति मेदः' ।

The word meda is derived from the Sanskrit word meaning oleation or to apply oil. Medo dhatu is the unctuous dhatu like ghee.

Synonyms

Mamsaja, mamsateja, asthikrit, vapa, vasa, goda.

Site

1) Medo dhatu is distributed throughout the body.
2) It is deposited under the skin.
3) But mainly it is deposited on buttocks, breast and abdomen.

Medovaha srotas

'मेदोवहानां स्रोतसां वृक्कौ मूलं वपावहनं च' । (Cha.Vi. 5/10)

Vrikka (kidneys), vapavahana (omentum) are roots of medovaha srotas.

In intrauterine life kidneys are formed from medo dhatu.

Anatomically large amount of fat is deposited around both kidneys which is called as perinephric fat. The organ which has been formed from medo dhatu, controls the formation of medo dhatu after birth. Omentum is a storehouse or depot of medo dhatu. According to Sushruta, kati (pelvic girdle) is a root of medo dhatu.

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'मेदोवहे द्वे, तयोर्मूलं कटी वृक्कौ च'। (Su.Sha. 9/12)

Medodhara kala

Medodhara kala holds & nourishes medo dhatu.

'तृतीया मेदोधरा (कला) मेदो हि सर्वभूतानाम् उदरस्थम् अण्वस्थिषु च महत्सु च मज्जा भवति'। (Su.Sha. 4/12)

Medodhara kala occupies peritoneum and small bones & mamsa. Medo dhatu is present inside the small bones.

'मेदसो अपि यत् स्थानं वसाबहुलं तत् अपि आमाशय एकदेशे एव'॥
(Chakrapanidatta on Cha.Vi. 6/28)

Small amount of medo dhatu is also deposited around amashaya (stomach)

Panchabhautika Constitution

1) Medo dhatu is made up of Jala and Prithvi mahabhutas

   'मेदो जलपृथिव्यात्मकम्'। (Bhanumati on Su.Su. 15/8)

2) According to Charaka, medo dhatu is made up of Jala mahabhuta.

Metabolism

'तथा मांसपोषणकालादुत्तरकालं मेदःपोषको रसभागो मेदः पोषयतीत्यादि'।
(Dalhan on Su.Su. 14/10)

After nourishment of mamsa dhatu, ahara-rasa nourishes medo dhatu.

'ततोऽपि निजवह्निपच्यमानान्मलः स्वेदः, स्थूलोंऽशो मेद एव, सूक्ष्मभागोऽस्थि·····'। (Dalhan on Su.Su. 14/10)

1) According to Kshira-dadhi nyaya, medo dhatu is formed after mamsa dhatu.
2) Oily, soft food products undergo digestion & according to Khale-kapota nyaya, immediately medo dhatu is produced in medovaha srotas.
3) Poshaka medo dhatu is acted upon by Agni of meda

dhatu and poshya medo dhatu, its upadhatu and mala are formed in medovaha srotas:

Nutrients of medo dhatu	Medovaha srotasa / Agni of meda	1) Formation of poshya meda 2) Formation of poshakasthi 3) Formation of upadhatu & mala

Time required for transformation of medo dhatu

'तदनन्तरं (रसानन्तरं) ये षड्धातवः, ते प्रत्येकं पंचभिः पंचभिः अहोभिः सम्पद्यन्ते'। (Su.Su. 14/4)

On 15th day stable medo dhatu is formed.

Qualities

1) unctuousness, 2) softness, 3) heaviness and 4) stability.

Quantity

'द्वौ मेदसः (अंजली)'। (Cha. Sha. 7/17)

Anjali pramana of medo dhatu is 2 anjali.

Absence of symptoms of increase or decrease in medo dhatu indicates normal quantity of medo dhatu.

'दोषधातुमलानां परिमाणं न तु विद्यते'। (Su.Su. 15/5)

Functions of Medo dhatu

'स्नेहः (मेदसः श्रेष्ठं कर्म)'। (A.Hr.Su. 11/4)

'मेदः स्नेहस्वेदौ दृढत्वं पुष्टिमस्थ्नां च'। (Su.Su. 15/5)

1) To lubricate every cell of the body is the most important function of medo dhatu.
2) It controls sweat formation.
3) It provides strength, energy to the body.
4) It controls dryness of Vata.

While emphasizing lubricating action of medo dhatu, Charaka has given following example - He says that

leather becomes more sturdy and strong due to application of oil or life of any machine can be improved by lubricating it with oil. In the same way regular application of oil on the body, provides strength to body constituents. Oily massage increases longevity.

5) Proper nourishment of medo dhatu gives proper shape to the body.
6) Medo dhatu acts as shock absorber.
7) Medo dhatu protects body from excess cold or hot climate.
8) In starvation energy can be obtained from medo dhatu.
9) Asthiposhan is a another important function of medo dhatu.

Symptoms of Medah sarata

'वर्णस्वरनेत्रकेशलोमनखदंतौष्ठमूत्रपुरीषेषु विशेषतः मेदः मेदःसाराणाम्। सा सारता वित्तैश्वर्यसुखोपभोगप्रदानानि आर्जवं सुकुमारोपचारताम् आचष्टे'।

(Cha.Vi. 8/105)

Person having uttam meda sarata has unctuous complexion, sweet voice. Eyes of such person are very unctous & moist. Person having good quality of meda sarata has abundant unctuousness in hair, nails, lips, urine & feces and teeth.

Such individuals are endowed with wealth, power, happiness, enjoyment, charity. They are very delicate (cannot withstand hard work) hence unable to bear physical strain.

'स्निग्धमूत्रनेत्र(स्वेद)स्वरं बृहच्छरीरं आयासासहिष्णुं मेदसा'।

(Su.Su. 35/16)

In spite of bulky body such person cannot perform hard work.

Upadhatus

'मेदसः स्नायुसम्भवः'। (Cha.Chi. 15/17)

Snayu is the upadhatu of medo dhatu
(Refer 'Upadhatu' for detail information of snayu)

Waste products

'स्वेदस्तु मेदस: (मल:)' । (Cha.Chi. 15/18)

Sweat is the waste product of medo dhatu

Disorders of Medo dhatu

Symptoms of Increase in Medo dhatu
(Medo vriddhi)

'तद्वन्मेदस्तथा श्रमम् अल्पेऽपि चेष्टिते श्वासं स्फिक्स्तनोदरलम्बकम्' ।
(A.Hr. Su. 11/10)

Over eating of sweet, oily heavy food, lack of body exercise leads to increase in meda dhatu. Fatigue, dyspnoea, pendulus growth of buttocks, breast, abdomen due to deposition of excess of medo dhatu.

Hot, light & dry food, heavy exercise, drugs like Triphala guggulu, Yogaraja guggulu reduces medo dhatu.

Symptoms of Decrease in Medo dhatu
(Medah kshaya)

'मेदसि स्वपनं कट्या: प्लीह्नो वृद्धि: कृशांगता' । (A.Hr. Su. 11/17)

Symptoms of medah kshaya are loss of sensation (supti) in the waist region. Enlargement of spleen, emaciation of the body. Due to loss of medo dhatu spleen becomes palpable. But it should be noted that spleen is not enlarged in this condition.

Substances homologues to medodhatu i.e. heavy, oily, sweet food along with proper rest, oil massage is advised in Medah kshaya.

'मेद:क्षये प्लीहाभिवृद्धि: सन्धिशून्यता रौक्ष्यं मेदुरमांसप्रार्थना च' ।
(Su.Su. 15/13)

Spleenomegaly, numbness around joints, dryness, craving for nonveg food are also the symptoms of medah kshaya.

ADIPOSE TISSUE

Adipose tissue is a type of loose connective tissue.

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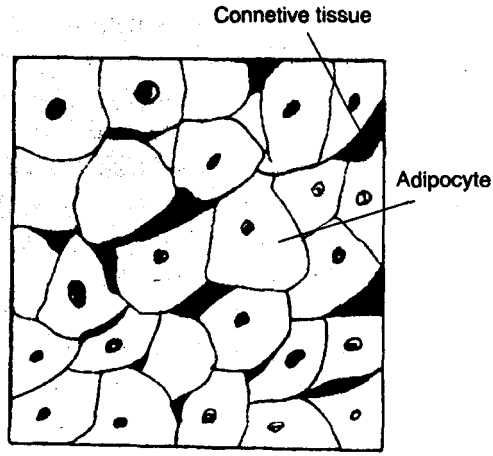

fig 5 : Histology - Cells of Adipose tissue - adipocytes

Adipocytes

Cells of Adipose tissue are called adipocytes.

Shape of adipocytes: Large, oval or round shape.

Distribution of adipose tissue

Adipose tissue is found in following structures:

1) Omentum
2) Mesentery
3) Perinephric region
4) Around heart surface
5) Marrow of long bones
6) Mammary glands (breast)

Adipose tissue is absent in

1) Eyelids
2) Scrotum
3) Labia minora
4) Cranial cavity
5) Lungs (except their roots)

Functions of adipose tissue

1) Gives specific shape to body,
2) Regulation of body temperature,
3) Storage of fat,
4) Provides energy,
5) Keeps the viscera in position,
6) Acts as shock absorber and
7) It secretes hormone Leptin.

Chapter 7

Asthi Dhatu

The hardest dhatu in the body is asthi dhatu or bone.

Synonyms

Kikas, kulya, medoja, medoteja, sara, karkara are the synonyms of asthi dhatu.

Site

It is present under the skin all over the body.

Moola sthana

'अस्थिवहानां स्रोतसां मेदोमूलं जघनं च' । (Cha.Vi. 5/8)

Medas dhatu & flat pelvic bones (jaghana) are roots of asthi dhatu.

Medas is formed before asthi dhatu. Nutrition of asthi dhatu depends on proper nourishment of medo dhatu. Pelvic bones, are pillars of the body, which serves the function of dharana, which is the function of asthi dhatu, hence jaghana is also a root of asthivaha srotas.

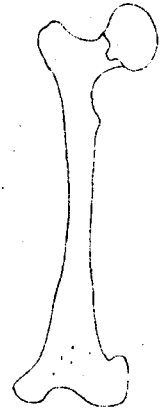

Fig 6 : Asthi Dhatu

Kala

'या एव कला पुरीषधरा सा एव अस्थिधरा' ।

(Dalhan on Su. Kalpa 4/40)

Purisha-dhara kala is the 5th kala which exist in large intestine i.e. in pakvashaya. Function of purisha-dhara kala is to separate constituents of kitta or waste products in colon. Vayu which is produced in pakvashaya (as anna-mala) is a poshaka vayu, which nourishes poshya vayu of the body.

Pakvashaya and asthi, both are main seats of Vata dosha. Therefore increased or decreased formation of Vata and purisha affects all sites of Vata, especially asthi dhatu. Hence purisha-dhara kala is also called as asthi-dhara kala.

Panchabhautika constitution

'अस्थि पृथिव्यानिलात्मकम्' । (Bhanumati on Su.Su. 15/8)

In spite of presence of all 5 mahabhutas, asthi has predominance of prithvi and vayu mahabhuta.

Qualities

'पृथिवि-अग्नि-अनिलादीनां संघात: श्लेष्मणाकृत: खरत्वं प्रकरोति अस्य जायते अस्थि ततो नृणाम्' । (Cha. Chi. 15/31)

Due to predominance of prithvi mahabhuta, asthi dhatu is very strong, rough, and dry and hard. Due to action of vayu and Agni and prithvi mahabhutas, asthi become dry, rough and hard.

Types

1) Nalakasthi - Long bones
2) Kapalasthi - Flat bones
3) Mandalakar asthi - Vertebrae
4) Ruchakasthi - Teeth
5) Tarunasthi - Cartilage

Metabolism

'ततोऽपि निजवह्निपच्यमानान्मल: स्वेद: स्थूलभाग: मेदम् सूक्ष्मभागोऽस्थि, ततोऽपि पच्यमानान्मल: केशलोमश्मश्रूणि, स्थूलोऽस्थि, सूक्ष्मस्तु मज्जा' ।

(Dalhan on Su.Su. 14/10)

'अस्थ्यपि द्रवरूपम् अस्त्येव स्रोतोवाह्यमिति कृत्वा अस्थिवहानाम् इत्युक्तम्' ।

(Chakrapani on Cha.Vi. 5/12)

Precursor of asthidhatu (Poshak asthi) is formed at the time of formation of medo dhatu.

Metabolism of Asthi dhatu takes place in the Asthivaha srotas.

Nutrients of asthi dhatu (Poshaka asthi)	Asthivaha srotas / Agni of asthi	1) Formation of poshya asthi dhatu 2) Formation of asthi mala & a upadhatu 3) Formation of poshaka majja dhatu

Time taken for formation

According to Parashar, Asthi dhatu is formed on the 6th day

'उक्तं हि पराशरे—"आहारोऽद्यतन:·····षष्ठे त्वस्थित्वं·····' ।

(Chakrapani on Cha.Chi. 15/20-35)

According to Sushruta, Asthi dhatu is formed on 20th day.

'तदनन्तरं (रसानन्तरं) ये षड्धातव: ते प्रत्येकं पंचभि: पंचभि: अहोभि: सम्पद्यन्ते' । (Su.Su. 14/4)

Functions

'धारणम् (अस्थ्न: श्रेष्ठं कर्म)' । (A.Hr.Su. 11/4)

'अभ्यन्तरगतै: सारै: यथा तिष्ठन्ति भूरुहा: ।
अस्थिसारै: तथा देहा ध्रियन्ते देहिनां ध्रुवम्' ।। (Su.Sha. 5/21)

1. Asthi dhatu supports the body, keeps body in erect position.

2. All soft structures like mamsa, sira, and snayus are situated around asthi dhatu or bones. Snayus connect skeletal muscles to bones. Snayus act like anchor hence muscles can contract or relax.

3. Asthi dhatu forms skeleton of the body. Function of asthi dhatu is compared to the hard core of bark of the tree.

4. Asthi dhatu protects various important organs, for e.g. skull bone protects brain, ribs protects lungs and heart.

5. Majja poshana is a function of asthi dhatu.

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'अस्थीनि देहधारणं मज्ज्ञः पुष्टिं च' । (Su.Su. 15/5)

Proper nourishment of majja dhatu depends on proper metabolism of asthi, because poshaka majja dhatu is formed during the formation of asthi dhatu.

Secondary Tissues - Upadhatus of Asthi dhatu

दन्ता अस्थ्नाम् उपधातुः' ।

(Adhamalla on Sharngadhar 1/5/16-17)

According to Sharngadhara, teeth are upadhatus of asthi dhatu.

(Detail information of teeth is given in chapter on upadhatu.)

Waste products of asthi dhatu

'केशलोमास्थ्नः (मलः)' । (Cha.Chi. 15/30)

'कफः पित्तं·····प्रस्वेदो नखरोम च' । (Su.Su. 46/529)

Hair and nails are waste products of asthi dhatu.

Symptoms of Asthi sarata

'पार्ष्णिगुल्फजान्वरत्निजत्रुचिबुकशिरःपर्वस्थूलाः स्थूलास्थिनखदन्ताश्च अस्थिसाराः । ते महोत्साहाः क्रियावन्तः क्लेशसहाः सारस्थिरशरीराः भवन्ति आयुष्मन्तश्च' ।

(Cha.Vi. 8/109)

Heels (parshni), ankles (gulpha), knee joints, elbow (aratni), clavicles (jatru), chin (chibuka), head, metacarpo-phalangeal joints, nails and teeth bones of asthi sara person are larger, and stronger. Asthi sara individual is very enthusiastic in nature. Since the bones gives good strength and power, these persons can carry out heavy manual work or exercise. They are endowed with stable body and longevity.

'महाशिरःस्कन्धं बृहद्दंतहन्वस्थिनखम् अस्थिभिः' । (Su.Su. 35/16)

According to Sushruta, head, shoulders, teeth, nails, bones, mandibles of asthi sara person are prominent and are large in size.

Disorders of Asthi Dhatu

Symptoms of Increased Asthi-dhatu

(Asthi-vriddhi)

'अस्थ्यध्यस्थीन्यधिदन्तांश्च' । (Su.Su. 15/18)

Extra bones like cervical spine or calcaneal spur (adhyasthi), over crowding of teeth are (adhidanta) the symptoms of asthi vriddhi.

Asthi dhatu and Vata dosha are related to each other. Their relationship is called as 'ashrayashrayi sambandha'.

Symptoms of Decreased Asthi dhatu

(Asthi-kshaya)

'अस्थिक्षयेऽस्थिशूलं दन्तनखभङ्गो रौक्ष्यं च' ॥ (Su.Su. 15/13)

'केशलोमनखश्मश्रूद्विजप्रपतनं श्रमः ।
ज्ञेयमस्थिक्षये रूपं संधिशैथिल्यमेव च' ॥ (Cha.Su. 17/67)

Painful joints, pain in bones, falling of hair, breaking of nails, unhealthy, weak teeth are the symptoms of asthi kshaya.

Excess of Vata has a reciprocal effect on asthi dhatu. This means that if the patient has excess of vata, he may suffer from asthi kshaya due to rarefaction of bones (osteoarthritic changes). Effects of asthi kshaya can be observed on the waste products of asthi dhatu i.e. on nails, hair and teeth.

Triphala guggulu, Yogaraja guggulu, oil massage and basti are very helpful in asthi kshaya.

SKELETAL TISSUE

Skeletal tissue or bone is a connective tissue. Skeletal system consists of all bones, joints and cartilages between joints.

Bony tissue consist of following structures:

Bone matrix: It is inter cellular substance. It surrounds cells of bone tissue. Intercellular substance contains (1) collagenous fibers, (2) mineral salts.

Mineral salts of bone

Calcium phosphate, calcium carbonate, magnesium hydroxide and fluoride etc. These salts are deposited in the framework of collagenous fibers.

Because of these salts bone tissue hardens.

Cells of bone tissue

1. Osteogenic cells give rise to osteoblast cells.
2. Osteoblast cells are related with bone formation.
3. Ostecytes are mature bone cells or principle bone cells.
4. Osteoclasts cells function in bone degradation.

Type of bony tissue

Compact bone tissue & Spongy bone tissue

Compact bone tissue.

1. This type of bone tissue is present at diaphysis.
2. Provides protection and support to long bones.

Compact bone contains few spaces

Histology compact bone consist of:

1] Central canal (Haversian canal)

2] Concentric lamellae - These are rings of hard intercellular substance and are present around central canal.

3] Lacunae - Spaces between the lamellae are called as lacunae. Lacunae contains osteocytes.

4] Canaliculi - These are small canals radiating from

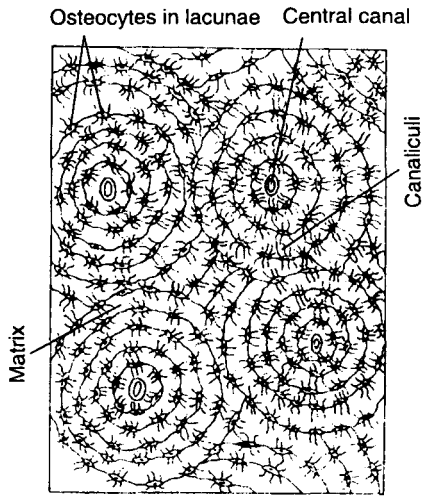

Fig 7 :

lacuna. Canaliculi connect with central canal. They provide nutrients to ostescytes and remove waste products.

Central canal + concentric lamellae + lacunac + Canaliculi = Haversian system.

Volkmann's canals: Blood vessels and nerves from the periosteum enter compact bone through Volkmann's canals.

Spongy bone: 1) Consists of larger spaces (2) These spaces are filled with red bone maarow. Short, flat irregular bones, epiphyses of long bone consist of spongy bone tissue.

Histology of spongy bone tissue

Spongy bone tissue consist of trabeculae. These are irregular network of thin plates of bone. The spaces inside are filled with bone marrow osteocytes and are present in marrow cavity.

Functions of skeletal system

1. Skeletal system supports the body
2. This system provides frame work
3. Gives support to soft organ
4. Muscles are attached to bones, hence movements are possible.
5. Ribs protect heart, lungs. Cranial bones protect brain.
6. Bones store minerals.
7. Red bone marrow produces blood cells.

Disorders

1) Fracture -break in the bone structure is called fracture. It may be partial, simple, compound, hair line or green stick.
2) Rickets -Vitamin D deficiency in children produce this disease.
3) Osteoporosis - Bones become porous, weak due to removal of calcium from bones.
4) Osteomyosytis -Infectious disease of bones.

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Chapter 8

Majja Dhatu

The sixth dhatu nourished after asthi dhatu is majja dhatu. It is embedded deep within asthi hence it is called as majja.

Synonyms

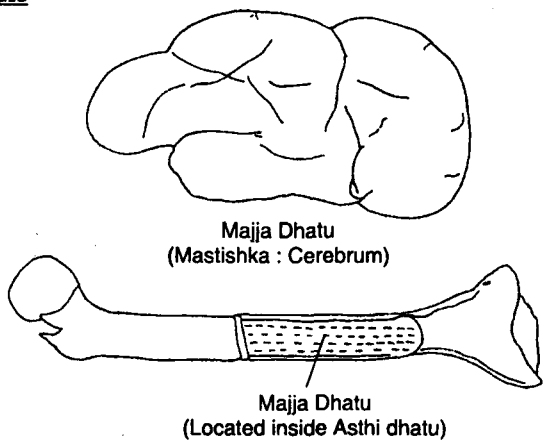

Fig 7 : Majja Dhatu

Asthi sneha, asthi sambhava, shukrakara, vimajjana sara are the synonyms of majja dhatu.

Site

'मज्जवहानां स्रोतसां अस्थीनि मूलं सन्धयश्च' । (Cha.Vi. 5/8)

The cavity inside the long bones is filled with majja dhatu.

Majja dhatu is deeply situated in the body.

'महत्सु च (अस्थिषु) मज्जा भवति । स्थूल अस्थिषु विशेषेण मज्जा तु अभ्यन्तराश्रित:' । (Su.Sha. 4/12)

Moola sthana

Bones & joints are roots of majjavaha srotas.

1] Majja dhatu resides in the long bones, poshaka majja dhatu is obtained from asthi dhatu, hence bones are root of majjavaha srotas.

The another view must be highlighted here to explore relationship between hard, dry asthi dhatu & unctuous heavy & soft majja dhatu.

Asthi dhatu is very light and dry. The hollow part in asthi dhatu is the main site of Vata dosha. Long bones have cavity (akasha) inside them. Unctuous majja dhatu inside the long bones keep the balance between asthi dhatu & Vata dosha.

2] Joints are also root of majjavaha srotasa.

'एवं यैव पित्तधरा सैव मज्जधरा (कला)' ।

(Dalhan on. Su. Kalpa 4/40)

The sixth Pittadhara kala is considered as majja dhara kala.

Majja dhatu & Mastulunga (Brain)

'तदेव (मेद:) च शिरसि कपालप्रतिच्छन्नं मस्तिष्काख्यं मस्तुलुंगाख्यं च·····' ।

(A.S.Sha. 5/4)

Mastulunga (brain) is a sadyahpranahara marma. Mastulunga is present inside the flat bones of skull. Astanga Sangraha describes mastulunga as a majja dhatu & appearance of mastulunga is like solid ghee. Mastulunga is a majja dhatu.

Constitution

'मज्जा·····च आप्यम्' । (Bhanumati on Su.Su. 15/8)

There is predominance of Jala and Prithvi mahabhuta in majja dhatu.

Metabolism

'अस्थ्नो मज्जा तत: शुक्रं·····' । (Cha.Chi. 15/16)

'अस्थि मज्ज्ञ: पुष्टिं च (करोति)' । (Su.Su. 15/5)

Poshaka majja dhatu is formed during three fold transformation of asthi dhatu.

Unctuousness of meda oozes through porous asthi dhatu & accumulates in the cavity of bones & after the action of dhatu-agni of majja, stable majja dhatu is formed.

'ततोऽपि पच्यमानान्मल: केशलोमश्मश्रूणि स्थूलभाग: अस्थिं सूक्ष्मस्तु मज्जा; ततोऽपि मज्ज्ञ: पावक पच्यमानान्मलो नयनपुरीषत्वचां स्नेह; स्थूलो भागो मज्जा; सूक्ष्म: शुक्रम्····· ।
(Dalhan on Su.Su. 14/10)

Nutrients of majja dhatu: (Poshaka majja dhatu)	Majjavaha srotasa / Agni of majja dhatu	1] Formation of majja dhatu 2] Formation of poshaka shukra dhatu 3] Formation of majja mala

According to Khale-kapota nyaya, nutrients of majja dhatu are directly transported to majjavaha srotas to form majja dhatu. Almonds, walnuts, pure ghee are some majja promoting substances.

Time taken for formation of majja dhatu

'सन्तत्या भोज्यधातूनां परिवृत्तिस्तु चक्रवत्' । (Cha.Chi. 15/21)

'तदनन्तरं (रसानन्तरं) ये षड्धातव: ते प्रत्येकं पंचभि: पंचभि: अहोभि: सम्पद्यन्ते' । (Su.Su. 14/4)

According to Charaka, dhatu formation is a cyclic process.

According to Sushruta Samhita majja dhatu is formed on 25th day after formation of ahara-rasa.

According to Parashar majja dhatu is formed on the 7th day

'उक्तं हि पराशरे·····सप्तमे त्वियात् मज्जतां·····' ।
(Chakrapani on Cha.Chi. 15/32)

Waste products of majja dhatu

'मज्ज्ञ: स्नेहोऽक्षिविट्त्वचाम्' । (Cha.Chi. 15/19)

'नेत्रविट्त्वक्षु च स्नेह: (मज्ज्ञ: मल:)' । (Su.Su. 46/527)

Sneha (oily substance) excreted through eyes, faeces & skin is a waste product of majja dhatu.

Quantity

'एको (अंजलिः) मज्जायाः । मस्तिष्कस्य अर्धांजलिः' । (Cha.Sha. 7/15)

Anjali pramana of majja dhatu is one anjali. Anjali pramana of mastishka is ½ anjali.

Qualities

Majja dhatu is a heavy and unctuous.

Symptoms of Majja sarata

'मृद्वङ्गा बलवन्तः स्निग्धवर्णस्वराः स्थूलदीर्घवृत्तसन्धयश्च मज्जसाराः । ते दीर्घायुषो बलवन्तः श्रुतवित्तविज्ञानापत्यसम्मानभाजश्च भवन्ति' । (Cha.Vi. 8/110)

Person endowed with best quality of majja sarata has soft skin, & strong body. Complexion of such person is unctuous, voice is sweet. Joints are big, long & rounded. Such person is endowed with longevity, strength, intelligence, wealth, creativity, he loves children & gets respect in the society.

'अकृश उत्तमबलं स्निग्धगम्भीरस्वरं सौभाग्योपपन्नं महानेत्रं च मज्ज्ञा' ।
(Su.Su. 35/16)

According to Sushruta big eyes (maha netra) is a differentiating symptom of majja sarata.

Functions of Majja dhatu

'पूरणं (मज्ज्ञः श्रेष्ठं कर्म)' । (A.Hr.Su. 11/4)

'मज्जा स्नेहं बलं शुक्रपुष्टिं पूरणमस्थ्नां च करोति' । (Su.Su. 15/5)

1. The most important function of majja dhatu is purana as this dhatu fills cavity inside the bones, and controls Vata dosha.

2. As majja is an unctuous dhatu, it lubricates the body.

3. Nourishment of shukra dhatu is the function of majja

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dhatu. Poshaka shukra dhatu is formed during the metabolism of majja dhatu.

Secondary tissue (upadhatu)

'केशा: (मज्ज्ञ: उपधातु:)' । (Sharngadhar 1/5/17)

According to Sharngadhara hairs are secondary tissue of majja dhatu.

Disorders of Majja dhatu

Symptoms of Decreased Majja dhatu

(Majja kshaya)

'अस्थ्नां मज्जनि सौषिर्यं भ्रमस्तिमिरदर्शनम्' । (A.Hr.Su. 11/19)

Osteoporosis (asthi soushirya), giddiness fainting are the symptoms of majja kshaya.

Symptoms of Increased Majja dhatu

(Majja vriddhi)

'मज्जानेत्राङ्गगौरवं पर्वसु स्थूलमूलानि कुर्यात् कृच्छ्राण्यरूंषि च' ।

(A.Hr.Su. 11/11)

Heaviness of body & eyes, formation of painful nodules at interphalangeal joints (arunshi) are the symptoms of excess of majja dhatu.

MYELOID TISSUE

(Bone marrow)

Bone marrow is present in the medullary cavities of the bones. Bone marrow is the connective tissue.

Types

- Red bone marrow
- Yellow bone marrow

1] Red bone marrow: It consists of stem cells which are called as haemocytoblast. Haemocytoblasts of red bone marrow gives rise to red blood cells, white blood cells & platelets.

2] Red bone marrow is abounded in the of long bones, skill bones, ribs & vertebrae & pelvic bones.

3] Yellow bone marrow: It chiefly contains fat cells & in the cavity of long bones.

Functions of Bone marrow:

1] Formation of blood cells
2] Storage of iron in the form of ferritin & haemosiderin.
3] Bone cells are formed in bone marrow.

Chapter 9

Shukra Dhatu

This is the last dhatu formed & nourished from ahara-rasa.

Etymology

The word shukra is derived from the root '*shucha*' which means pure.

Synonyms

Shukla, akshaya, nirmala, majja samudbhava, ananda-prabhav, kittavarjita, pumsatva and virya, dhatusara, retas, paurusham, teja, bija are all the synonyms of shukra dhatu.

Site

'सप्तमी शुक्रधरा नाम (कला) या सर्वप्राणिनां सर्वशरीरव्यापिनी' ।

(Su.Sha. 4/20)

Shukra dhatu is present in entire body.

'यथा पयसि सर्पिस्तु गूढश्चेक्षौ रसो यथा ।
शरीरेषु तथा शुक्रं नृणां विद्याद्भिषग्वरः' ॥ (Su.Sha. 4/21)

As milk contains ghee, sugarcane contains juice, but ghee in milk, juice in sugarcane is invisible, that way shukra dhatu occupies the whole body.

General body examination is important in case of male sterility or infertility as shukra dhatu is localized in every part of the body.

Shukravaha srotas

Formation, transportation, ejaculation of shukra dhatu takes place in shukra vaha srotas.

'शुक्रवहानां स्रोतसां वृषणौ मूलं शेफश्च' । (Cha.Vi. 5/17)

Roots of shukra vaha srotas are testes & penis.

Sharngadhara have described it as Shukrashaya (testis).

According to Sushruta Samhita breasts & testes are roots of shukravaha srotas.

'शुक्रवहे द्वे (स्रोतसी) तयोर्मूलं स्तनौ वृषणौ च'। (Su.Sha. 9/12)

Panchabhautika Constitution

'शुक्रं च आप्यम्'। (Bhanumati Su.Su. 15/8)

In shukra there is predominance of Jala mahabhuta.

Shukra dhatu is related with Kapha dosha; hence shukra dhatu is a soumya dhatu.

'सौम्यं शुक्रम्'। (Su.Sha. 3/3)

Shukra dhatu in Female

'योषितोऽपि स्रवत्येव शुक्रं पुंसः समागमे।
तत्र गर्भस्य किञ्चिन्न करोतीति न चिन्त्यते'॥

(Bhavaprakash, Garbhaprakaran 3/187)

Shukra dhatu in female has been described by Bhavaprakasha. According to him function of feminine shukra is to moisten vagina during coitus.

'स्त्रीणां शुक्रं न गर्भाय भवेद् गर्भाय चार्तवम्'।

(Chakradatta on Su.Su. 14/14)

In female, artava (streebeeja) is responsible for reproduction.

Metabolism

Shukra is the last dhatu which is formed after majja dhatu.

'वृष्यादीनां क्षीरादिद्रव्याणां प्रभावो बलं शीघ्रं पुष्णाति,.....न यथोक्तधातुक्रमेणेत्यर्थः। एवं वृष्यादीनां प्रभावाच्छुक्राद्युत्पत्तिः शीघ्रं भवति'।

(Chakrapani on Cha.Chi. 15/20)

According to Khale-kapota nyaya milk is instant aphrodisiac substance.

Formation of Shukra dhatu

'ततोऽपि मज्ज्ञः पावकपच्यमानान्मलो नयनपुरीषत्वचां स्नेहः, स्थूलो भागो

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मज्जा, सूक्ष्म शुक्रं; ततः पुनः पच्यमानादुपमलो नोत्पद्यते, सहस्रधाध्मातसुवर्णवत्, स्थूलो भागः शुक्रमेव·····'। (Dalhan on Su.Su. 14/10)

Poshaka shukra is formed during the metabolism of majja dhatu. Poshya shukra is brought to shukravaha srotas & due to action of dhatvagni of shukra dhatu, poshya shukra dhatu is formed.

Nutrients of shukra dhatu (poshaka shukra)	Shukravaha srotas → dhatvagni of shukra	1] Formation of Poshya shukra dhatu

Time taken for the formation

'सन्तत्या भोज्यधातूनां परिवृत्तिस्तु चक्रवत्'। (Cha.Chi. 15/21)

Dhatu formation is a continuous process.

'स·····एवं मासेन रसः शुक्री भवति स्त्रीणां च आर्तवम्'। (Su.Su. 14/14)

Shukra dhatu is formed on 30th day from ahara rasa.

'उक्तं हि पराशरे—आहारोऽद्यतनः श्वो हि रसत्वं गच्छति नृणाम्।·····शुक्रतां याति नियमादष्टमे नृणाम्'। (Chakrapani on Cha.Chi. 15/32)

Though dhatu formation is a continuous process, according to Parashar shukra dhatu is formed on the 8th day.

Qualities

'स्फटिकाभं द्रवं स्निग्धं मधुरं मधुगन्धि च।
शुक्रमिच्छन्ति केचित्तु तैलक्षौद्रनिभं तथा'॥ (Su.Sha. 2/11)

1) Smell of shukra dhatu is like honey or oil, its smell is not irritating. Smell of vitiated shukra dhatu changes.

2) Colour of shukra dhatu may be white or like oil or honey.

Colour of freshly voided shukra dhatu is white, later after 3 to 10 minutes, it liquefied & become transparent. Vitiated shukra dhatu may become red, yellow or blue.

'स्निग्धं घनं पिच्छिलं च मधुरं चाविदाहि च।
रेतः शुद्धं विजानीयात् श्वेतं स्फटिकसंनिभम्'॥(Cha.Chi. 30/145)

3) Shukra dhatu is soft, slimy & liquid. Because of these

properties, shukra dhatu can traverse across vagina & unite with ovum.

4) Heaviness (gurutva) of shukra dhatu is essential for ejaculation. Due to heaviness & liquidity shukra dhatu can flow in downward direction.

5) Due to coldness, shukra dhatu do not produce any burning symptoms when it comes in contact with vaginal epithelium.

Quantity

'अर्धांजलि: शुक्रस्य' । (Cha.Sha 7/14)

Anjali pramana of shukra dhatu is half anjali (½ handful).

Functions

'गर्भोत्पाद: (श्रेष्ठ कर्म शुक्रस्य)' । (A.Hr.Su. 11/4)

1) Reproduction is the most important function of the shukra dhatu.

'शुक्रं धैर्यं च्यवनं प्रीतिं देहबलं हर्षं बीजार्थञ्च' । (Su.Su. 15/15)

2) Velour, courageousness, attraction towards opposite sex, strength, pleasure of coitus, reproduction, are the vital functions of shukra dhatu.

'शुक्रशोणितं जीवसंयोगे तु खलु कुक्षिगते 'गर्भ' संज्ञा भवति' ।
(Cha.Sha. 4/5)

When shukra dhatu unites with stree beeja (ovum), fertilization takes place or in other words shukra dhatu is able to fertilize ovum. Velour, courageousness are the psychological effects of shukra dhatu.

Symptoms of Shukra sarata

'सौम्या: सौम्यप्रेक्षिणश्च क्षीरपूर्णलोचना इव प्रहर्षबहुला: स्निग्धवृत्तसारसमसंहत-शिखरदशना: प्रसन्नस्निग्धवर्णस्वरा: भ्राजिष्णव: महास्फिचश्च शुक्रसारा: ते स्त्रीप्रियोप-भोगा: बलवन्त: सुखैश्वर्यारोग्यवित्तसम्मानापत्यभाजश्च भवन्ति' । (Cha.Vi. 8/109)

Personality of best shukra sara person is very attractive &

assuring. Eyes of such person are very attractive & seems to be filled with milk. The uttam shukra sara person has good sexual capacity.

Voice of shukra sara person is very soft and sweet. Complexion of shukra sara person is fresh & unctuous, skin is very radiant (bhrajishnu). Shukra sara person has broad pelvis (maha sphik). They have rounded, compact, smooth edged, white straight, strong teeth.

Shukra sara persons are popular in women. They have good physical and sexual strength. Shukra sara persons are endowed with happiness, health, wealth, children, honour & progeny.

'स्निग्धसंहतश्वेतास्थिदन्तनखं बहुलकामप्रजं शुक्रेण' ।(Su.Su. 35/16)

While describing symptoms of shukra sarata, Sushruta has emphasized only on characters of teeth, bones & nails. However while examining symptoms of shukra sarata, one should look for person's teeth, nail & eyes also. Along with this, development of secondary sex characters must be examined.

Upadhatu

1] According to Charka Samhita, shukra dhatu is the purest dhatu, hence it has no upadhatus.

2] According to Sharngadhar Samhita ojas is the upa dhatu of shukra dhatu.

Waste products

'स्वाग्निभिः पच्यमानेषु मलः षटसु रसादिषु ।
न शुक्रे पच्यमानेऽपि हेमनीवाक्षये मलः' ॥

(Dalhan on.Su.Su. 14/10)

Shukra dhatu is a pure dhatu. Sushruta has compared shukra dhatu with pure gold. Gold when heated thousands times & purified, cast off no residue. In the similar way shukra dhatu

is processed by agni & hence it don't have any waste product. However according to Sharngadhara Samhita mustache, hair on the skin and acne are waste products of shukra dhatu.

According to Ashtang Hridaya, ojas is the mala of shukra dhatu.

Disorders of Shukra dhatu

Symptoms Increased shukra dhatu
(Shukra-vriddhi)

'अतिस्त्रीकामतां वृद्धं शुक्रं शुक्राश्मरीमपि' । (A.Hr.Su. 11/12)

Increased libido (sexual desire), seminal calculi, are the symptoms of shukra vriddhi.

Symptoms of Decreased shukra dhatu
(Shukra-kshaya)

'शुक्रे चिरात् प्रसिच्येत शुक्रं शोणितमेव वा ।
तोदोऽत्यर्थं वृषणयोर्मेढ्रं धूमायतीव च' ॥ (A.Hr.Su. 11/20)

Delay in ejaculation, ejaculation accompanied with bleeding, severe pain in testicles, burning sensation in urethra are the symptoms of decrease in shukra dhatu.

'शुक्रक्षये मेढ्रवृषणवेदना अशक्तिः मैथुने चिरात् वा प्रसेकः प्रसेके च अल्परक्तशुक्रदर्शनम्' । (Su.Su. 15/9)

Pain in penis, testes, impotency, early or late ejaculation of semen or ejaculation of semen with blood dhatu.

'दौर्बल्यं मुखशोषश्च पाण्डुत्वं सदनं भ्रमः ।
क्लैब्यं शुक्राविसर्गश्च क्षीणशुक्रस्य लक्षणम्' ॥ (Cha.Su. 17/69)

Weakness, dryness of mouth, pallor, vertigo, impotency, delayed ejaculation are the symptoms of shukra kshaya.

Chikitsa

Heavy, unctous, sweet food promotes formation of shukra dhatu. Milk instantly produces shukra dhatu. Milk, ghee, eggs, black gram (urida) are shukra promoting food items

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while ashwagandha, musk, saffron are some shukra promoting dravyas.

MALE REPRODUCTIVE SYSTEM

Physiology of male reproduction system

Male reproductive system consists of following organs:

1] Testis 2] Ductus deferens (Vas deferens)
3] Ejaculatory ducts 4] Urethra

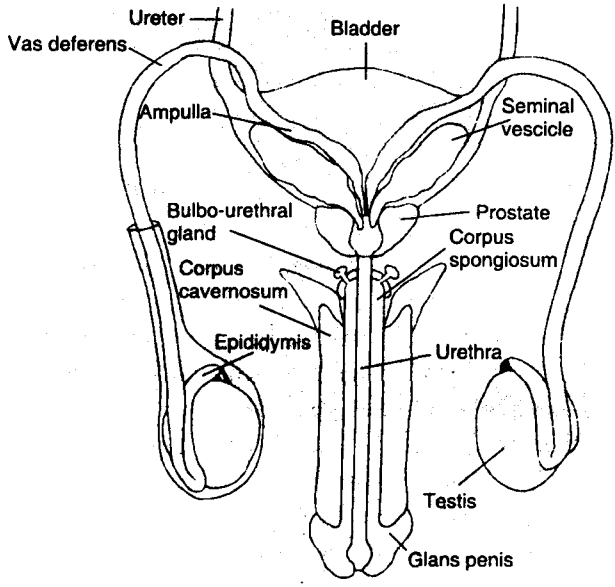

Fig 9 (a) : Posterior view of male reproductive system

Accessory sex glands:

1] Seminal vesicles, 2] Prostate gland, 3] Bulbo urethral gland

Supporting structures:

1] Scrotum and 2] Penis

Stages of the spermatogenesis

Spermatogenesis takes place in testes.

The process of formation of mature spermatozoa is called as

spermatogenesis. Sperms are produced in seminiferous tubules.

Seminiferous tubules are coiled tubules which are present in the lobules (compartments) of testes.

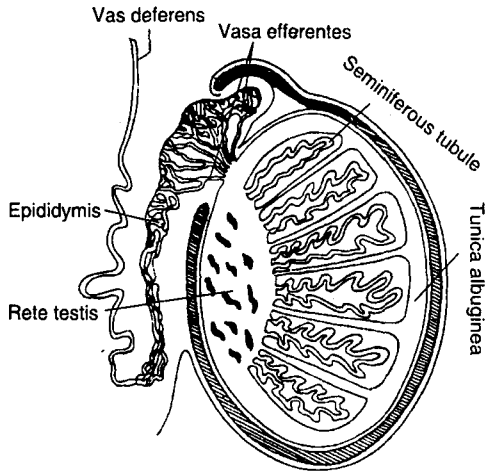

Fig 9 (b) : The Adult Testis, Epididymis and Vas dererens

Functions of testis

1] Spermatogenesis
2] Secretion of hormones i) Testosterone
ii) Inhibin

Site of spermatogenesis: Seminiferous tubules of testes.

Following Hormones are required for spermatogenesis:

1] Gonadotropin releasing hormone (GnRH) secreted by Hypothalamus
2] Follicle stimulating hormone (F.S.H)
Leutinizing hormone (LH) secreted by anterior pituitary gland
3] Testosterone and inhibin secreted by testis

Steps of spermatogenesis: Sperms are developed from most immature stem cells called as spermatogonia. Spermatogonia

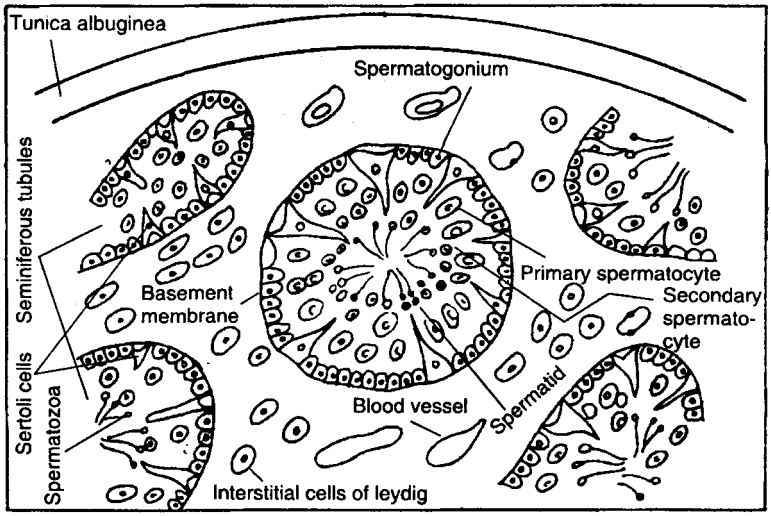

Fig 10 : Transverse section of seminiferous tubules showing stages of spermatogenesis

Testies (T.S.)

develop in primary and secondary spermatocytes, spermatid and then mature spermatozoa are formed.

- Spermatogonium is a diploid (2n) cell which consists of 23 pairs (46) of chromosomes.
- Spermatozoa are a haploid cell which consists of only 23 chromosomes.
- From one spermatogonium four spermatozoa are produced.
- Each spermatozoa consists of either X or Y sex chromosome

Time required for spermatogenesis - 74 days

Nourishment of sperms

Sperms get nourishment from sertoli cells.

Transport of sperms

1] Spermatogenesis takes place in seminiferous tubules of testis.

2] Sperms are then moved to straight tubules.
3] Straight tubules lead to testis.
4] From testis sperm are transported to efferent ducts.
5] From efferent ducts sperms are brought to ductus epididymis.
6] In ductus epididymis sperm become capable for fertilization.
7] Sperms remain in ductus epididymis for 10 to 14 days.
8] Sperm are stored in ductus epididymis.
9] Then sperms are brought to vas deferens.
10] Vas deferens conveys sperm from epididymis to ejaculatory duct.
11] Ejaculatory duct eject spermatozoa into the prostatic urethra prior to the ejaculation.

In this way transportation of sperms takes place.

Clinical importance

Vasectomy - Surgical removal of portion vas deference is called vasectomy. This is the easiest procedure for sterilization in males.

Due to vasectomy sperms cannot reach the exterior as vas deferences are cut. and sperms are destroyed by phagocytosis.

Factors affecting spermatogenesis

1] Temperature-Spermatogenesis takes place at comparatively low temperature. Testicular temperature is low by 2 to 3 degree than that of core temperature. Normal position of testis in scrotum makes testicular temperature low.

2] Exposure to X-ray radiation } Inhibit
Alcoholism } spermatogenesis

3] Disorders of thyroid gland, adrenal gland, pituitary gland can affect spermatogenesis.

4] Vitamin E deficiency can inhibit spermatogenesis.

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Spermatozoa

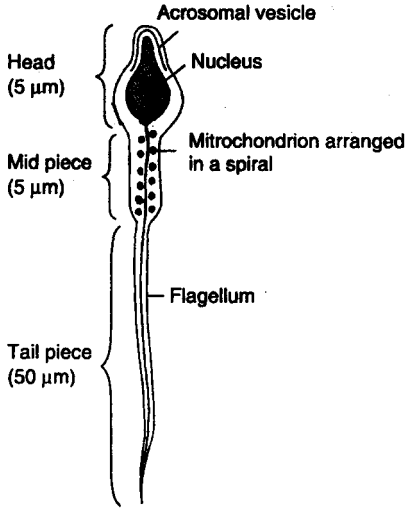

Fig 11 : A Mature Spermatozoon
in Longitudinal Section

Parts of spermatozoa

1] Head, 2] neck, 3] body,4] tail and 5] end piece

Spermatozoa are motile cells.

Motility of spermatozoa - Its vaginal motility is 1-3 mm/ min.

After entering in vagina sperm takes 45 minutes to reach fallopian tubes.

Fate of spermatozoa cell

In vagina sperm is viable for 72 hours. If ovum is absent or if fertilization doesn't take place than sperm degenerates or die after 72 hours.

Semen (Seminal fluid) - seminal fluid consist of sperms, secretion of seminal vesicles, and prostatic secretion, secretion of bulb urethral glands.

Average volume of semen: 2.5ml to 5 ml per ejaculation.

Normal sperm count: 50 to 150 million / ml.

Oligospermia: Sperm count less than 20 million/ml

Ph of semen: 7.20 to 7.60

Appearance of semen: 1] Milky due to prostatic secretion, 2] Mucoid due to bulbourethral secretion.

Functions of semen

1] To provide transportation medium for spermatozoa.
2] To provide nutrients to sperms.

Enzyme present in semen

Seminal plasmin

This enzyme destroys bacteria.

When semen is ejaculated into vagina, liquid semen coagulates. This seminal clot liquefied within 5 to 20 minutes. Due to liquefaction sperm can reach cervix of the uterus.

Chapter 10

Ojas

'सर्वधातुसारम् ओजः अभिधीयते' ।

Ojas is a sara (essence) of all dhatus. Ojas is vigor. Ojas is an independent principle of Ayurveda, the principle which supports life, which protects life against various diseases.

Definition

'तत्र रसादीनां शुक्रान्तानां यत्परं तेजः तत् खलु ओजः । यत् खलु ओजः तदेव बलम् इति उच्यते स्वशास्त्रसिद्धान्तात्' । (Dalhan on Su.Su. 15/19)

Essence of all seven dhatus is called as Ojas, on which strength of the body depends. The word strength is applied to many concepts. For e.g. strength means immunity.

Ojas provides strength to body; hence body can be sustained against various infections.

Synonyms

Dhatu sara, dhatu teja, bala, prana, dhatu sneha, jiva shonita, rasa, shukra sara are synonyms of ojas which indicates its vitality in life.

'द्विविधम् ओजः (दर्शयति) परम् अपरं च' ।

(Chakrapani on Cha. Su. 15/9)

Types - 1) Para ojas and 2) Apara ojas

Volume of Para ojas is 8 drops and its site is heart. Site of Apara ojas is whole body and its volume is ½ Anjali.

'हृदि तिष्ठति यच्छुद्धं रक्तमीषत्सपीतकम्' । (Cha.Su. 17/74)

'ईषदिति अल्पप्रमाणं—तेन अष्टबिंदुकम् ओजः इति दर्शयति । तदुक्तं तंत्रातरे—"प्राणाश्रयस्यौजसोऽष्टौ बिन्दवो हृदयाश्रया" इति । एतच्च अष्टबिन्दुकं परम् ओजः ज्ञेयम् । अर्धांजलिपरिमाणं तु यद् ओजः तद् अप्रधानं·····' ।

(Chakrapani on Cha.Su. 17/74-75)

'सकलशरीरव्यापिनः तस्य षट् बिंदुकस्य विशेषेण हृदयं स्थानम्' ।

(Arundatta on A. Hr.Su. 11/37-38)

Formation of Ojas

'येनौजसा वर्तयन्ति प्रीणिताः सर्वजन्तवः ।
यदृते सर्वभूतानां जीवितं नावतिष्ठते ॥
यत्सारमादौ गर्भस्य यत्तद्गर्भरसाद्रसः ।
संवर्तमानं हृदयं समाविशति यत्पुरा ॥
यस्य नाशात्तु नाशोऽस्ति धारि यद् हृदयाश्रितम् ।
यच्छरीररसस्नेहः प्राणा यत्र प्रतिष्ठिताः' ॥

(Cha.Su. 30/9-11)

Function and formation of ojas has been explained in Charaka Sutrasthana.

The description of ojas in the above verses is applicable to the formation of Para ojas.

At the time of conception, ojas is the essence of shukra and artava, which is called as garbha rasa. This garbha rasa is a nourishing fluid, which nourishes growing embryo. According to Ayurvedic concept of embryology, fetal heart is formed in 4th month of gestation.

After heart is being formed in the fetus, the ojas which is nourishing the garbha enters heart and then cardiac activity of fetus begins. The ojas which nourishes the garbha and which enters the heart of garbha is a Para type of ojas of garbha.

Destruction of Para ojas results in death.

'धातूनां तेजसि रसे तथा जीवितशोणिते ।
श्लेष्मणि प्राकृते वैद्यैरोजःशब्दः प्रकीर्तितः' ॥

(Hemadri on A.Hr.Su. 11/37)

Apara ojas pervades whole body through circulation of rasa-rakta. It is essence of all dhatus and predominantly exists in rasa, shleshma, and rakta and shukra dhatu.

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'भ्रमरैः फलपुष्पेभ्यो यथा सञ्चीयते मधु।
तद्वदोजः शरीरेभ्यो गुणैः संम्रियते नृणाम्' ॥
(Chakrapani on Cha.Su. 30/7)

As bees collect honey from the fruits and flowers, that way essence of all dhatus comprises ojas. This description of ojas formation is applicable Apara ojas.

Ojas and Food

Formation of Apara ojas depends on qualities of dhatus. Dhatu formation depends on quality of food digestion of food. Therefore food, jatharagni plays important role in the formation of ojas.

'प्राणिनां पुनर्मूलमाहारो बलवर्णौजसां च'। (Su.Su. 1/28)

Sattvic vegetarian food enhances formation of ojas.

'आयुर्वर्णो बलं स्वास्थ्यमुत्साहोपचयौ प्रभा।
ओजस्तेजोऽग्नयः प्राणाश्चोक्ता देहाग्निहेतुकाः' ॥ (Cha.Chi. 15/2)

Different opinions regarding Ojas

'.....ओजश्च सप्तमम्।
इति धातुभवा ज्ञेया एते सप्तोपधातवः' ॥ (Sharngadhar 1/5/17)

'शुक्रस्य सारम् ओजः'। (A.S.Sha. 6/29)

'प्राकृतस्तु बलं श्लेष्मा विकृतो मल उच्यते।
स चैवोजः स्मृतः काये स च पाप्मोपदिश्यते' ॥ (Cha.Su. 17/117)

'कफः पित्तं मलाः खेषु स्वेदः स्यान्नखरोम च।
स्नेहोऽक्षित्वग्विशामोजो धातूनां क्रमशो मलाः' ॥ (A.Hr.Sha. 3/63)

1. According to Sarngadhar, Ojas is an upadhatu of shukra dhatu.
2. Ojas is an essence of shukra.
3. Ojas is like a shleshma (kapha).
4. Accrding to Ashtang Sangraha, Ojas is the mala of shukra dhatu.

'सर्वधातूनां स्नेहोजः क्षीरे घृतमिव। शुक्रस्नेहात् क्षीरस्य घृतम् इव अभिन्नम् ओजः शुक्रेण।

5. Every drop of milk consists of ghee, but it is invisible. In the same way every drop of shukra dhatu consists of ojas.

Qualities of kapha dosha and ojas are same. The body strength depends on balanced kapha dosha and ojas. Shleshma and ojas promote cellular growth and prevent cellular destruction. Hence shleshma and ojas are inter-dependent concepts.

'दशप्राणायतनानि तद्यथा—मूर्धाकण्ठहृदयं नाभिः गुदं बस्तिः ओजः शुक्रं, शोणितं, मांसमिति' । (Cha.Sha. 7/9)

Ojas protects life, hence it is a pranayatana. It is an important site of prana, if ojas is affected it can cause sudden death.

Qualities

'हृदि तिष्ठति यच्छुद्धं रक्तमीषत्सपीतकम् ।
प्रथमं जायते ह्योजः शरीरेऽस्मिञ्छरीरिणाम् ॥
सर्पिर्वर्णं मधुरसं लाजगन्धि प्रजायते' ॥ (Cha.Su. 30/74-75)

Ojas which resides in heart is predominantly yellowish; reddish in colour. Appearance of ojas is like ghee. Its taste is like honey and the smell is like fried paddy (laja).

'गुरु शीतं मृदु श्लक्ष्णं बहलं मधुरं स्थिरम् ।
प्रसन्नं पिच्छिलं स्निग्धमोजो दशगुणं स्मृतम्' ॥ (Cha.Chi. 24/31)

Heavy, cold, soft, sweet, stable, fresh, slimy and unctuousness are the qualities of ojas.

Functions

'हृदि तिष्ठति यच्छुद्धं रक्तमीषत्सपीतकम् ।
ओजः शरीरे संख्यातं तन्नाशान्ना विनश्यति' ॥ (Cha.Su. 17/74)

Destruction of ojas residing heart causes death ojas which resides in the heart is a Para type of ojas, which protects life.

Para ojas is a site of prana hence to protect life is the function of ojas.

'तत्र रसादीनां शुक्रान्तानां धातूनां यत्परं तेजः तत् खलु ओजः तदेव बलमित्युच्यते स्वशास्त्रसिद्धान्तात्। तत्र बलेन स्थिरोपचितमांसता सर्वचेष्टासु अप्रतिघातः स्वरवर्णप्रसादः बाह्यानाम् आभ्यन्तराणां च आत्मकार्यप्रतिपत्तिर्भवति'।

(Dalhan on Su.Su. 15/19)

Dhatus, ojas and bala are interdependent constituents of the body. Ojas enhances stability of mamsa dhatu. Ojas increase endurance power. All physical and mental activities run smoothly. Ojas maintains complexion and voice. Ojas stimulates functions of five senses and mind, ojas maintains integrity of body - mind - senses - soul.

'ओजोविवृद्धौ देहस्य तुष्टिपुष्टिबलोदयाः'। (A.S.Su. 11/43)

Energetic state of mind (tushti), growth of body and strength depend on ojas.

Disorders of Ojas

Destruction of Para ojas leads to death.

Disorders of Apara ojas are: 1) Ojovyapat, 2) Ojovisramsa and 3) Ojahkshaya.

In ojovyapat flow of Apara ojas is obstructed, while in ojovisramsa it gets contaminated by the vitiation of doshas.

Symptoms of Ojovisramsa

'सन्धिविश्लेषो गात्राणां सदनं दोषच्यवनं क्रियाऽसन्निरोधश्च'।

(Su.Su. 15/24)

Weakness in joints, numbness, body weakness, displacement of doshas from their proper sites. Suppressed physical and mental activities are the symptoms of ojovisramsa.

Ojovyapat

In ojovyapat, ojas is contaminated by vitiated doshas and dhatus.

'स्तब्धगुरुगात्रता वातशोफो वर्णभेदो ग्लानिस्तन्द्रानिद्रा च व्यापन्ने'।

(Su.Su. 15/24)

Heaviness in the body, restricted body movements, edema due to vitiated Vata, drowsiness, and excess sleep are the symptoms of ojovyapat.

Varnabheda (change in the colour complexion) is a symptom of ojovyapat.

Ojas is vitiated in prameha, and in pandu also, so the symptoms of prameha and pandu can be taken as ojovyapat.

Ojahkshaya

Over exertion, dieting, dry light food, exposure to hot windy climate, depression, less sleep, over indulgence of sex, vomiting, dhatu kshaya, old age, trauma, anger and anxiety are the few causes of ojahkshaya.

'बिभेति दुर्बलोऽभीक्ष्णं ध्यायति व्यथितैन्द्रियः ।
दुश्छायो दुर्मना रूक्षः क्षामश्चैवोजसः क्षये' ॥ (Cha.Su. 17/73)

Weakness, fear, fatigue of sense organs, dryness of body, imbalanced mind and depression are the symptoms of ojah-kshaya.

According to Sushruta, syncope, mamsa dhatukshaya, delirium and death are the symptoms of ojahkshaya.

'मूर्च्छा मांसक्षयो मोहः प्रलापो मरणमिति च क्षये' । (Su.Su. 15/26)

In this way though ojas can not be shown in the body, but its existence can be felt by its action on the body. Proper function of all srotasas, body growth, stability of mamsa dhatu, proper functioning of five senses, proper circulation indicates normal functioning of ojas.

Vyadhikshamatva (Immunity)

'व्याधीक्षमत्व नाम व्याधीबलविरोधित्वं व्याधीः उत्पादप्रतिबन्धकत्वम् इति' ।
(Chakrapani on Cha.Su. 28/7)

Concept of immunity comprises of two factors:

'व्याध्युत्पादप्रतिबन्धकत्वम्' ।

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1) Resistance to formation of diseases and resistance to causative factors of diseases.

'व्याधीबलविरोधित्वम्' ।

2) Capacity to prevent the spread of diseases in the body and capacity of body of blocking the diseases in its primary stage is called as immunity.

Importance of Immunity

'स्वस्थस्य स्वास्थ्यरक्षणम् आतुरस्य व्याधिपरिमोक्षः' ।

Conservation of health and to cure diseases is the principle of Ayurveda.

If people belonging to same socio-economical background are exposed to same type of environment, then some of them will suffer from respiratory disorders, some of them will suffer from gastro-intestinal disorders, or some people will not be affected at all and they will be able to maintain their health status. This is because of difference in immunity level in these persons.

Ayurveda emphasizes on the people having good immunity and people who have poor immunity or people who lacks immunity. We must know the factors responsible for good immunity and those who lack immunity.

Following factors maintains vyadhikshamatva (immunity)-

1. Uattam dhatu sarata.
2. Normal functioning of srotasas,
3. Normal functioning of agni,
4. Ojas, Kapha dosha,
5. Balanced state of doshas, dhatus and malas.
6. Kapha constitution is a less prone to diseases.
7. Causative factors of vyadhi will not be able to attack healthy srotasas.

All the factors mentioned above leads to good body strength.

Dhatu sarata, balanced state of doshas, health of srotasas and Agni must be maintained with proper diet and regimen to maintain immunity.

But in spite of proper diet and regimen some people get affected by causative factors of diseases, and suffer from various disorders.

What are the factors which lowers the immunity?

'शरीराणि च अतिस्थूलानि अतिकृशानि अनिविष्टमांसशोणित अस्थीनि दुर्बलानि असात्म्य आहार उपचितानि अल्पाहाराणि अल्पसत्त्वानि च भवन्ति अव्याधिसहानि विपरीतानि पुनः व्याधिसहानि' । (Cha.Su. 28/7)

Immunosuppressant factors according to Ayurvedic concepts are - Obesity, emaciation, unhealthy condition of mamsa, rakta and asthi dhatu, weakness, faulty diet, fasting, mal nourishment and unstable weak mind.

The immuno-suppressant factors affects doshas, dhatus, srotasas and agni, lowers the immunity of body, and such people can not with stand causative factors of diseases and suffer from various disorders frequently.

Strength (immunity) promoting factors are:

'बलवृद्धिकरास्तु इमे भावा भवन्ति। तद् यथा—बलवत् पुरुषे देशे जन्म, बलवत्पुरुषे काले च, सुखश्च कालयोगः बीजक्षेत्रगुणसंपच्च, आहारसंपत् च शरीरसंपत् सात्म्यसंपत् च, सत्त्वसंपत् च, स्वभावसंसिद्धिः च, यौवनं च, कर्म च, संहर्षः च इति' । (Cha.Sha. 6/13)

1. Heredity (Anuvamshikata)
2. Middle age (Madhya vaya)
3. Winter season (Hemanta ritu)
4. Suitability of all types of food and environment.
5. Energetic state of mind, young age and proper exercise promotes immunity.

IMMUNITY

Human body has capacity to resist micro-organisms or

toxins, which can damage tissues or organs. This capacity of resistance is called as immunity.

Types of Immunity

1) Innate immunity 2) Acquired immunity.

Innate Immunity: It is a non-specific resistance of body to micro-organisms.

Acquired Immunity: Most of the immunity is acquired immunity.

Acquired immunity is developed when human body is attached by micro-organisms for the first time.

Innate immunity:

Innate immunity includes following processes to protect body from micro organisms, they are:

1. Phagocytosis by white blood cells.
2. Intact skin resists organisms to enter the body.
3. Mucous traps microbes in GI tract and respiratory tract.
4. Hairs in the nose filter dust, microbes in the nose.
5. Saliva washes debris, microbes from the teeth and oral cavity.
6. Acid in stomach kills organisms.
7. Lacrymal fluid protects eyes from dust and organisms.
8. Some chemical compounds in the blood attacks organisms and destroy them.

Chemical compounds in the blood are -

1) Lysozyme -It attacks bacteria and destroy them.
2) Complement complex -It is a group of 20 proteins present in the blood. They destroy the bacteria.
3) Properdin - works with complement.

4) Interferon - Protects uninfected host cells from viral infections.

Role of lymphatic system in immunity

Lymph nodes filters lymph and foreign bodies, tonsils and spleen produces lymphocytes and antibiotics.

Types of Acquired Immunity are

1) Cellular immunity
2) Humoral immunity

Antibody formation - activated T lymphocytes are produced in cellular immunity, which is called as T cell immunity.

In Humoral immunity antibodies are formed against specific antigens, this type of immunity is called as B cell immunity.

Cellular Immunity - In cellular immunity specially sensitized T lymphocytes are formed. In embryonic life T lymphocytes are preprocessed in thymus gland, hence called as T lymphocytes.

T lymphocyte are then migrated to lymphoid tissue.

1. T lymphocytes come in contact with antigen.
2. Large number of activated T cells are released in blood through lymph.

T cells are classified into three major groups:

1) Helper T cells 2) cytotoxic T cells (3) suppressor T cells

All three types of cells are required for cellular immune system to work.

Humoral Immunity (B cell Immunity)

In humoral immunity antibodies are formed by B lymphocytes against antigens.

Antigens (Ags): Antigen is a chemical substance which enters the body, causes body to produce specific antibodies by B lymphocytes.

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Antibodies (Abs): Antibody is a protein produced by B antigen.

Each antibody is specific for a particular antigen. Antibodies belong to a group of proteins called as globulins, so the antibodies are called immunoglobulin (Ig).

Types of Immunogobulins (Ig)

1) IgG (2) IgA (3) IgM (4) IgD (5) IgE

Chemical structure of each antibody is different. IgG antibodies are most numerous antibodies. Normal person has 75% IgG

IgG enhances phagocytosis.

Immunization

Immunization is an acquired immunity against specific diseases. Various vaccines are injected to protect against several diseases, vaccines are prepared either directly from the dead organisms. These dead organisms have their chemical antigen but they cannot produce diseases, antibodies are formed in the body against these specific antigens and person gets immunized against particular disease, for e.g. typhoid, whooping cough and diptheria.

In some vaccines, organisms are grown artificially in the animals; these organisms are attenuated organisms still carry antigens required for immunization. Such attenuated vaccines are used to protect poliomyelitis measles, small pox etc.

Passive Immunity

Acquired immunity is an active immunity because body develops antibodies or activated T cells in response to antigen. But in passive immunity direct antibodies or activated T cells are injected. These antibodies remain in the recipient's body for 2 to 3 weeks and person is protected

against disease. This type of transfusion of antibodies is called as possessive immunization.

Transfer of antibodies from breast milk to body is also a type of passive immunity.

Disorders of immune system

1) Allergic diseases in which antibody antigen reaction causes harmful side effects. People may have allergy of specific food dust, clothes etc.

2) Autoimmune diseases: Body develops antibodies against its own tissue. Rheumatoid arthritis, hyperthyrodisom, glomerulo nephritis are autoimmune diseases.

3) Acquired immune deficiency syndrome (AIDS)

This disease attacks immune system. There is deficiency of T cell lymphocytes, so patient can't stand against any infection.

Chapter 11

Upadhatu - Secondary Tissues

Definition

Secondary tissue is the important concept in Ayurveda. Secondary tissue is formed as a byproduct of tissues during metabolism of the tissue.

'रसात् स्तन्यो ततो रक्तमसृजः कण्डराः सिराः ।
मांसाद् वसा त्वचा षट् च मेदसः स्नायुसंभवः' ॥

(Cha.Chi. 15/7)

Information about concept of 'upadhatu' is explained in 1st chapter of this book.

Dhatu	*Upadhatu*
Rasa	Stanya, Raja
Rakta	Sira, Kandara
Mamsa	Vasa, Twacha
Meda	Snayu
Asthi	*Danta
Majja	*Kesha
Shukra	*Ojas

*According to Sharngadhara Samhita, danta & kesha are upadhatus of asthi & majja dhatu respectively.

*According to Sharngadhara Samhita Ojas is the upadhatu of shukra dhatu.

Upadhatu of Rasa

1) Stanya: Breast milk

'स्तन्यं क्षीरं रसस्य उपधातुः' । (Adhamalla on sha. 1/15,16)

Stanya is the secondary tissue (upadhatu) of rasa dhatu.

Stanya is the secondary tissue pertaining to female body only.

Stanya is secreted in the female breast in the purperium period immediately after the baby is being delivered.

Nirukti of Stanya (Etymology)

For the nourishment of baby the milk which is secreted in the breast is called as Stanya.

Synonyms

Paya, dugdha, kshira, gorasa are the synonyms of stanya.

Site of Stanyavaha srotas

'स्रोतांसि नासिके कर्णौ नेत्रे पाय्वास्यमेहनम् ।
स्तनौ रक्तपथश्चेति नारीणामधिकं त्रयम्' ॥ (A.Hr.Sha 3/40)

Breast is the root of stanya vaha srotas. Stanya is formed in breast and, expelled out from the nipple.

Breast is a secondary sex organ of females. After puberty, growth of female reproductive system begins. During that time, along with growth of other organs of artava vaha srotas, breast enlargement also starts which is called as budding of breasts.

'धमन्याः संवृतद्वाराः कन्यानां स्तनसंश्रिताः ।
तासामेव प्रजातानां गर्भिणीनां च ताः पुनः ।
स्वभावादेव विवृता जायते·····' । (Su.Ni. 10/16-17)

Raja, the secondary tissue of rasa, enhances breast development.

Two dhamanis of breast conduct breast milk and breast milk is expressed out of the nipples.

'द्वे (धमन्यौ) स्तन्यं स्त्रियावहतः स्तनसंश्रिते' । (Su.Sha. 9/5)

Pregnancy & breast development during pregnancy

'गृहीतगर्भाणाम् आर्तववहानां स्रोतसां वर्त्मानि अवरुध्यन्ते गर्भेण तस्माद् गृहीतगर्भाणाम् आर्तवं न दृश्यते ततस्तद् अधः प्रतिहतम् आगतम् अपरं चोपचीयमानम्

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अपरा इत्यभिधीयते । शेषं च उर्ध्वतरम् आगतं पयोधरौ अभिप्रपद्यते तस्माद् गर्भिण्य: पीनोन्नतपयोधरा भवन्ति' । (Su.Sha. 4/24)

During pregnancy reproductive srotas (artava vaha srotas) of a pregnant woman gets obstructed by the fetus & hence menstrual cycle is ceased during pregnancy.

Obstructed raja takes part in the formation of placenta (apara) while the rest of raja ascends, reaches the breasts & breasts of the pregnant woman become full & heavy.

Formation of breast milk

'रसप्रसादो मधुर: पक्वाहारनिमित्तजा ।
कृत्स्नदेहात् स्तनौ प्राप्त: स्तन्यमित्यभिधीयते' ॥ (Su.Ni. 10/18)

Stanya is the secondary tissue of rasa dhatu. Rasa dhatu is formed from digested food. Rasa dhatu circulates in the whole body, when rasa dhatu reaches breast, stanya or breast milk is formed from the sweetness of rasa dhatu.

Touch, sight or even thought of child stimulates secretion & expulsion of breast milk.

'सिराणां हृदयस्थानां विवृतत्वात् प्रसूतित: ।
तृतीयेऽह्नि चतुर्थे वा स्त्रीणां स्तन्यं प्रवर्तते ॥ (A.Hr.U. 1/11)

Immediately after labor, artava vaha srotas constricts due to excess of vata dosha & due to these lactiferous ducts in the breast dilates & actual secretion of milk begins on the 3rd or 4th puerperal day.

On the first & second day of purperium, breast secretes thick, heavy, yellowish fluid which is called as piyush & from third day actual milk is secreted.

Volume of breast milk - 2 Anjali.

'द्वावंजली तु स्तन्यस्य' । (A.Hr.Sha. 3/82)

Importance of breast milk

'मातुरेव पिबेत् स्तन्यं तत्परमं देहवृद्धये' । (A.Hr.Su. 1/16)

All infants should be fed on breast milk. Breast milk enhances growth of body and it also provides immunity to the baby.

Qualities of breast milk

Breast milk is sweet, unctuous, light & it is easily assimilated by child.

'यत् क्षीरमुदके क्षिप्रमेकीभवति पाण्डुरम् ।
मधुरं चाविवर्णं च प्रसन्नं तद् विनिर्दिशेत्' ॥ (Su.Ni. 10/25)

Normal breast milk easily mixes with water. It is white & sweet and produces satiety in child.

Functions of breast milk

'जीवनं बृहणं सात्म्यं स्नेहनं मानुषः पयः' । (Cha.Su. 27/224)

'जीवनं बालानां तेषाम् एव स्त्रीक्षीरसात्म्यत्वात्' ।
(Dalhan on Su.Su. 15/5)

Breast milk is formed from the digested food of a mother, so it contains all the nutrients required for proper nourishment of body constituents.

Infant can easily digest breast milk. Breast milk built up immunity in the child. Breast milk is a complete food for the infants. For first 6 months breast milk should be given to child.

Factors responsible for secretion of breast milk

1) Secretion of breast milk depends on proper nourishment of Rasa dhatu.

2) Secretion of breast milk depends on diet of mother. Sweet, liquid, light food will enhance secretion of breast milk. Diet of lactating mother should consist of sufficient quantity of water, milk, ghee, green leafy vegetables. Sweet herbs like shatavari stimulate lactation.

'आहाररसयोनित्वादेवं स्तन्यमपि स्त्रियाः ।
तदेवापत्यसंस्पर्शाद् दर्शनात् स्मरणादपि' ॥ (Su.Ni. 10/20)

3) Lactating woman's affection towards child is the most important factor for proper lactation. Touch or even sight of baby stimulates secretion of breast milk.

4) Psychological status of lactating woman also has effect on lactation. Sad and depressed mood can inhibit secretion of breast milk.

2) Raja

Raja is the secondary tissue of rasa dhatu.

Regular production of raja indicates well functioning of female reproductive system. In Ayurveda raja & artava these two words are used as synonyms of each other. To avoid confusions, specification of the terms raja & artava have done which will be described shortly.

Artava

'ऋतौ भवति इति आर्तवम्' । (A.S.Sha. 1/10)

Artava means ovum which is responsible for fertilization. Ritu indicates specific time or period. The time in which ovum (artava) matures is called as ritu or ritukala. The constituent which is produced in ritukala, is called as artava or streebeeja.

Definition of artava

'स्त्रीणां शुक्रं न गर्भाय । भवेत् गर्भाय च आर्तवम्' ।
(Adhamalla on Sharngadhar 1/6/11-12)

'रक्तलक्षणम् आर्तवं गर्भकृच्च' । (Su.Su. 15/5)

In female artava (ovum) is responsible for fertilization.

Panchabhautika constitution of artava

'आर्तवम् तु आग्नेयम्' । (Su.Su. 14/7)

In artava, there is predominance of teja mahabhuta.

Formation of Artava

'एवं मासेन रस: शुक्रं स्त्रीणां चार्तवं भवति' । (Su.Su. 14/14)

In female it takes one month to form artava from ahara rasa.

Ritu kala

Exact period of fertilization is called as ritu kala.

'ऋतुस्तु द्वादशरात्रं भवति दृष्टार्तवः, अदृष्टार्तवोऽपि अस्तीत्येके भाषन्ते' ।

(Su.Sha. 3/6)

The first twelve nights after the cessation of menstrual flow are considered as ritu kala.

Site of Artavavaha srotas

'आर्तववहे द्वे तयोर्मूलं गर्भाशयः आर्तववाहिन्यश्च धमन्यः' ।

(Su.Sha. 9/12)

Sushruta has described artava-vaha srotas. Roots of artava vaha srotas are uterus & tubes conducting artava. (artava-vahi dhamanis).

Concept of Raja

'मासि मासि रजः स्त्रीणां रसजं स्रवति त्र्यहम् ।
वत्सराद्वादशादूर्ध्वं याति पंचशतः क्षयम् ॥ (A.Hr.Sha. 1/7)

Bleeding per vagina for three days every month is called as raja. This period is called as rajakala or menses.

Menses commences in female at the age of 12 & ceases at the age of 50 years. Raja is a constituent which is excreted during menstrual phase of menstrual cycle.

Appearance of healthy raja

'शशासृक्प्रतिमं यत्तु यद्वा लाक्षारसोपमम् ।
तदार्तवं प्रशंसन्ति यद्वासो न विरंजयेत्' ॥ (Su.Sha. 2/17)

Colour of artava is red like blood of hare or lac. It leaves no stain on clothes and can be washed off easily. The description of artava in this verse implies to raja.

'मांसेनोपचितं काले धमनिभ्यां तदार्तवम् ।
ईषत्कृष्णं विगन्धं च वायुर्योनिमुखं नयेत्' ॥ (Su.Sha. 3/10)

The raja which is accumulated in the uterus in one month is

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brought to cervix of the uterus & under the influence of vayu; this raja is excreted in the form of vaginal bleeding. This vaginal bleeding is odorless & blackish.

Raja is responsible for growth of endometrium of uterus, so that fertilized ovum can be implanted in the uterus. If fertilization doesn't take place then non fertilized stree beeja is excreted in the form of vaginal bleeding.

Volume of raja - 4 anjali.

'स्त्रीणां रजसः अञ्जलयश्चत्वारः' । (A.S.Sha. 5/124)

Factors responsible for regular menstrual cycle

1) Healthy reproductive system (Female reproductive system includes uterus, ovaries, fallopian tubes and vagina).
2) Proper formation of rasa dhatu.
3) Proper functioning of Apana vayu.
4) Proper diet & regimen.

Effects of menstrual cycle on female body

'रजसि च उपचीयमाने शनैः शनैः स्तनगर्भाशययोन्यभिवृद्धिर्भवति' ।
(Su.Su. 14/18)

Raja enhances growth of organs of female reproductive system (growth of artava vaha srotas). Raja also stimulates growth of secondary sex character i.e. development of breast.

Function of Artava

'शुक्रशोणितजीवसंयोगे तु खलु कुक्षिगते 'गर्भ' संज्ञा भवति' ।
(Cha.Sha. 4/5)

Artava unites with shukra to produce fetus.

Function of Raja

'गृहीतगर्भाणाम् आर्तववहानां स्रोतसां वर्त्मानि अवरुध्यन्ते गर्भेण, तस्माद् गृहीतगर्भाणाम् आर्तवं न दृश्यते; ततस्तद् अधः प्रतिहतम् ऊर्ध्वम् आगतम् अपरं चोपचीयमानम् अपरा इत्यभिधीयते । शेषं च उर्ध्वतरम् आगतं पयोधरौ अभिप्रपद्यते तस्माद् गर्भिण्यः पीनोन्नतपयोधरा भवन्ति' । (Su.Sha. 4/24)

In pregnant woman, due to growing fetus, menstrual cycle ceases & the raja then forms placenta (apara) & helps in breast development.

'रजः प्रसेकान्नारीणां मासि मासि विशोधयेत् ।
सर्वं शरीरं धातूंश्च प्रमेहन्त्यतः स्त्रियः' ॥

(Dalhan on Su. Chi. 11/3)

According to Dalhana, due to menstrual bleeding female body is internally cleansed hence women don't suffer from the diseases like prameha. This opinion of Dalhana is a subject of research.

Disorders of Artava

1. Menorrhagea, body ache, foul smelling, menstrual flow are the symptoms of increase in artava.

'आर्तवम् अङ्गमर्दम् अतिप्रवृत्तिं दौर्गन्ध्यं च' । (Su.Su. 14/16)

2. Irregular menses, oligomenorrhaea, dysmenorrhea are symptoms of artavakshay .

'आर्तवक्षये यथोचितकालादर्शनमल्पता वा योनिवेदना च' । (Su.Su. 14/2)

Physiology of Menstruation:

Organs of female reproductive system:

1) Uterus 2) Fallopian tubes 3) Ovaries

Ovaries

Anatomical features of ovaries are as follows:

Number - 2

Synonym: Female gonads

Width of ovary: 3.5 cm

Thickness: 1.5 cm

Position: Situated in the upper pelvic cavity one on each side of the uterus.

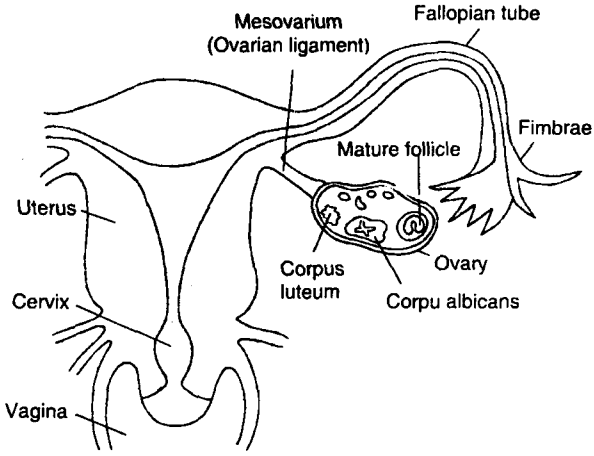

Fig 12 : Female Reproductive System

Histology

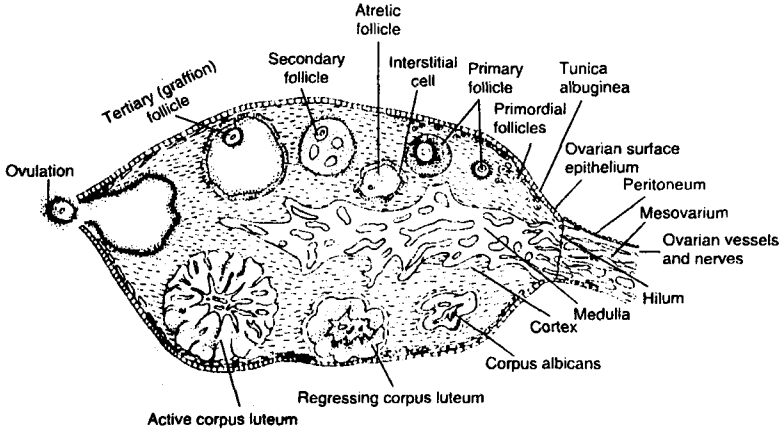

Fig 13 : Ovary (T.S.)

Each ovary consists of following parts:

Germinal epithelium - It is a simple epithelium that covers surface of ovary.

Tunica albuginea - Connective tissue covering lies beneath the epithelium.

Stroma - Parts of stroma are cortex & medulla.

Cortex - Outer functional part of ovary contains ovarian follicles.

Medulla - Inner loose layer of connective tissue of stroma.

Ovarian follicles - Immature ova in various stages of development.

Graffian follicle - Large follicle filled with fluid contains immature ovum. This follicle secretes hormone estrogens.

Corpus luteum - Formed after ovulation due to rupture of graffian follicle, secretes progesterone.

Functions of ovaries

1. Production of secondary oocyte.
2. Ovulation (discharge of oocyte)
3. Overies secrets female hormones such as- i) estrogen, ii) progesterone, iii) relaxin and iv) inhibin

Development of oocyte

Oogenesis: Formation of mature ova in the ovaries is called as oogenesis.

Primordial follicles

Primary oocyte surrounded by a single layer of flattened follicular (epithelial) cells is called primary follicles. At the age of puberty, primary oocytes develop into primordial follicles.

From puberty, development of primordial follicles begins under the influence of follicle stimulating hormone & leutinizing hormone (F.S.H. & L.H.)

Graffian follicle

This follicle is developed from primordial follicle. At the time of ovulation Graffian follicle rupture.

After rupture of Graffian follicle, secondary oocyte is released in the pelvic cavity this process is called as ovulation. After ovulation, in presence of sperm, secondary oocyte

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splits into ovum (mature egg). This ovum unites with sperm forming zygote.

Ovum is a hyploid cell, because it contains 23 chromosomes. (n); Oogonium is a diploid cell because it contains 23 pairs of chromosomes (2n); Development of hyploid (n) ovum from diploid oogonium (2n) is called as Oogenesis.

Ovarian cycle

Cyclic changes taking place in the ovaries during & after the maturation of an oocyte, this is called as ovarian cycle.

Menstrual cycle (Artava charka)

Phages of Menstrual Cycle - 1) Menstrual phase, 2) Preovulatory phase (proliferative), 3) Ovulation and 4) Postovulatory phase.

Changes taking place in the endometrium of the uterus are for the purpose of preparing the saebed for fertilization of ovum. If fertilization does not take place, then the endometrium (stratum functionalis) is shaded this is called as menstrual cycle.

Female reproductive cycle consist of ovarian as well as menstrual cycle.

Hormones controlling female reproductive cycle are as follows:

Hormones of Anterior pituitary - i) F.S.H. - Follicle stimulating hormone, ii) Leutinizing hormone (LH)

Ovarian hormones: i) estrogen and ii) progesterone and

GnRH, a hormone secreted by hypothalamus controls female reproductive cycle.

Menstrual cycle:

1) Menstrual phase:

Synonym: Menses, menarche.

Duration: 4 to 5 days.

Uterine events: i) shading of endometrium of uterus along with unfertilized ovum, ii) rupture of blood vessels.

Contents of menstrual flow: i) 50-150 ml. blood, ii) tissue fluid, iii) mucus and iv) epithelial cell.

After each menstrual cycle, endometrium becomes thin and only stratum basalis remains. The menstrual fluid passes out of vagina.

Cause of discharge: Low progesterone level.

2) Preovulatory phase

This phase is between menstruation & ovulation.

Duration: 6 to 13 days in 28 day cycle. During this phase under the influence of F.S.H. secondary follicles begins to grow. Then one secondary follicle develops into graffian follicle.

Size of graffian follicle: 20-22 mm in diameter.

Follicle secretes estrogen: Effect of estrogen on uterus in preovulatory phase -i) repairing of endometrium, ii) growth of endometrium.

3) Ovulation

Rupture of graffian follicle & the release of the secondary oocyte into the pelvic cavity is called as ovulation.

Ovulation occurs on the 14th day in a 28 day cycle.

High levels of estrogen & LH are responsible for ovulation. After ovulation corpus luteum is formed in the cavity of ruptured follicle.

Function of corpus luteum

Corpus luteum secretes following hormones - i) progesterone, ii) estrogen, iii) relaxin and iv) inhibin.

4) Post ovulatory phase (Luteal phase)

1) LH stimulates growth of corpus luteum. During this phase progesterone level increases. This is also called as luteal phase.

Effect of progesterone & estrogen produced by corpus luteum on uterus - Due to these hormones endometrial glands grow in size, blood flow of endometrium increases and endometrium thickens up to 12- 18mm.

These uterine changes take place one week after ovulation for implantation of fertilized ovum. If fertilization doesn't take place then corpus luteum starts degenerating after 2 weeks of ovulation.

Effects of degeneration of corpus luteum

1) Progesterone & estrogen level of blood decreases,
2) Inhibin level decreases
3) Due to negative feedback, level of GnRH, FSH, LH increases.
4) And due to decrease in estrogen & progesterone levels, menstrual phase of menstrual cycle begins & in ovaries growth of new primordial follicles into secondary follicles begins.

Amenorrhea: Absence of menstruation

Menopause: Stoppage of menstrual cycle after the age of 45.

Puberty: The age at which secondary sex characters of male & female starts developing is called as the age of puberty.

Upadhatu of Rakta

1) Sira (Blood vessels)

Definition of sira

'सरणात् सिराः' । (Cha.Su. 30/12)

Siras are hollow structures which originate from the heart.

Siras conduct rasa & rakta dhatu in the body.

Embryology of sira

मेदसः स्नेहमादाय सिरा स्नायुत्वामप्नुयात् ।
सिराणां तु मृदुः पाकः स्नायूनां च ततः खरः' ॥(Su.Sha. 4/29-30)

In the fetal life blood vessels are formed from the sneha of meda dhatu. Due to mridu paka, soft and flexible sira are formed in the body.

Number of sira

According to Ayurveda there are 700 sira in the body.

Functions of sira

'सप्त सिराशतानि भवन्ति; याभिरिदं शरीरमाराम इव जलहारिणीभिः केदार इव च कल्याभिरुपस्निह्यतेऽनुगृह्यते चाकुञ्चनप्रसारणादिभिर्विशेषैः; द्रुमपत्रसेवनीनामिव तासां प्रतानाः; तासां नाभिर्मूलं, ततश्च प्रसरन्त्यूर्ध्वमधस्तिर्यक् च' । (Su.Sha. 7/3)

The verses from Sushruta, describes network of blood vessels present in the body. Here network of blood vessels is compared to the network of veins present on the central vein of the leaf of a tree.

Central vein of the leaf gives off many branches, in the same way blood vessels originate from the heart & ramify to form network in the peripheral region of the body for supplying nutrients to every cell of the body. Blood vessels nourish the tissues like the central water canal in the field. Supply of nutrients is called as 'upasnehana'.

Functions

i) To conduct rasa & rakta dhatu along with doshas ii) To conduct nutrients to tissues and iii) To conduct prana to tissues, are the functions of siras.

Types of sira

'तत्रारुणा वातवहाः पूर्यन्ते वायुना सिराः ।
पित्तादुष्णाश्च नीलाश्च शीता गौर्यः स्थिराः कफात् ।

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असृग्वहास्तु रोहिण्यः सिरा नात्युष्णशीतलाः' ॥ (Su.Sha. 7/18)

On the basis of predominance of particular dosha, siras are divided into 4 types.

1) Gauri sira: Sira which are whitish in colour, & carries predominantly kapha dosha along with rakta.
2) Neela: These are bluish in color and carry pitta dosha with rakta dhatu.
3) Aruna sira: The sira which are yellowish red in colour & which carry vata dosha.
4) Tamra sira: These red colored vessels conduct pure rakta dhatu.

Siras are upadhatu of rakta dhatu. Hence disorders of rakta affects blood vessels, e.g. i) engorgement of blood vessels (sirapurnatva) due to rakta vriddhi and ii) collapsing blood vessels (sirashaithilya) due to decrease in rakta dhatu.

Fat or medo dhatu is a constitutional content of the blood vessels so disorders of medo dhatu also affects blood vessels.

Increase in medo dhatu in the body affects blood vessels & excess of meda deposits on the innermost membrane of the blood vessels. Knowledge of blood vessels is clinically important to understand relationship between disorders of rakta & medo dhatu & blood vessels.

2) Kandara (Tendon)

'वृत्तास्तु कण्डराः' । (Su.Sha. 5/31)

'महास्नायोस्तु कण्डरा इति संज्ञा' । (Dalhan on Su.Sha. 5/29)

According to Sushruta Samhita Kandara is the type of vritta (round) snayu, which are large & long.

There are 16 Kandara in the body.

'षोडश कण्डराः' । (Su.Sha. 5/11)

'तासां चतस्रः पादयोः तावत्योहस्तग्रीवापृष्ठेष्विति हस्तयोश्चतस्रः, ग्रीवायां चतस्रः, पृष्ठे चतस्रः' । (Dalhan on Su.Sha. 5/11)

4 Kandara are present in lower extremities
4 Kandara are present in upper extremities,
4 Kandara are present in the neck region and
4 Kandara are present in the back

During intra uterine life Kandara are formed from the sneha of medo dhatus. Due to action of Agni & Vata dosha, the sneha of medo dhatu become firm, stable & tough & snayu & Kandara are formed. Kandara can be compared with muscle tendons.

Kandara fastens the joints of the neck, back & extremities very firmly, hence all the joints can perform various movements and bear force applied to it. Firmness of back, neck & head depends on the strength of Kandara.

Upadhatu of Mamsa

Upadhatu of Mamsa dhatu are 1) Twacha (Skin) & 2) Vasa (Muscle fat).

'मांसाद् वसा त्वचः षट् च' । (Cha.Vi. 15/17)

1) Skin (Twacha)

Synonyms: Twak, charma, valka, valkal, sparshan, chadani are the synonyms of skin.

Formation of skin

'तस्य खल्वेवंप्रवृत्तस्य शुक्रशोणितस्याभिपच्यमानस्य क्षीरस्येव सन्तानिकाः सप्त त्वचो भवन्ति' । (Su.Sha. 4/4)

In the fetal life skin is formed & deposited on rapidly growing embryo in the same manner as layers of cream are formed on the boiling milk. Due to similarity between function of skin & mamsa dhatu, skin is considered as a secondary tissue of mamsa.

Function of mamsa dhatu is to cover the bones & give support to the body. Skin also exist in the form of external

covering of the body & protects the body. Skin is nourished at the time of metabolism of mamsa dhatu.

Relations of skin to doshas, dhatus & malas

1) Skin is the largest sense organ of touch
2) Skin is the seat of vata dosha.
3) Skin is the seat of bhrajaka pitta.
4) Radiant glowing skin indicates proper functioning of rakta dhatu.
5) Person who is endowed with uttam rasa sarata has beautiful and delicate skin.
6) Waste product of majja dhatu is excreted through skin & keeps skin unctuous.
7) Healthy skin is the mirror of balanced doshas, dhatus & malas.

Functions of skin

1) Conduction of touch - Skin is a seat of Vata dosha, function of vata dosha is to conduct touch impulse. Vata dosha in the skin allow us to know various types of touch & protect the body from harmful types of touch which can produce pain.

2) Maintenance of complexion of skin - Bhrajaka pitta is present in the skin, which maintains normal colour of skin. Skin is permeable to oils & fats. Medicated oils and fats which are applied during abhyanga, are absorbed through the skin & digested by bhrajaka pitta. Later on these substances can nourish the skin & other structures beneath the skin. Therefore various herbal pastes applied to the skin can improve the skin complexion as well as they can be useful for treating different skin disorders.

3) Lepana is the function of skin & so skin protects the body.

Layers of skin according to Charaka

'शरीरे षट् त्वचः; तद्यथा—उदकधरा त्वग् बाह्या, द्वितीया तु असृग्धरा, तृतीया

सिध्मकिलाससम्भव अधिष्ठाना। चतुर्थी दद्रुकुष्ठसम्भव अधिष्ठाना, पंचमी अलजीविद्रधीसम्भव अधिष्ठाना, षष्ठी तु यस्यां छिन्नायां ताम्यति अंध इव च तमः प्रविशति यां च अपि अधिष्ठाय अरूषि जायन्ते, पर्वसु कृष्णरक्तानि स्थूलमूलानि दुश्चिकित्स्यतमानि च'। (Cha.Sha. 7/4)

According to Charaka there are six layers of skin:

1) 1st layer: Udaka dhara
2) 2nd layer: Asrigdhara
3) 3rd layer: This layer of skin is the seat of skin diseases such as - i) siddhma and ii) kilasa, both these are comparable to leukoderma.
4) 4th layer: The forth layer of the skin is the seat of kushtha (leprosy) & dadru (ringworm infection).
5) 5th layer: This layer of skin is the site of skin diseases such as- i) vidradhi (abscess) and ii) alaji (adenitis).
6) 6th layer: If this layer of skin gets traumatized or incised then one may get giddiness & become unconscious. This layer is also a seat of glandular growth called as arunshi.

The first layer of skin which is called as Udaka dhara is concerned with regulation of water balance.

The second layer which is named as Asrigdhara as it has rich blood supply. The remaining four layers of skin are the site of many skin diseases.

Layers of skin & related diseases are the matter of research.

Layers of skin according to Sushruta

According to Sushruta skin is made up of 7 layers.

'तासां प्रथमाऽवभासिनी नाम, या सर्वान् वर्णान् अवभासयति पञ्चविधां च छायां प्रकाशयति, सा व्रीहेः अष्टादशभागप्रमाणा, सिध्मपद्मकण्टक अधिष्ठाना; द्वितीया लोहितानाम्, षोडशभागप्रमाणा, तिलकालकन्यच्छव्यंग अधिष्ठाना; तृतीया श्वेता नाम, द्वादशभागप्रमाणा, चर्मदल-अजगल्लिका-मशक अधिष्ठाना; चतुर्थी ताम्रा नाम अष्टभागप्रमाणा, विविधविलासकुष्ठ अधिष्ठाना; पञ्चमी वेदिनी नाम पञ्चभागप्रमाणा, कुष्ठविसर्पाधिष्ठाना; षष्ठी रोहिणी नाम व्रीहिप्रमाणा, ग्रन्थ्यपच्यर्बुदश्लीपदगलगण्डा-धिष्ठाना; सप्तमी मांसधरा नाम व्रीहिद्वयप्रमाणा, भगन्दरविद्रध्यर्शोऽधिष्ठाना'।

(Su.Sha. 4/4)

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In Sushruta samhita thickness of skin layer is compared to the thickness of vrihi (yava grain).

'व्रीहिस्त यवः' । (Dalhan on Su.Sha. 4/4)

No. of skin layer	*Name of skin layer*	*Thickness of skin layer*	*Name of disease*
1.	Avabhasini	18th part of brihi	1) Sidhma 2) Padmakantaka
2.	Lohita	16th part of brihi	1) Tilakalaka
3.	Shweta	12th part of brihi	1) Charmadala 2) Ajagallika 3) Mashaka
4.	Tamra	8th part of brihi	1) Kilas kushtha
5.	Vedini	5th part of brihi	1) Kushtha 2) Visarpa (Erysipelas)
6.	Rohini	One brihi	1) Apachi (Adenitis) 2) Arbuda (Mallignant/ Tumors) 3) Shlipada (Filariasis)
7.	Mamsa-dhara kala	Two brihi	1) Galaganda (Goiter) 2) Bhagandara (Fistula) 3) Vidradhi (Abscess) 4) Arsha (Haemorrhoides)

According to Sushruta, the first layer of skin-avabhasini reflects luster and colour of the skin, while 2nd layer of the skin, reddish color to skin.

The remaining five layers of skin are important to explain

relationship between these layers and skin disorders. In this way knowledge of layers of skin gives the information of disorders taking place in every layer, relationship of skin to doshas, dhatus & malas. This is useful for the diagnosis & treatment of the skin disorders.

Concept of Chhaya & Prabha (Luster)

'वर्णमाक्रामति च्छाया भास्तु वर्णप्रकाशिनी ।
आसन्ना लक्ष्यते च्छाया भा: प्रकृष्टा-प्रकाशते' ॥

(Cha.Indriya 7/16)

Chhaya: Vata dosha is responsible for chaya of the skin. Due to chaya the complexion and the skin becomes dull.

'खादीनां पञ्च पञ्चानां छाया विविधलक्षणा: ।
नाभसी निर्मला नीला सस्नेहा सप्रभेव च ॥
रूक्षा श्यावारुणा या तु वायवी सा हतप्रभा ।
विशुद्धरक्ता त्वाग्नेयी दीप्ताभा दर्शनप्रिया ॥
शुद्धवैदूर्यविमला सुस्निग्धा चाम्भसी मता ।
स्थिरा स्निग्धा घना श्लक्ष्णा श्यामा श्वेता च पार्थिवी ॥
वायवी गर्हिता त्वासां चतस्र: स्यु: शुभोदया: ।
वायवी तु विनाशाय क्लेशाय महतेऽपि वा' ॥

(Charak. Indriya. 7/10-13)

Types of chaya	*Characteristics of chaya*
1) Nabhasi	Pure, blue, unctuous, lustrous
2) Vayavi	Rough, blackish, reddish, lustrous
3) Agneyi	Pure, red, brilliant, charming
4) Ambhasi	Clear, unctuous
5) Parthiva	Stable, unctuous, solid, smooth, sky col ored or white

Vayavi chaya may cause death or calamity while other four types of shadows are shubha or auspicious

Prabha (Luster): Prabha shows predominance of teja maha-bhuta.

'स्यात्तैजसी प्रभा सर्वा सा तु सप्तविधा स्मृता ।

रक्ता पीता सिता श्यावा हरिता पाण्डुराऽसिता ।।
तासां या स्युर्विकासिन्य: स्निग्धाश्च विपुलाश्च या ।
ता: शुभा रूक्षमलिना: संक्षिप्ताश्चाशुभोदया:' ।।

(Cha.Indriya 7/14-15)

Types of Prabha (Luster) - i) Red, ii) yellow, iii) white, iv) blackish, v) greenish, vi) pale and vii) black.

Functions of skin:

Skin is the largest organ in the body. Skin is organ of beauty & attraction. The functions performed by skin are given below:

1) Intact skin protects all interior organs in the body by preventing entry of bacteria.

2) Skin regulates body temperature.

3) Skin synthesizes vitamin D from sterols present in skin by using ultraviolet rays of sun light.

4) Skin is the largest sense organ and is responsible for sensations of heat, pain, cold and pressure.

5) Skin excretes sodium chloride & urea in a small quantity through sweat.

6) Certain oils, fat soluble substances, drugs are absorbed through the skin.

7) Skin maintains water balance by altering sweat secretion, for e.g. in hot climate excretion of sweat is more while in cold climate excretion of sweat is reduced.

8) Skin stores water, fat, salt & glucose in small amount.

9) Skin secrets sebum which provides oiliness to the skin.

10) Skin reflects the age of man.

11) Melanin in skin gives colour to the skin; also melanin protects the body from bright ultraviolet rays of sun.

2) Vasa (Muscle fat)

Vasa is the secondary tissue of mamsa dhatu.

'मांसाद् वसा त्वच: षट् च' । (Cha.Vi. 15/7)

'शुद्धमांसस्य य: स्नेह: सा वसा परिकीर्तिता' । (Su.Sha. 4/13)

Sneha of shuddha mamsa is called as vasa. In Sanskrit vasa means 'to cover'.

'वसति शरीरे विशेषत: मासे इति वसा' ।
'आच्छादयति शरीरं मांसम् उदरादिकं इति वसा:' ।

Vasa is the sneha present in the mamsa dhatu. It is the muscle fat deposited around abdominal organs. Vasa is the muscle fat which can be obtained by boiling the muscle tissue in the water, the fat which floats on the water is called as vasa.

According to Ayurveda ghee, oil, vasa (muscle fat) & majja are the mahasneha (oleating substances) which can be used for oleation therapy. Meda, vapa & vasa are used as synonyms of each other, but they are different substances. Meda is the tissue, vapa is the peritoneal fat.

Properties of vasa

Vasa is unctous and heavy.
Volume of vasa is 3 anjali.

'त्रयो (अंजलय:) वसाया:' । (Cha.Sha. 7/15)

Functions of vasa

Vasa means muscle fat which provides strength to mamsa dhatu. Vasa lubricates mamsa dhatu.

Upadhatus of Medo dhatu

Snayu (ligaments)

Site of snayu:

Snayus are distributed in all over the body.

Embryology of snayu

'मेदस: स्नेहमादाय सिरास्नायुत्वमाप्नुयात् ।
सिराणां तु मृदु: पाक: स्नायूनां च तत: खर:' ॥(Su.Sha. 4/29-30)

In fetal life snayus are formed from the sneha of medo dhatu.

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Due to khara-paka snayus are formed. The khara-paka of snayu indicates prolonged action of fire (agni) on the sneha of medo dhatu. Due to this snayu become tough & strong. There are total 900 snayus in the body.

Types of snayus:

1) Pratanvati (ramifying)
2) Vritta (kandara/tendons)
3) Prithu (flat snayus, aponeurosis)
4) Sushira (sphinctors)

'प्रतानवत्यो वृत्ताश्च पृथ्व्यश्च शुषिरास्तथा' । (Su.Sha. 5/30)

1) Ramifying ligaments are present at all joints & in upper & lower extremities.

2) Tendons are present in upper & lower exterminates & in the back.

3) Flat ligaments are present in chest, back, and head.

4) Sphincters of stomach, small & large intestines are circular in shape & they belong to sushira type of snayus.

Pyloric sphincter, ilio-cecal sphincter, external & internal sphincters of anal canal belong to sushira type of snayus.

Functions of snayus

'नौर्यथा फलकास्तीर्णा बन्धनैर्बहुभिर्युता ।
भारक्षमा भवेदप्सु नृयुक्ता सुसमाहिता ।
एवमेव शरीरेऽस्मिन् यावन्तः सन्धयः स्मृताः ।
स्नायुभिर्बहुभिर्बद्धास्तेन भारसहा नराः' । (Su.Sha. 5/32-33)

In the above verses human body is compared to a boat made up of wooden plates. For making boat planks & timber is fastened together by large ropes, such boat become stable, firm. Such boat can float & carry large load. Similarly human body is bound & fastened at joints by snayus (ligaments). Due to these snayus body becomes tough & endures lot of manual work.

Upadhatu of Asthi

Danta (Teeth)

According to Sharngadhara, teeth are the secondary tissue of bones.

Synonyms: Dwija, ruchaka, danta and ruchakasthi.

Relationship between doshas, dhatus to teeth

1) Teeth are smaller in size in Vata constitution.
2) Vata constitution persons suffer from weak teeth and carries.
3) Pitta constitution persons suffer from gingivitis, bleeding gums and the color of their teeth is white.
4) Kapha constitution persons have strong teeth.
5) Asthi sara persons also have strong and big teeth.
6) They are very compact, smooth & white in shukra sara persons.
7) In meda sarata the teeth are unctuous.

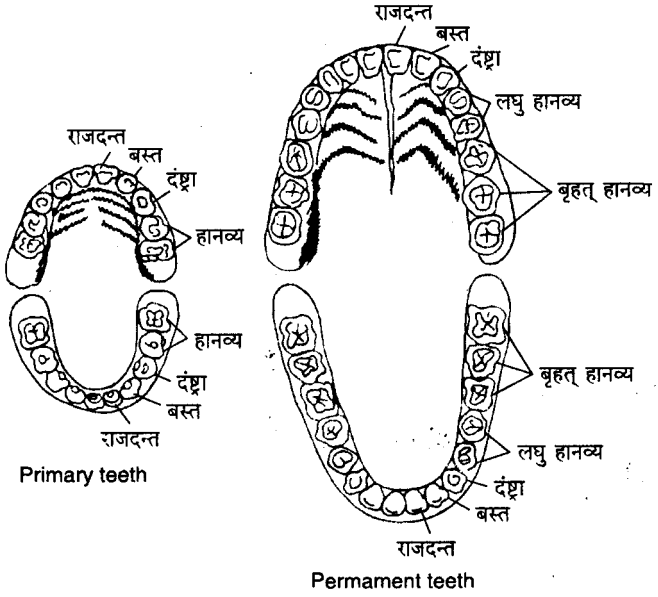

Fig 14 : Teeth

Functions of teeth: Mastication of food:

1) Proper digestion of food depends on mastication of food.

2) In old age when the teeth are lost or due to loose fitting denture, food is not properly chewed, many disorders of gastro-intestinal tract occur.

(For more information on teeth refer Sharira kriya Vijnyana Part-I)

Chapter 12

Mala - Waste Products

Malas are those constituents of the body which are regularly eliminated from the body and thus keep the body clean.

Definition of Mala

'मलिनिकरणात् मला:' ।

The constituents of body, which can vitiate body (when they accumulate in large amounts or decrease), are called as malas.

Malas which are formed during the process of digestion are called as **'anna-mala'** while malas which are formed in the metabolism of dhatus are called as **'dhatu-mala'**. The malas (waste products) in body are listed in the following verse.

'किट्टमन्नस्य विण्मूत्रं रसस्य तु कफोऽसृज: ।
पित्तं, मांसस्य खमला, मल: स्वेदस्तु मेदस: ॥
स्यात् किट्टं केशलोमास्थ्नो, मज्ज्ञ: स्नेहोऽक्षिविट् त्वचाम् ।

(Cha.Chi. 15/18,19)

Waste products of food are urine (mutra) and faces (purisha), while waste products (by-product) of rasa dhatu are kapha, that of rakta and mamsa dhatu are pitta and kha-mala respectively. Waste product of medo dhatu is sweat (sweda) waste products of asthi dhatu are hair (kesha and loma) while sneha of eyes, faces and skin are the waste products of majja dhatu.

'कफ: पित्तं मला: खेषु स्वेद: स्यान्नखरोम च ।
स्नेहोऽक्षित्वग्विट्मोजो धातूनां क्रमशो मला:' ॥

(Ash.San.Sha. 5/63)

According to Ashtang Sangraha ojas is the waste product of shukra dhatu while as per Dalhana, mustache and beard are waste products of shukra dhatu.

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Health is maintained when these waste products are eliminated properly. When they accumulate in excess various diseases are produced.

Purisha (Feces)

'किट्टम् अन्नस्य विण्मूत्रं.....' । (Cha.Chi. 15/18)

Purisha (feces) is the waste product of food.

Synonyms: Shakrit, upaveshana, vit, gutha, varchas are the synonyms of purisha.

Panchabhautika constitution of purisha - Purisha predominantly consists of agni and vayu mahabhuta.

'पुरीषं पार्थिवम् ' । (Bhanumati on Su.Su. 15/8)

Constituents of purisha - Purisha consist of undigested food material and sneha of majja mala. Undigested food material forms the major bulk of purisha.

Qualities

'तत्राच्छं किट्टमन्नस्य मूत्रं विद्याद्घनं शकृत्' ॥ (Ash.Hr.Sha 3/61)

Purisha is a solid waste product. Colour of purisha is yellowish to brown. Its consistency depends on the ingested food and water intake. Sama purisha is heavier, with foul smell and it sinks in the water while nirama purisha is lighter and floats on the water.

Colour, consistency and odor of purisha changes in many diseases like kamala (jaundice), grahani, atisara (loose motions), pravahika etc. Normally purisha is a yellowish colored and semisolid in nature. Consistency of purisha changes depending on the type of constitution. In Vata prakriti it is hard, in Pitta it is semi solid or watery and in Kapha it is soft and solid. Rasa of purisha is katu.

Site of formation

'पुरीषवहानां स्रोतसां पक्वाशयो मूलं स्थूलगुदं च' । (Cha.Vi. 5/8)

'तत्र वातवर्चोनिरसनं स्थूलान्त्रप्रतिबद्धं गुदं नाम मर्म' । (Su.Sha. 6/25)

Purishavaha srotas is a site of formation and excretion of purisha.

Pakvashaya (large intestine) and sthula guda (anal canal) are the roots of purisha vaha srotas. Purisha-dhara kala plays vital role in the formation of purisha. Purisha dhara kala is also called as 'mala-dhara kala'.

पंचमी पुरीषधरा नाम; या अन्तःकोष्ठे मलम् अभिविभज्यते पक्वाशयस्था' ।
(Su.Sha. 4/16)

'यकृत् समन्तात् कोष्ठे च तथाऽन्त्राणि समाश्रिता ।
उण्डुकस्थं विभजते मलं मलधरा कला' ॥ (Su.Sha. 4/17)

Site of mala-dhara kala is the antra (colon) which is anatomically related to the hepatic region and unduka (cecum). Mala-dhara kala separates solid and liquid constituents of kitta. Purisha is formed as a result of digestion of food. Regular elimination of purisha indicates balanced functioning of agni, samana vayu, pachaka pitta and apana vayu.

Quantity

'सप्त (अंजलयः) पुरीषस्य' । (Cha.Sha. 7/15)

Quantity of purisha is eight anjali.

Functions of Purisha

'अवष्टम्भः पुरीषस्य (कार्यम्)' । (Ash.Hr.Su. 11/5)

Avashtambha (to give support) is the function of purisha. Purisha is formed and eliminated from purisha vaha srotas. A small quantity of purisha is always present in pakvashaya, which supports the body. Weakness, fatigue in dehydration due to atisara (loose motion) indicates that purisha in pakvashaya is required to support the body. In Rajayakshma, virechana chikitsa is contraindicated because due to severe dhatu kshaya, purisha is the only constituent in Rajaya-kshma which gives support (avashtambha) to the body.

'पुरीषमुपस्तम्भं वाय्वग्निधारणं च' । (Su.Su. 15/8)

Another function of purisha is dharana of vayu and agni. Formation and regular elimination of purisha maintains balanced state of Vata (samana & apana) and jatharagni. Urge of hunger, ingestion of food, its digestion, and excretion of waste products is a cyclic process, and formation and elimination of purisha maintains this cycle. Disorders of purisha affect normal functioning of agni and vayu.

Disorders of Purisha

Symptoms of Increased Purisha
(Purisha-vriddhi)

'कुक्षौ आध्मानम् आटोपं गौरवं वेदना शकृत्' । (Ash.Hr. 11/12)

Adhmana (abdominal distention due to gases), atopa (gurgling of intestines), gaurava (heaviness) and pain in abdomen are the symptoms of purisha vriddhi. Drinking warm water with ghee, swedana, abdominal massage and basti are helpful in this condition.

Symptoms of Decreased Purisha
(Purisha-kshaya)

'पुरीषे वायु आंत्राणि सशब्दो वेष्टयन्निव कुक्षौ भ्रमति यात्यूर्ध्वं हृत्पार्श्वे पीडयन् भृशम्' । (Ash.Hru.Su. 11/21)

Abdominal discomfort, gurgling of intestines, pain in flanks and cardiac region are the symptoms of purisha kshaya. Green leafy vegetables, pulses, fibrous food is advised in this condition.

FECES

Feces is the waste products of food.

Site of formation: Large intestine.

Physiology of Formation of Feces

1) Feces is formed in large intestine.

2) Food is digested & absorbed in small intestine.
3) Chyme passes from ileum to large intestine. Chyme remains in large intestine for three to ten hours.
4) Water is absorbed in large intestine.
5) The last stage of digestion takes place in the large intestine.
6) Large intestine does not secrete digestive enzymes.
7) Intestinal glands secrete mucus.
8) Intestinal bacterial acts on chime.
9) Intestinal bacteria ferment remaining carbohydrates, proteins and fats.

Carbohydrate fermentation: Hydrogen, carbon dioxide and methane gas is formed in the fermentation of carbohydrates.

Protein fermentation : Indole, skatole, hydrogen sulphide and skatole are formed. Indole and stercobilin gives odor to feces.

Some of the skatole and indole are transported to liver for converting them in the less toxic substances.

10) Some vitamins of B complex group & vitamin K are synthesized & absorbed in this way.

11) After 3 to 10 hours feces is formed in the large intestine by action of bacteria on the feces.

Contents of Feces

1) Water, 2) inorganic salts, 3) undigested parts of food, 4) various gases formed due to bacterial fermentation and 5) epithelial cells.

Reaction of feces: Neutral or acidic.

Color: Yellowish brown due to stercobilin.

Odor: Specific odor due to indole, skatole and H_2S

Amount of gas formed: Approximately 500 c.c.

Quantity: Approx. 150 gm/24 hours.

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Consistency: Semisolid / hard / well formed. Consistency depends on intake of water. Vegetarian food increases bulk of feces.

Physiology of Defecation

1) Feces are stored in large intestine.
2) When large intestine is full of feces then mass peristalsis appear in colon.
3) Due to mass peristalsis feces are pushed from sigmoid colon into the rectum.
4) Stretching of rectal wall initiates defecation reflex.
5) Due to shortening of rectum, increased abdominal pressure, contraction of diaphragm & abdominal muscles, internal anal sphincter opens up & feces is excreted through anus.
6) External anal sphincter is under voluntary control. Voluntary relaxation of external anal sphincter causes fecal excretion.

Disorders of Feces

1) Diarrhea: Frequent defecation of liquid feces caused by increased intestinal motility.
2) Constipation: Difficult defecation due to hardening of stool.

Mutra (Urine)

'तत्र अच्छं किट्टं अन्नस्य मूत्रं विदयात् घनं शकृत्' ।(Ash.Hru.Sha. 3/61)

Mutra or urine is a liquid waste product of food.

Synonyms - Bastimala, meha, mutra, nrijalam, strava and prastrava.

Site of Mutravaha stoats

'मूत्रवहानां स्रोतसां बस्तिर्मूलं वंक्षणौ च' । (Cha.Vi. 5/8)

Basti and vankshana (pelvic region) are the roots of

mutravaha srotas. Poshaka mutra collects kitta from all body. Its formation starts in pakvashaya (large intestine). Purisha-dhara kala separates poshaka mutra from kitta in pakva-shaya, therefore pakvashaya is considered as root of mutra-vaha srotas. Urinary bladder, ureters are pelvic organs so the pelvic region is the root of mutravaha srotas.

'मूत्रवहे द्वे तयोर्मूलं बस्तिर्मेढ्रं च' । (Su.Sha. 9/12)

According to Sushruta Samhita, basti (urinary bladder) and medhra (penis) are the roots of mutravaha srotas.

Basti is an organ situated in pelvic region. It is bahirmukha srotas (external orifice). Basti is a pranayatan (site of prana) and it is also sadyahpranahara marma (marma causing sudden death due to injury). This important organ is related to urine formation and penis is related to excretion of urine.

Panchabhautika constitution of urine.

'मूत्रं जलानलात्मकं' । (Bhanumati on Su.Su.. 15/8)

Mutra predominantly consist of Jala and Agni mahabhuta.

Qualities of urine

Laghu (light), tikshna (sharp) and hot (ushna) are the qualities of mutra. It is pungent and salty.

'चत्वारो (अंजलयः) मूत्रस्य' । (Cha.Sha. 7/14)

Volume of urine is four anjali.

Ayurvedic concept of urine formation

'पक्वाशयगतास्तत्र नाड्यो मूत्रवहास्तु याः ।
तर्पयन्ति सदा मूत्रं सरितः सागरं यथा ॥
सूक्ष्मत्वान्नोपलभ्यन्ते मुखान्यासं सहस्रशः ।
नाडीभिरुपनीतस्य मूत्रस्यामाशयान्तरात् ॥
जाग्रतः स्वपतश्चैव स निःस्यन्देन पूर्यते ।
आमुखात् सलिले न्यस्तः पार्श्वेभ्यः पूर्यते नवः' । (Su.Ni. 3/18-20)

This verse explains formation of urine. Process of urine

formation begins in pakvashaya. The poshaka mutra which is separated from kitta is absorbed from pakvashaya and brought to basti in the following manner.

As water in the river is drained into ocean continuously, in the same way urinary ducts (mutravaha nadi) from pakvashaya carry poshaka mutra to basti.

Urinary ducts and their fine branches are spread in the abdominal cavity around pakvashaya and amashaya, which constantly drains poshaka mutra to basti. Basti-purana (drainage of urine) is a continuous process which is compared with new ghata (earthen pot) immersed in water. When earthen pot is new, it is very porous, and it permeates water easily that way urine from urinary ducts enter the basti, and urine is formed and stored in basti. When basti gets filled with urine, due to action of apana vayu, urine is excreted.

The fact that urine is formed in kidneys can't be neglected. According to new thoughts of researchers, poshaka mutra is formed in pakvashaya. This is then absorbed in blood and then in kidneys many metabolic waste products mix with poshaka mutra, and later on this mutra is transferred to basti by ureters.

'अपानोऽपानगः श्रोणिबस्तिमेढ्रोरूगोचरः ।
शुक्रार्तवशकृन्मूत्रगर्भनिष्क्रमणक्रियः' ।। (Ash.Hru.Su. 12/9)

The process of micturition is controlled by Apana vayu.

Functions of Urine

'मूत्रस्य क्लेदवाहनम्' । (Ash.Hru.Su. 11/4)

Kleda-vahana and basti-purana are the functions of mutra.

'बस्तिपूरणविक्लेदकृन्मूत्रम्' । (Su.Su. 15/8)

Kleda is unctuous moisture in the body. Transportation and excretion of kleda with urine is called as kleda-vahana

constant draining of urine in basti is called as basti-purana. If urine fails to conduct kleda; kleda accumulates in the body which can result in many diseases like prameha and obesity.

'मानुष मूत्रं तु बिषापहम्' । (Ash.Sa. 6/142)

Disorders of urine

Symptoms of Increased Urine
(Mutra-vriddhi)

'मूत्रं तु बस्तिनिस्तोदं कृतेऽप्यकृतसंज्ञताम्' । (Ash.Hru.Su. 17/13)

Suprapubic pain (basti-nistoda) and urinary incontinence are the symptoms of mutra vriddhi.

Astringent substances like jack fruit (jambu) and udumbara reduces mutra vriddhi.

Symptoms of Decreased Urine
(Mutra-khaya)

Scanty urine formation, dysurea, heamaturea and change in normal colour of urine are the symptoms of mutra kshaya.

'मूत्रेल्पं मूत्रयेत् कृच्छ्राद् विवर्णं सास्रमेव वा' । (Ash.Hru. 11/22)

Gokshura, musta, punarnava are few therapeutic drugs which enhances urine formation.

Kidneys

Anatomical consideration of kidneys

Kidneys are main organs of urinary system.

Number: 2

Position: Retroperitoneal

Layers of tissue around the kidneys are:

1) Renal capsule, 2) adipose capsule, 3) renal fascia

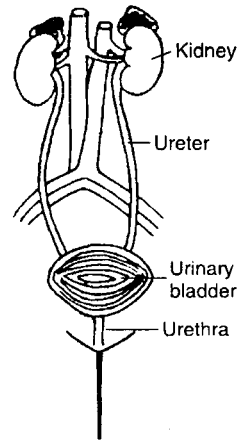

Fig 15 : Urinary System

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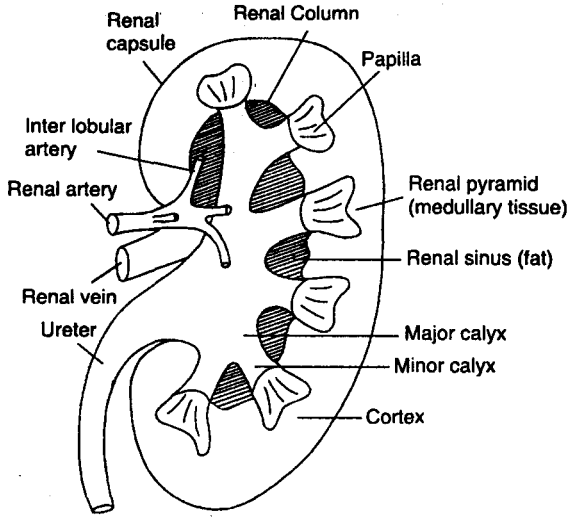

Fig 16 : Cross-sectional view of Left Kidney

Internal structures of kidneys

1) cortex, 2) medulla, 3) renal pyramids, 4) renal pelvis, 5) calyces.

Functional Unit of kidneys is called as nephron.

Parts of nephron are- 1) Renal tubule, 2) Bowman's capsule (glomerular capsule)

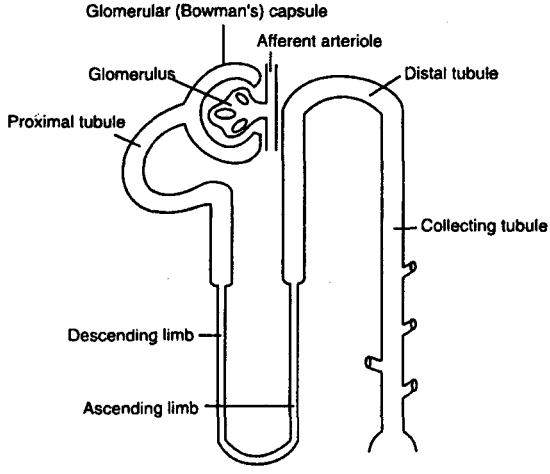

Fig. 17 : Structure of Nephron

Glomerular capsule - Cup like structure from which renal tubules starts.

Glomeruls - The tuft of capillaries which is surrounded by Bowman's capsule is called as glomerular capsule.

Parts of renal tubules are - 1) proximal convoluted tubule, 2) descending tubule of nephron, 3) loop of Henle, 4) ascending tubule, 5) distal convoluted tubule, 6) collecting tubule.

In the medulla, the collecting tubules combine to form papillary ducts which open at the renal papillae into minor calyces. Blood supply of kidney is through renal arteries.

Blood flow of kidneys: 1200 ml. / minute

Nerve supply: Renal plexus

Physiology of urine formation

Nephron plays important role in urine formation.

Processes required for urine formation

1. Glomerular filtration
2. Tubular reabsorption
3. Tubular secretion.

Glomerular filtration

1) Blood enters the glomeruls.

2) Due to blood pressure water and dissolved components pass through endothelial capsular membrane.

3) The fluid filtered is called as filtrate.

4) Filtrate is a fluid filtered through endothelial capsular fluid. Filtrate consists of all the materials present in the blood except some elements and proteins, which are so large that they can not be passed through endothelial capsular membrane.

Glomerular filtration rate (G.F.R.)

The amount of filtrate that flows out of renal corpuscles of both kidneys is called as G.F.R.

G.F.R. : 125ml / min
180 liters / day

Contents of Filtrate

Water, glucose, amino acids, chlorides, carbonic acid, potassium, urea, uric acid, creatinine, hemoglobin. Plasma proteins do not pass through endothelial capsular membrane.

Tubular Reabsorption

Filtrate formed in Bowman's capsule pass through renal tubules. 99% of filtrate is reabsorbed. 1% of filtrate leaves the body.

Function of proximal convoluted tubule

1. Reabsorption of Glucose,
2. Reabsorption of Amino acids,
3. Reabsorption of Na+, Cl Hco_3, K and
4. Reabsorption of urea.

Function of descending tubule of the loop of nephron

Passive reabsorption of water

Function of ascending tubule

Reabsorption of Na, Cl and urea

Function of Distal convoluted Tubule

Reabsorption of sodium, creatinine, chlorine, carbonic acid.

Collecting tubules:

Reabsorption of sodium chlorides and urea.

Sodium is reabsorbed under the influence of aldosterone

Importance of tubular reabsorption:

Tubular reabsorption conserves the important substances that body need, for e.g. glucose sodium chlorides etc. These substances are returned to blood.

Tubular secretion

Third process takes place in urine formation is tubular secretion.

Tubular secretions are mixed with filtrate.

1. H ions are secreted in proximal convoluted tubules
2. Potassium ions (K), NH_3, creatinine are secreted in distal convoluted tubule.
3. H ions and k ions are secreted in collecting tubules.

Due to H^+ ion secretion urine is acidic in nature.

In this way by 1) Filtration, 2) reabsorption, 3) tubular secretion, urine is formed.

Urine formed in the collecting tubule passes to minor and major calyces via papillary ducts to renal pelvis and from renal pelvis it is carried to bladder via ureters.

Functions of Kidneys

1. Kidneys maintain blood pH by secreting H^+ ions
2. Kidneys maintain blood pressure
3. Kidneys help to keep water balance
4. Excretions of drugs
5. Excretion of ammonia urea, uric acid
6. Maintains osmotic pressure in the blood
7. Kidneys are related to vit D metabolism

Ureters

Number: 2

Length: 25 to 30cm

Ureter is a extension of renal pelvis. They do not have valves.

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Function of ureters:

To transport urine from renal pelvis into urinary bladder. Urine is transported by peristaltic movements.

Urinary Bladder

It is a hollow muscular organ.

Position

It is situated posterior to the symphysis pubis. To store the urine is the function of bladder. Due to transitional epithelium bladder can be stretched and store urine.

Average capacity: 700 to 800 ml.

Micturation: Act of urinary excretion from urinary bladder is called as micturation.

1) When urinary bladder is filled with urine, wall of bladder is stretched.

2) Strech receptors in the wall of the bladder transmit impulses to lower portion of spinal cord. These impulses initiate desire to expel urine.

Urinary incontinence

A lack of voluntary control micturition is called as Urinary incontinence.

Urine retention

Failure to empty bladder is called as Urine retention.

Normal constituents of urine

1. Organic constituents

Urea	30.0 gm
Creatinine	1.0 gm
Uric acid	0.7 gm
Hippuric acid	0.7 gm
Indican	0.01 gm
Acetone bodies	0.04 gm

2. Inorganic constituents of urine

Nacl	15 gm
Kcl	3.3 gm
So4	2.4 gm
Po4	2.5 gm
NH3	0.7 gm
Mg++	0.1 gm
Ca++	0.3 gm
Fe	0.05 gm
Other	0.2 gm

Total amount of urine = 1500 ml. in 24 hours

Total solids = 60 gm.

1. Average volume of urine = 1500 ml / 24 hrs
2. Colour : Pale yellow variable, depends on diet & water intake.
3. Appearance - fresh urine is clear, transparent
4. Odor = Aromatic
5. pH : It is 6.0
6. Specific gravity = 1.001 to 1.0035 depends on concentration.

Factors affecting urine volume

Average volume of urine - 1500 ml / 24 hrs.

Following factors affects urine volume:

1. Blood pressure
2. Blood concentration
3. Diet
4. Temperature
5. Mental state
6. General health
7. Exercise

High blood pressure reduce urine volume. High concentration of sodium ion in blood increases urine volume

Intravenous saline injection promotes urination.

High temperature reduces urine volume.

Diuretics

Certain chemicals reduces secretion of anti diuretic hormone (ADH) and urine output increases, such chemicals are called diuretics e.g. tea, coffee, alcohol are diuretics. Exercise always reduces urine volume.

Abnormal constituents of Urine

1) Albumin	2) Glucose	3) Bile salts
4) Bile pigments	5) Ketone bodies	6) Erythrocytes

Sweda (Sweat)

Sweda (sweat) is the waste product of medo dhatu.

Etymology (Nirukti) of Sweda

'स्विदयते अनेन इति स्वेद:' ।

'यच्चोष्मणा अनुबद्धं लोमकूपेभ्यो निष्पतत् स्वेदशब्दमवाप्नोति' ।

(Cha.Sha. 7/15)

Literal meaning of sweda is to cook or to steam. It is the perspiration produced due to exercise or heat.

Synonyms - sweda, gharma, nidagha are the synonyms of sweda.

Panchabhautik constitution of sweda

'स्वेद: च आप्यम्' । (Bhanumati on Su.Su. 15/8)

It predominently consist of jala and teja mahabhuta.

Location of sweda

Swedavaha srotas is a site of sweda.

'स्वेदवहानां स्रोतसां मेदोमूलं रोमकूपाश्च' । (Cha.Vi. 5/8)

Medo dhatu and lomakupa (pores of the skin) are the roots of swedavaha srotas.

Sweda is formed during the metabolism of medo dhatu.

Heavy exercise, hot climate enhances sweat formation.

'स्वेददोषाम्बुवाहीनि स्रोतांसि समधिष्ठित: ।
अन्तरग्नेश्च पार्श्वस्थ: समानोऽग्निर्बलप्रद:' ॥ (Cha.Chi. 28/8)

Swedavaha srotas is the site of samana vayu. It regulates excretion of sweat and also regulates body heat.

'व्यानो हृदि अवस्थित:....स्वेदासृकस्त्रावणादि क्रिय:....' ।
(Ash.San.Su. 20/)

Vyana vayu helps in the excretion of sweat from the body. Conduction of sweat from the roots of the hair, opening of the skin pores and to help in the excretion of sweat, all these functions belong to vyana vayu.

Sweat is the important site of pitta.

'नाभिरामाशय: स्वेदो लसीका रूधिरं रस: ।
दृक् स्पर्शनं च पित्तस्य नाभिस्त विशेषत:' ॥ (Ash.Hru.Su. 12/2)

Constitutions and sweating

1) Vata constitution - less sweating
2) Kapha constitution - less sweating
3) Pitta constitution - profuse sweating with strong smell

Due to dryness Vata constitution has tendency of less sweating.

Due to coldness of kapha dosha, kapha constitution has less sweating. Due to hotness of pitta, pitta prakriti person has profuse sweating with strong odor.

Functions of sweda

'स्वेदस्य केशविधृति: (क्लेदविधृति: इति अपि पाठ:)' ।
(Ash.Hru.Su. 11/5)

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1) Kleda vidhriti or holding some moisture in the skin is the function of sweda. In cold climate, body needs more kleda (moisture) therefore sweat excretion is reduced.

'स्वेदः क्लेदत्वक्सौकुमार्यकृत्' । (Su.Su. 15/8)

2) Maintenance of kleda (moisture) & to maintain soft texture of the skin is the functions of sweda.

3) Nourishment of loma (hair) of the skin is the function of sweda.

4) Sweda is the site of pitta & it controls hotness of pitta dosha by altering sweat formation.

Disorders of Sweda

Symptoms of Increased Sweat
(Sweda-vriddhi)

'स्वेदोऽति स्वेददौर्गन्ध्यकण्डूः एवं च लक्षयेत्' । (Ash.Hru.Su. 11/14)

Over exercise, hot climate, anger and fear enhances sweat formation.

Profuse sweating, bad odor of sweat, itching are the symptoms of increased formation of sweat.

Cold, astringent herbal powders reduces sweating, e.g. sandal powder.

Symptoms of Decreased Sweat
(Sweda-kshaya)

'स्वेदे रोमच्युतिः स्तब्धरोमता स्फुटनं त्वचः' ॥ (Ash.Hru.Su. 11/23)

Loss of hair on the skin, dry skin, roughness of hair on the skin are the symptoms of decreased sweat.

Exercise, warm clothes stimulates sweat production.

Dhatu Mala (Waste product of dhatus)

'कफः पित्तं मलाः खेषु स्वेदः स्यान्नारोम च ।
स्नेहोऽक्षित्वग्विट्मोजो धातूनां क्रमशो मलः' ॥ (Ash.San.Sha. 3/63)

Waste products of dhatus are formed during the metabolism of dhatu.

1) Waste product of Rasa dhatu - Kapha

Mala of rasa dhatu is kapha which is formed during the metabolism of Rasa dhatu.

Waste product of rasa, kapha accumulates at the site of kapha dosha & excreted from nose & throat.

Rasa vriddhi or rasa kshaya can increase or decrease its waste product kapha respectively.

2) Waste product of Rakta dhatu - Pitta

Mala of rakta dhatu is pitta which is formed during the metabolism of rakta dhatu. Rakta mala 'Pitta' accumulates at the site of pitta & excreted with feces & urine imparting yellow color to them.

Rakta-vriddhi or Rakta-kshaya can increase or decrease its waste product pitta respectively.

'द्विविधा वातादय: प्राकृता वैकृताश्च । तत्र प्राकृता: सप्तविधाया: प्रकृते: हेतुभूता: शरीरैकजन्मान: । वैकृतास्तु गर्भाद्भिनि: सृतस्य आहाररसस्य मला: संभवति । प्राकृतेषु अवरोहन्ति' । (Ash.San.Sha. 8/6,12)

Waste products kapha & pitta are vaikrita doshas formed from food, while doshas which are present since conception & which forms prakriti (constitution) are called as Prakrita doshas.

3) Waste product of Mamsa dhatu - Kha-mala

Kha means cavity. The waste product which accumulates in the external orifices of the body is called as kha-mala.

Kha-mala accumulates in nose, ears, oral cavity, oleates the orifices & protects the orifices from the external organisms.

For examples wax in ear prevent foreign bodies to enter the ears.

Kha-mala in the nasal cavity moisten the nostrils, organisms are trapped in this Kha mala of nostrils & organisms can not enter respiratory tract.

4) Waste products of Asthi dhatu

1. Kesha (hair) and 2.Loma (hair on the skin):

Synonyms: Bala, kacha, chikur, kuntal, murdhaja are the synonyms of kesha.

Hair on the scalp are called as - kesha
Hair on the skin are called as - loma.
Hair on the face is called as - beard - shmashru.
Hair on the lips is called as - smashru - mustache.

Formation of Hair

Hair is formed in the sixth month of embryonic life.

At puberty axillary, pubic & facial hair grows due to influence of shukra dhatu in males & due to commencement of menstrual cycle in females.

Hair should be soft, dark, firmly rooted & should not be very thick.

'प्रशस्तकेश–एकैकजा मृदवोऽल्पा: स्निग्धा: सुबद्धमूला: कृष्णा: केशा: प्रशस्यन्ते' । (Cha.Sha. 8/51)

Earth is the main mahabhuta of hair.

Loma: Hair on the skin of extremities, chest is called as loma.

The root of a loma is called as lomakupa.

Relationship between loma & rasa dhatu

'तत्र स्निग्धश्लक्ष्णमृदुप्रसन्नसूक्ष्माल्पगंभीरसुकुमारलोमा सप्रभेव च त्वक् त्वक्साराणाम्' । (Cha.Vi. 8/103)

'त्वकसारं रससारम्' । (Dalhan on Su.Su. 35/16)

Symptoms of rasa sarata includes examination of hair on the skin i.e. loma.

Person endowed with rasa sarata have smooth, delicate, unctuous and firm rooted loma.

Relationship between loma & constitution (Prikriti)

Constitution	*Characteristics of loma*
Vata	Dry, few and rough
Pitta	Few, light brown and soft
Kapha	Unctuous and smooth

Relationship between hair & constitution

Constitution	*Characteristics of hairs*
Vata	Dry, split hair, rough hair
Pitta	Thin, light brown, soft and oily hair
Kapha	Thick, oily and dark hair

Disorders of asthi dhatu affect nourishment of hair. For example hair loss is aggravated in asthi kshaya. Therefore in the treatment of hair loss, role of asthi dhatu should not be neglected. According to Sharngadhara Samhita, hairs are secondary tissue of majja dhatu.

Waste product of Asthi dhatu - Nail

Synonyms - Karaja, karashoola, kamankusha are the synonyms of nails.

Appearance - Hard and firm waste product nails have predominantly earth element in them.

'स्थिरा वृत्ताः स्निग्धास्ताम्रास्तुङ्गाः कूर्माकाराः करजाः' । (Cha.Sha. 8/51)

Relationship of nails to dosha, dhatus & nails

In Vata constitution nails are dry, small and rough. There is tendency of nail biting. In Pitta constitution nails are red colored. In Kapha constitution nails are long nails.

In rakta-sarata nails are red and beautiful. In meda-sarata nails are unctuous and lustrous. In asthi-sarata nails are large, firm and hard. In shukra-sarata nails are oily, firm and whitish.

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Waste product of Majja dhatu - Akshivit & twak sneha

Unctuous substance excreted alongwith feces, unctuous layer spread over skin and unctuous substance which accumulate in the eyes is called as 'akshi vit twak sneha', which is formed during the metabolism of unctuous majja dhatu.

This unctuous waste product makes the concerned constituents very soft. Feces become very soft and is excreted smoothly. Skin also becomes soft & smooth and eyes become soft and smooth & are protected from bright light, dust & heat.

Chapter 13

Indriya Vijnan

Indriya

Indra is a synonym of soul (atma). With the help of Jnanendriya (sense organ), soul can perceive knowledge, and hence indriya are those who convey knowledge to soul (Indra or atma).

'इन्द्रो हि शरीरे परमैश्वर्यवान् आत्मा चेतनाधात्वपरपर्यायः, तस्य इदं रूपदर्शने साधनं करणं वा इति'।

Synonyms

Indriya, Jnanendriya, karana, sadhana are the synonymous.

Types of Karana (Indriya)

Types of Karana (Indriya)

- Bahya Karana
  - 1) 5 Sense organs
  - 2) 5 Motor organs
- Abhyantara Karana
  - 1) Mind (mana)
  - 2) Ego (Ahamkara)
  - 3) Buddhi (Intellect)

Number of sense organs are 5:

'तत्र चक्षुः श्रोत्रं घ्राणं रसनं स्पर्शनमिति पञ्चेन्द्रियाणि'। (Cha.Su. 8/8)

1)	Sense organ of vision	Chakshurindriya
2)	Sense organ of sound	Shrotrendriya
3)	Sense organ of Smell	Ghranendriya
4)	Sense organ of taste	Rasanendriya
5)	Sense organ of touch	Sparshanendriya

These are the five Jnanendriya (sense organs).

Panchabhautik constitution of sense organs

'सर्वं द्रव्यं पाञ्चभौतिकम् अस्मिन् अर्थे' । (Cha.Su. 28/11)

According to Ayurveda five sense organs are composed of five mahabhutas.

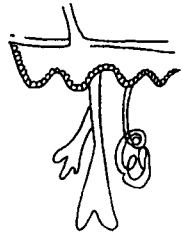
'भौतिकानि च इन्द्रियाणि आयुर्वेदे वर्ण्यन्ते, तथा इन्द्रियार्थाः' ।
(Su.Sha. 1/14)

Though five sense organs are composed of five mahabhutas, every sense organ has predominance of one mahabhuta.

'एकैकाधिकयुक्तानि खादीनामिन्द्रियाणि तु ।
पञ्च कर्मानुमेयानि येभ्यो बुद्धिः प्रवर्तते' ॥ (Cha.Sha. 1/24)

Sense organ (Jnyanendriya)	*Predominant Mahabhuta*
Chakshu (eyes)	Teja
Shrotra (ears)	Akash
Ghrana (nose)	Prithvi
Rasana (Tongue)	Jala
Sparshana (skin)	Vayu

Ear (Karna)
Adhishthana of Shrotrendriya



Skin (Twacha)
Adhishthana of Sparshanendriya

Eye (Netra)
Adhishthana of Chakshurindriya

Nose (Nasa)
Adhishthana of Ghranendriya

Tongue (Jihva)
Adhishthana of Rasanendriya

Fig 18 : Sthula Adhishthanas of Sense Organs

Indriya Panchak (five aspects of sense organs)

'पञ्चेन्द्रियद्रव्याणि खं वायुः ज्योतिः आपः भूरिति' । (Cha.Su. 8/8)

'पंच इंद्रियाधिष्ठानानि–अक्षिणी कर्णौ नासिके जिह्वा, त्वक् चेति । पंच इंद्रियार्थाः–शब्दस्पर्शरूपरसगंधाः । पंच इंद्रियबुद्धयः—चक्षुर्बुध्यादिकाः ताः पुनः इन्द्रियार्थसत्वात्मसन्निकर्षजाः क्षणिका निश्चयात्मिकाश्च' । (Cha.Su. 8/10-12)

Sense organ	*Indriya dravya*	*Adhishthan (location)*	*Artha (object)*	*Buddhi (perception)*
Chakshu	Teja	Eyes	Vision	Chakshusha
Shrotra	Akasha	Ears	Sound	Shravana
Ghrana	Prithvi	Nose	Smell	Gandhana
Rasana	Jala	Tongue	Taste	Rasana
Sparshana	Vayu	Skin	Touch	Sparshana

Sense organs: Five sense organs which exist in the body are chakshu, shrotra, ghrana, rasana and sparshana.

Indriya dravya (Five matters of sense organs): It has been already explained that according to Ayurveda, five sense organs are composed of five mahabhutas, and every sense organ has predominance of one mahabhuta.

Adhishthana (Site of sense organs): Site of sense organs are eyes, ears, nose, tongue, skin respectively. Sense organs (Jnanendriya) are subtle while their locations or seats (adhishthana) are gross.

Artha (Objects): Vision, sound, smell, taste, touch are the five objects of five sense organs. Objects are perceived by respective sense organs, for e.g. sound is the object of shrotrendriya, vision is the object of chakshurindriya etc. (refer table of Indriya-panchaka)

Sound is the quality of Akasha mahabhuta, and there is predominance of Akasha mahabhuta in shrotrendriya. Hence sound is perceived by shrotrendriya. Objects of sense organs are qualities of mahabhutas, from which these five

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sense organs are composed of. Buddhi is the result of conjugation of soul, mind, sense organs and their respective object.

'या यदिन्द्रियमाश्रित्य जन्तोर्बुद्धिः प्रवर्तते'। (Cha.Sha. 1/32)

Perception depends on contact of sense organs with their subject.

Buddhi (Variations in the knowledge)

'भेदात् कार्येन्द्रियार्थानां बह्व्यो वै बुद्धयः स्मृताः।
आत्मेन्द्रियमनोऽर्थानामेकैका सन्निकर्षजा'॥ (Cha.Sha. 1/33)

We can perceive knowledge only after sannikarsha (conjugation) of atma, mind and sense organs.

Centers of sense organs

'शिरसि इंद्रियाणि इंद्रियप्राणवहानि च स्रोतांसि सूर्यमिव गभस्तयः संश्रितानि'। (Cha.Siddhi. 9/4)

Vital centers of sense organs are situated in the head.

Prana vayu and sense organs

'प्राणोऽत्र मूर्धगः। उरकंठचरो बुद्धिहृदयेन्द्रिय चित्तधृकः'॥ (Ash.Hru.Su. 12/4)

Head is the seat of prana vayu. Prana vayu controls the activities of mind and sense organs.

Inputs received by sense organs are conveyed to mind by prana vayu.

'सर्वेन्द्रियाणाम् उद्योजकः, सर्वेन्द्रियार्थानाम् अभिवोढा'। (Cha.Su. 12/8)

Vata dosha stimulates sense organs towards their respective subjects.

Prana vayu is concerned with the functioning of sense organs.

Mind and Sense organs

'इन्द्रियाभिग्रहः कर्म मनसः स्वस्य निग्रहः'। (Cha.Sha. 1/21)

Mind has control over five senses. Mind tries to concentrate on the objects of sense organs. Mind motivates sense organs towards its objects, and after acquiring knowledge, disconnect the linkage between sense organs and objectives. This function of mind is called as Indriyabhigraha.

'मन:पुर:सराणीन्द्रियाण्यर्थग्रहणसमर्थानि भवन्ति' । (Cha.Su. 8/7)

The sense organs can perceive their objects only when they are supported by mind.

Ayurvedic concept of Perception

(Concept of jnana-grahan)

According to Ayurveda, sensory organs receive knowledge, which is conveyed to mind and soul.

Soul or atma is the chetana dravya of the body. Soul receives knowledge with the help of mind and sense organs.

'आत्मा मनसा संयुज्यते मन इंद्रियेण इंद्रियमर्थेन तत: प्रत्यक्षम्' ।
(Tarkasangrah, Dipica vyakhya)

Perception depends on the sannikarsha of mind and sense organ with their concerned objects and this type of knowledge is called as 'Pratyaksha buddhi'. Pratyaksha buddhi is related to only preset events.

'आत्मेन्द्रियमनोऽर्थानां सन्निकर्षात् प्रवर्तते ।
व्यक्ता तदात्वे या बुद्धि: प्रत्यक्षं सा निरुच्यते' ।। (Cha.Su. 11/20)

Nourishment of sense organs

'शिरस्थ: चक्षुरिन्द्रियतर्पणात् तर्पक:' । (Ash.Hru.Su. 20/)

Tarpaka kapha nourishes sense organs. Sense organs are the site of Panchabhautik agni.

Role of sense organs in maintenance of health

'समदोष: समाग्निश्च समाधातुमलक्रिय: ।
प्रसन्नात्मेन्द्रियमन: स्वस्थ इत्यभिधीयते' । (Su.Su. 15/45)

Along with balanced doshas, dhatus and malas, energetic

state of soul (atma), sense organs and mind plays vital role in maintaining health. When doshas, dhatus and malas work properly then sense organs also co-ordinate with mind and soul properly.

Imbalance of health may come from the external environment in the form of heat or cold (sparsha), loud noises (shabda), for e.g. loud noises or sound pollution can cause syncope, palpitation, deafness etc.

Hence sense organs have got great importance in maintaining health. Hence proper care should be taken to maintain health of sense organs. Regular oil massage of skin, putting oil in the ears, cleaning of tongue, nasal instillation and tarpan of eyes, maintains health of sense organs. For nourishment of sense organs, they require food consisting of all five elements as well as six rasas (sweat, salty etc) and proper qualities (heavy, unctuous... etc).

Now let us learn the concept of sense organs in detail.

Sense organ of sound - Shrotrendriya

The sense organ which perceives sound is called shrotrendriya.

Indriyapanchaka of Shrotrendriya

Sense organ of hearing - Shrotrendriya

Adhishthan : (location) - Ears

Mahabhuta - Akasha

Artha (object) - Shabda (sound)

Buddhi (perception) - Hearing (shravan buddhi)

Dhamanis - Two dhamanis conduct sound from ears to mind.

Two ears are the seat of shrotrendriya.

'कर्णविवरवृत्ति आकाशमेव श्रोत्रेंद्रियम्' । (Vaisheshik)

External auditory meatus and external auditory canal are hollow structures of the ears, which show predominance of Akasha mahabhuta.

Sound can travel through hollow external auditory canal and can be conducted to the mind and soul. Two dhamanis are related to ears, which are meant for conduction of sound.

Ayurvedic concept of perception of sound

'आत्मा मनसा संयुज्यते मन इंद्रियेण इंद्रियमर्थेन ततः प्रत्यक्षम्' ।

(Tarkasangraha, Dipika Vyakhya)

Sound which is heard by shrotrendriya is a phonic sound. After perception of sound, with the help of intellect (buddhi), mind analyses the sound and can interpret type of sound, pitch of sound etc.

Shrotrendriya and chakshurendriya have well co-ordination, so after hearing the sound, eyes turns to the direction of sound.

According to Tarkasangraha sound which is produced in the environment enters the ears in the form of waves. These sound waves are compared to the oceanic waves. Sound waves from the object pass in the ear and are conveyed to mind.

Sense organ of Touch : Sparshanendriya

The sense organ that perceives touch is called as sparshanendriya.

Indriyapanchaka of Sparshanendriya

Sense organ of touch : Sparshanendriya.

Adhishthan (location) : Skin

Mahabhuta : Vayu

Artha (object) : Sparsha (touch)

Buddhi (perception) : Touch of an object (sparshana buddhi)

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Dhamanis : Two sparshavaha dhamanis and their branches are spread in the skin, to conduct touch from skin to mind.

'ऊध्वर्गा: (धमन्य:) शब्दस्पर्शरूपरसगन्ध····अभिवहन्य:····शरीरं धारयन्ति' ।
(Su.Sha. 9/5)

'स्पर्शग्रहणं पुन: तिर्यग्गानां (धमनीनां) कर्म वक्ष्यति' ।
(Su.Sha. 9/5, Dalhana)

Skin is the largest sense organ of the body. According to Ayurveda, skin is not a just external organ, but sparshanendriya is in contact of all remaining sense organs and mind.

'तत्रैकं स्पर्शनमिन्द्रियाणामिन्द्रियव्यापकं, चेत:समवायि' । (Cha.Su. 11/38)

Due to contact of sparshanendriya, subtle mind can occupy whole body.

'स्पर्शनेन्द्रियसंस्पर्श: स्पर्शो मानस एव च ।
द्विविध: सुखदु:खानां वेदनानां प्रवर्तक:' ॥ (Cha.Sha. 1/133)

Sparshanendriya occupies mind also, so mind can experience favorable, unfavorable conditions (sukha, duhkha) and can feel pain also.

Due to knowledge of pain physician can diagnose disorders. Pain is perceptible by skin. Only skin conducts various sensations like roughness, dryness, hotness and cold touch. It also conducts vibrations and pressure. Therefore skin is the largest sense organ. Due to tactile sense organ mind can understand position of body also.

'खरद्रवचलोष्णत्वं भूजलानिलतेजसाम् ।
आकाशस्याप्रतीघातो दृष्टं लिङ्गं यथाक्रमम् ॥
लक्षणं सर्वमेवैतत् स्पर्शनेन्द्रियगोचरम्' । (Cha.Sha. 7/29-30)

Coarseness, liquidity, movement and temperature are the characteristics of Prithvi Jala, Vayu, and Teja mahabhuta respectively and non-resistance (apratighata) is a characteristic of Akasha mahabhuta. All these characteristics can be perceived by the skin.

Ayurvedic concept of perception of touch

'आत्मा मनसा संयुज्यते मन इंद्रियेण इंद्रियमर्थेन ततः प्रत्यक्षम्' ।

(Tarkasangraha, Dipika Vyakhya)

Atma and mind conjugates with sparshanendriya and skin can establish contact with its object. Prana vayu facilitates this process of conjugation and impulse of touch is transferred to mind by dhamanis.

When mind perceives touch, body responds to the touch. If the touch is unfavorable, then body rejects that perception. Vyana vayu generates movements in the body in response to touch for example; on account of hot touch hand is immediately taken away from the hot object. Vaso-constriction results due to cold touch. Vaso-dilatation results due to hot touch.

In this way sparshanendriya plays a important role in the perception of touch, in awareness of disorders and protection of body.

Sense organ of Vision: Chakhurendriya

Indriyapanchak of Chakhurendriya

Sense organ of Vision: Chakshurendriya

Adhishthan (location) : Eyes

Mahabhuta : Teja

Artha (object): Vision

Buddhi (perception): Visual perception of an object (chakshusha buddhi).

Dhamanis: Two rupavaha dhamanis conduct visual impulse to mind then mind can get visual perception.

'उर्ध्वगाः (धमन्यः) शब्दस्पर्शरुपरसगंध·····अभिवहन्त्यः शरीरं धारयन्ति' ।

(Su.Sha. 9/5)

Role of Alochak Pitta

'रूपालोचनतः स्मृतम् । दृकस्थमालोचकम·····' । (Ash.Hru.Su. 12/4)

Alochak pitta is a type of pitta dosha. Alochak pitta is present in the eyes. This pitta is necessary for normal visual perception. When light rays from an object falls on the eyes, image of object is formed on retina, and then this visual impulse is transmitted to mind. Alochak pitta has got important role in the formation of image of an object in the eyes.

Ayurvedic concept of Visual perception

'आत्मा मनसा संयुज्यते मन इंद्रियेण इंद्रियमर्थेन ततः प्रत्यक्षम्' ।

(Tarkasangraha, Deepika Vyakhya)

Atma and mind conjugates with chakshurendriya and eyes can establish contact with its object. Prana vayu facilitates this process of conjugation and impulse of vision is transferred to mind by dhamanis.

Importance of Chakshurendriya

'चक्षूरक्षयां सर्वकालं मनुष्यैर्यत्नः कर्तव्यो जीविते यावदिच्छ' ।

(Ash.Hru.Uttartantra. 3/13)

Eyes can perceive both the color and the shape of the object. This is very much useful for knowledge.

Sense organ of Taste - Rasanendriya

(Indriyapanchaka of Rasanendriya)

Sense organ of Taste - Rasanendriya

Adhishthan (location) : Tongue

Mahabhuta: Jala mahabhuta

Artha (object) : Taste of a substance

Buddhi (perception): Perception of taste (Rasana buddhi)

Dhamani: Two taste conducting dhamanis conduct taste impulse to mind.

'उर्ध्वगाः (धमन्यः) शब्दस्पर्शरूपरसगंध·····अभिवहन्त्यः शरीरं धारयन्ति' ।

(Su.Sha. 9/5)

'शब्दादींश्चतुर: प्रत्येकं द्वाभ्यां द्वाभ्यामिती····धमनीभि: गृण्हि' ।
(Dalhan on Su.Sha. 9/5)

Tongue should be pink, flat and soft.

'आयामविस्तारोपपन्ना श्लक्ष्णा तन्वी, प्रकृतिवर्णयुक्ता जिह्वा ।'
(Cha.Sha. 8/51)

Constitution of tongue

'कफशोणितमांसानां साराज्जिह्वा प्रजायते' । (Su.Sha. 4/28)

In embryonic life tongue is made from kapha, rakta and mamsa dhatu. Function of rasanendriya (tongue) is perception of taste of a substance. There are six types of tastes : 1) Madhura (Sweet), 2) Amla (Sour), 3) Lavana (Salty), 4) Katu (Bitter), 5) Tikta (Pungent), 6) Kashaya (Astringent).

'रसा: स्वाद्वम्ललवणतिक्तोषणकषायका:' । (Ash.Hru.Su. 1/14)

Role of Bodhak Kapha in perception of taste

'बोधको रसनास्थायी । रसबोधनात् कफा:' । (Ash.Hru.Su. 14/1)

When any food substances are kept on the tongue, Bodhak kapha mixes with the substance and the taste is perceived. Rasavaha dhamanis conduct taste impulse to the mind.

Ayurvedic Concept of perception of taste

'आत्मा मनसा संयुज्यते मन इंद्रियेणइंद्रियमर्थेन तत: प्रत्यक्षम्' ।
(Tarkasangrah. Deepikavyakhya)

Atma and mind conjugates with Rasensendriya and tongue can establish contact with its object. Prana vayu facilitates this process of conjugation and impulse of taste is transferred to mind by dhamanis.

Favorable taste of a substance is accepted and unfavorable taste is rejected by mind.

Importance of Rasanendriya

Rasanendriya conveys knowledge of taste to mind. Appreciation of taste of food by mind can affect intake of

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food. When mind appreciates taste of food then only the person can eat favorable food in proper quantity. Happy state of mind due favorable taste of food is the important factor in proper digestion.

In the disorders of tongue, person can not taste food properly and cannot eat proper quantity of food, for e.g. glossitis (mukhapaka).

Sense organ of smell - Ghranendriya

Indriyapanchaka of Ghranendriya

Sense organ of Smell : Ghranendriya

Adhishthan (location) : Nose

Mahabhuta: Prithvi

Artha (object) : Smell of an object

Buddhi (perception) : Smell of an object

Dhamani: Two smell conducting dhamanis conduct perception of smell to mind.

'उर्ध्वगा: (धमन्य:) शब्दस्पर्शरूपरसगंध·····शरीरं धारयन्ति' ।(Su.Sha. 9/5)

Nose is an organ of respiratory system. Nose is a seat of Kapha dosha also nose is related to respiration.

Phana marma is present on both sides of nostrils.

'घ्राणमार्गमुभयत: स्रोतोमार्गप्रतिबद्धे अभ्यन्तरत: फणे नाम (मर्मणी)' ।
(Su.Sha. 6/27)

Injury of phana marma results in loss of perception of smell.

'फणावुभयतो घ्राणमार्गं श्रोत्रपथानुगौ ।
अंतर्गलस्थितौ वेधाद् गंधविज्ञानहारिणौ' । (Ash.Hru.Sha. 40/30)

Nose is a gate of cranial cavity hence in the diseases of head, ear and nose nasya chikitsa (nasal instillation of medicated oil or powders) plays important role.

'नासा हि शिरसो द्वारं' । (Ash.San.Su. 1/20)

Ayurvedic concept of perception of smell

'आत्मा मनसा संयुज्यते मन इंद्रियेण इंद्रियमर्थेन ततः प्रत्यक्षम्' ।

(Tarkasangrah, deepikavyakhya)

Atma and mind conjugates with Ghranenendriya and nose can establish contact with its object. Prana vayu facilitates this process of conjugation and impulse of smell is transferred to mind by dhamanis.

When particles of volatile substances enter nasal mucosa, then due to simulation of nasal mucosa impulse of smell is generated.

Importance of Ghranendriya:

Ghranendriya stimulates appetite. Good aroma of food can stimulate activity of agni. Bad odor can produce disorders of gastro-intestinal system for e.g. foul smell can produce nausea or vomiting.

Co-ordination of Five senses

Five sense organs are well coordinated with each other, hence eyes can turn towards the sound or smell of food can stimulate salivation.

Role of indriya in maintenance of health

Five sense organs are continuously receiving the inputs or knowledge.

The inputs or knowledge perceived by mind should be in favor of body. Dhi, dhriti and smriti help mind to analyse the inputs received.

Intellect (dhi), restraining capacity (dhriti) and memory (smriti) which are the qualities of mind, prevents sense organs from getting conjugated with harmful objects. This control of mind over sense organs is important to maintain health.

'असात्म्येन्द्रियार्थ संयोगः प्रज्ञापराध परिणामश्चेति त्रयास्त्रिविधविकल्पा हेतवा विकारणां, समयोगयुक्तास्तु प्रकृति हेतवो भवन्ति' ॥ (Cha.Su. 11/43)

Asatmyendriyartha samyog, prainaparadha and parinama are the three main causes of disease.

FIVE SENSE ORGANS

1) Optic pathway (pathway of Vision)

(Rupagrahana Marga)

Accessory structures of eye

1) Eyebrows
2) Eyelids
3) Eyelashes
4) Lachrymal apparatus

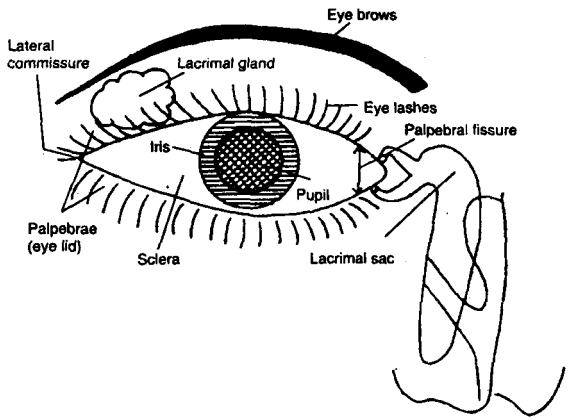

Fig 19

Structure of eyeball

Diameter of eyeball: 2.5 cm

Anatomically eyeball is divided into:

1) Fibrous tunic (layer)
2) Vascular tunic
3) Nervous tunic or retina

Fibrous Tunic

This layer consist of:

1) Sclera: White of eye is called as sclera.

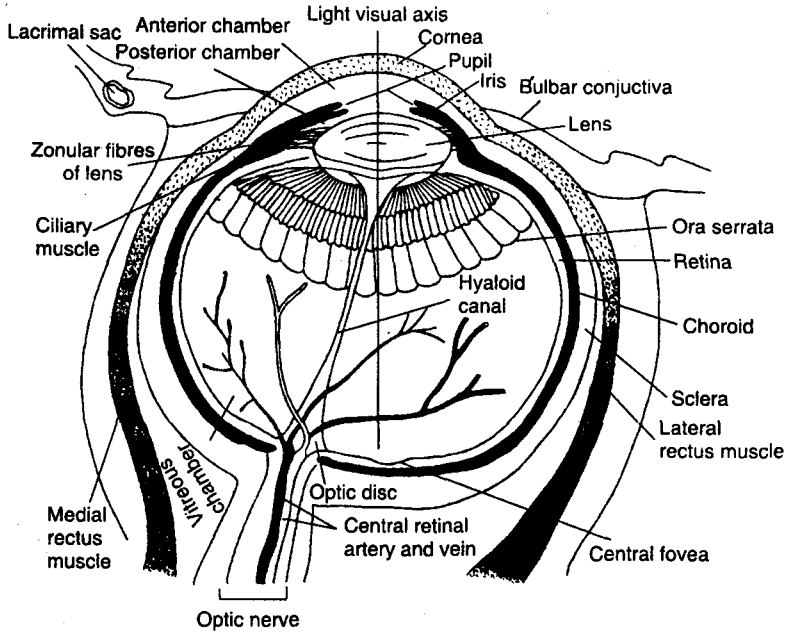

Fig 20 : Transverse Section of Eye Ball

2) Cornea: Non-vascular transparent fibrous coat through which iris can be seen is called as cornea.

Canal of schlemm: It is a venous sinus at the junction of sclera and cornea.

<u>Vascular Tunic</u>

Middle layer of eye ball constitutes vascular tunic.

<u>Parts of vascular tunic</u>

1) <u>Choroids</u> - It contains blood vessels, absorbs light hence light is not reflected.

2) <u>Ciliary body</u> - This consists of ciliary processes and ciliary muscles. Ciliary processes secrete aqueous humor. Ciliary muscle alters the shape of the lens for vision, which is called as accommodation.

3) <u>Iris</u> - This is a colored part seen through cornea, which is made up of circular and radial muscles.

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4) Pupil - It is a black hole in the center the iris, through which light enters the eyeball. Bright light results in constriction of pupil while dim light results in dilatation of pupil.

Nervous Tunic (Retina)

Retina contains 3 zones of neurons.

Zones of retinal neurons

1) Photoreceptor neurons (rods and cones)
2) Bipolar neurons
3) Ganglion neurons

There are two types of dendrites of photoreceptor neurons - 1) Rod-shaped photo receptor, 2) Cone-shaped photo receptor. Cones are responsible for color vision. 100 millions rods are present in retina while 3 millions cones are present in the eye.

Macula lutea: It is a center of the posterior portion of Retina

Fovea: It is a small depression in the macula. At this place number of cones is maximum. Fovea is the area of sharpest vision.

Rods are absent in macula and fovea. Number of rods are more at peripheral portion of retina.

Blood supply of retina: Central retinal artery.

Bipolar neurons: It is a middle nervous zone of retina.

Ganglion neurons: The inner most retinal zone is composed of ganglionic neurons.

Optic disc: The axons of the ganglion neurons extend posteriorly to a small area called as optic disc. Through optic disc axons of ganglionic neurons exit the eyeball and form optic (II) nerve.

Optic disc doesn't have rods and cones, so it is called as Blind spot.

Lens: Lens is present posterior to pupil and iris lens is made up of proteins. These proteins are called as Crystellins. These proteins are arranged like layers of onions. It is avascular. Lens is transparent biconvex, held in a position by suspensory ligaments. Opacity of lens is called as cataract.

Interior of Eye ball

Interior of eyeball is divided into: 1) Anterior cavity and 2) Posterior cavity (Vitreous chamber). It is between lens and retina.

Anterior cavity is divided in anterior chamber and posterior chamber.

Anterior chamber lies behind the cornea and in front of iris. Posterior chamber lies behind the iris and in front of lens and suspensory ligaments.

Aqueous humor : Fluid in the anterior chamber is called as aqueous humor. This fluid is secreted by ciliary process. Intra ocular pressure creates pressure which is called as Intra ocular pressure.

Intra Ocular Pressure (Normal IOP) - is 10 mm of Hg.

IOP is increased in glaucoma, which may result in blindness.

Vitreous Chamber (Posterior Cavity)

It contains jelly like substance called as vitreous body it maintains shape of eyeball.

Four processes which are concerned with the formation of image on the retina are as follows :

1) Refraction of light rays through lens
2) Accommodation of lens.
3) Constriction of pupil.
4) Convergence of eye ball (focusing of both eyes on only one set of object)

Accommodation of lens and constriction of pupil is described in the following passage.

Light rays entering the eye pass through the cornea, aqueous humor, lens and vitreous body and then retinal image is formed due to accommodation of lens.

A change in the curvature of the lens to adjust for the vision is called as accommodation. In near vision due to contraction of ciliary muscles lens bulges out while in far vision lens flattens due to relaxation of ciliary muscles. This is called as accommodation. Constriction of pupil is also a part of accommodation. Accommodation and constriction occurs simultaneously.

Images are focused upside down on retina. Image undergoes mirror reversal, but we do not see inverted world because brain coordinates visual images with exact locations of the objects.

After an image is formed on retina, light energy is converted to nerve impulse and due to excitation of rods and cones; signals are transmitted to bipolar and ganglionic layers of retina.

Visual Field of the Eye

Everything that is seen with eye is that eye's visual field.

Human vision is binocular. Two eyes concentrate on only one object at one time, so there is overlapping of the visual fields of two eyes.

1. Light reflected from right side of an object hits left side of retina
2. Light reflected from left side of an object hits right side of retina.

Division of visual field

Nasal half (central half)	Temporal half (peripheral half)

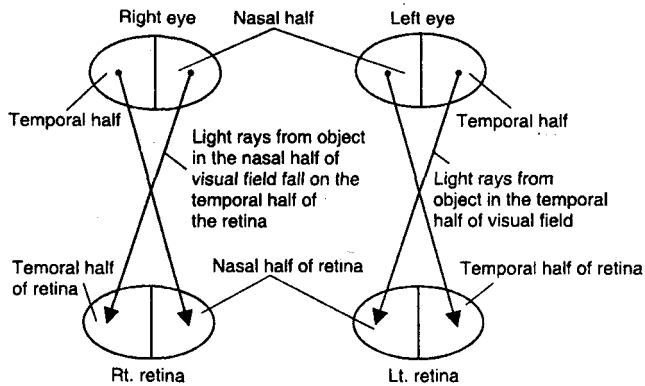

Fig. 21 : Nasal Field

Rays from temporal half of visual field falls on nasal half of retina. Rays from nasal half of visual field falls on temporal half of retina.

Receptors of visual pathway

1) Rods - Receptors for black and white vision.
2) Cones - Receptors for brightness, sharpness and color.

Visual pathway consist of-

1) Optic nerves - Axons of ganglionic cells form optic nerve. It conducts visual impulse.
2) Optic chiasma - Crossing point of optic nerve fibers is called as optic chiasma.
3) Optic tract - Which extends from optic chiasma to lower geniculate body of thalamus.
4) Optic radiations - Extend from thalamus to primary visual area of occipital lobe of cerebral cortex.

Visual pathway

After an image is formed on retina, light energy is converted into nerve impulse and due to stimulation of rods and cones signals are transmitted to bipolar and ganglionic layers of retina. Also note that there are two special types of cells present in retina - in nervous tunic- called horizontal cells

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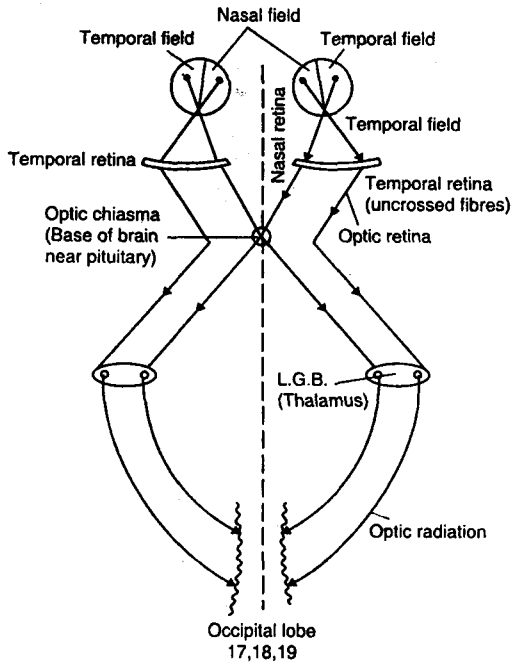

Fig. 22 : Optic Pathway

and amacrine cells. These cells form laterally directed pathways that modify and control the message that is transmitted along the direct pathway.

1) Axons of ganglion neurons form optic nerve. Optic nerve leaves the eye ball through optic disc.

2) Visual impulse is conducted by optic nerve to optic chiasma.

3) In optic chiasma partial decussation (crossing) of axons of optic nerve takes place.

In optic chiasma fibers coming from the temporal halves of retina remain uncrossed. In optic chiasma fibers coming from the nasal halves of retina cross to opposite sides. Crossing of the fibers occurs at the base of the brain.

<u>Optic tracts:</u> Optic tract begins after crossing of the nerve

fibers in optic chiasma. Axons of the optic tracts contain axons of the temporal half of the same side and axons of the nasal half of the opposite side. For e.g. right optic tract consist of temporal axons of right retina and nasal axons of the left retina.

Optic tract extends from optic chiasma to lateral geniculate body (L.G.B.) of thalamus.

Axons of optic tract synapse in lateral geniculate body of thalamus.

Axons of thalamus form optic radiations.

Axons of optic radiations go to primary visual area (area 17) of occipital lobe of parietal cortex.

Signals are also transmitted to visual association area (area 18 and 19) of occipital cortex, from primary visual area.

Function of Primary Visual (Area 17)

This area determines shape, color and movement of visual stimuli.

Function of visual association area (area 18, 19)

This area receives impulses from primary visual area and thalamus. It is related to memory of visual experiences. It recognizes, evaluates what is seen.

Role of midbrain in visual function

1) Control of size of pupil in response to light.
2) Movement of head and eyes in response to audio, visual stimuli.

1) Some axons from retina directly pass to superior colliculus of midbrain to control size of pupil and head and neck movements.
2) Some axons from retina pass to hypothalamus to establish sleep patterns.

2) Gustatory pathway (pathway of Taste)
(Rasagrahana Marga)

Taste is a chemical sense.
Taste is a function of the taste buds.
Taste buds are present on the tongue.
Taste buds are numerous on posterior part of the tongue.
Very few taste buds are present in the throat and on the soft palate.
Taste buds are present in papillae of the tongue. Papillae are projections of the tongue.

Types of papillae

1) Circumvallat papillae
2) Fungiform papillae
3) Filiform papillae

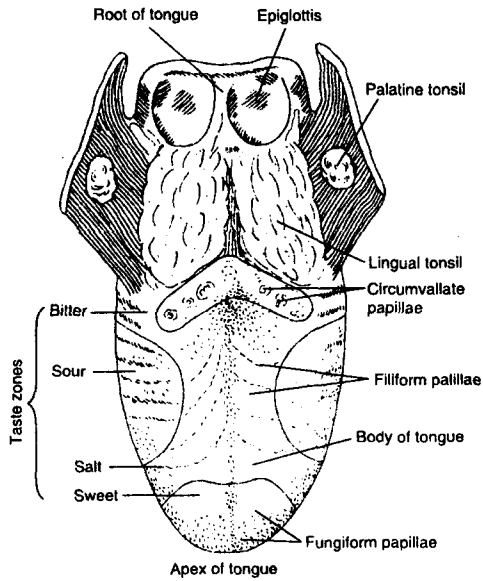

Fig 23 : Tongue

Taste buds consist of following cells:

1) Supporting cells.

2) Gustatory cells
3) Basal Cells.

Gustatory cells contains hair like processes

Gustatory cells make contact with taste stimuli. Gustatory cells are present inside the epithelium of supporting cells.

Function of basal cells is to produce supporting and gustatory cell of taste buds.

Types of Taste: 1) Sweet 2) Salty 3) Sour 4) bitter.

Taste buds receive stimulus of taste of substance kept on tongue. When the food substance gets dissolved in saliva then the taste buds comes in contact with particles of substance.

Taste buds receive the stimulus of taste and taste impulse is generated.

Taste impulse is conducted from the taste buds to paraital lobe of cerebral cortex. This path of conduction of taste impulse is a gustatory pathway.

Following nerves conduct impulse of taste. These nerves are as follows-
1) Facial nerve (VII) - Conduct taste impulses from anterior $^{2}/_{3}$ of tongue via lingual nerve then through chorda tympani into facial nerve.
2) Glossopharyngeal nerve (IX) - Conduct taste impulses from posterior $^{1}/_{3}$ rd of the tongue.
3) Vagus nerve (X) - Conduct impulses from throat.

1st order neuron extends from taste buds to the tractus solitarius of medulla oblongata.
2nd order neuron, extends from tracts soliterius of medulla up to thalamus.
3rd order neuron, extends from thalamus to the parietal cortex of cerebrum.

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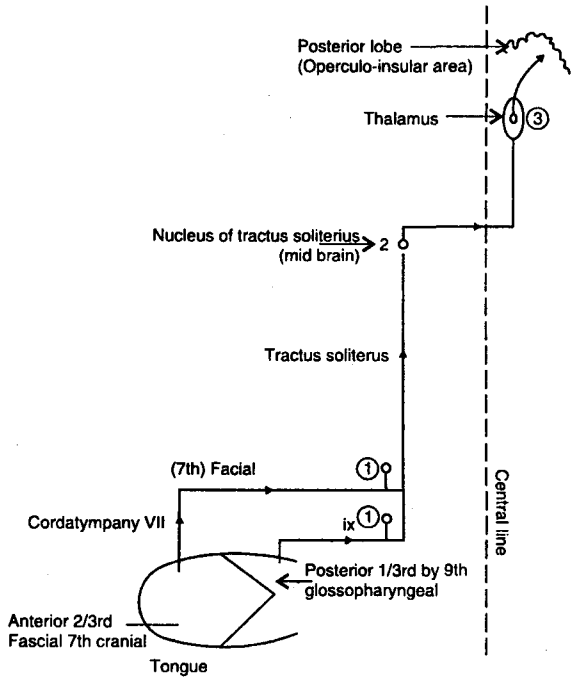

Fig. 24 : Gustatory Pathway

From Anterior two-third portion of tongue, taste impulse from taste buds pass into lingual nerve, then through chorda tympani into the facial nerve and pass to tractus solitarius.

From posterior one-third portion of the tongue nerve impulse is conducted by glossopharynegeal nerve to tractus soliterius.

Axons of second order neuron terminate in the thalamus. From thalamus third order neuron terminates in the gustatory center of parietal lobe of cerebral cortex.

Taste reflex: From tractus soliterius a large number of taste signals are transmitted in the medulla itself to superior and interior salivary nuclei and these in turn transmit motor signal to salivary glands to control salivary secretion.

3) Olfactory Pathway (Pathway of smell)

(Gandhagrahan Marga)

Sense of smell is a chemical sense. For the generation of impulse of smell substance must be in a gaseous form. Volatile substances generally have strong odors.

Olfactory area - Parts of the nasal cavity which takes part in the process of olfaction is called as olfactory area.

Nose is concerned with sense of smell.

Olfactory epithelium - Olfactory epithelium is the part of nasal epithelium. Olfactory epithelium is sensitive to smell.

The olfactory area is formed by:

1) Superior nasal conchi of nose.
2) Upper part of nasal septum.
3) Roof of the nose.

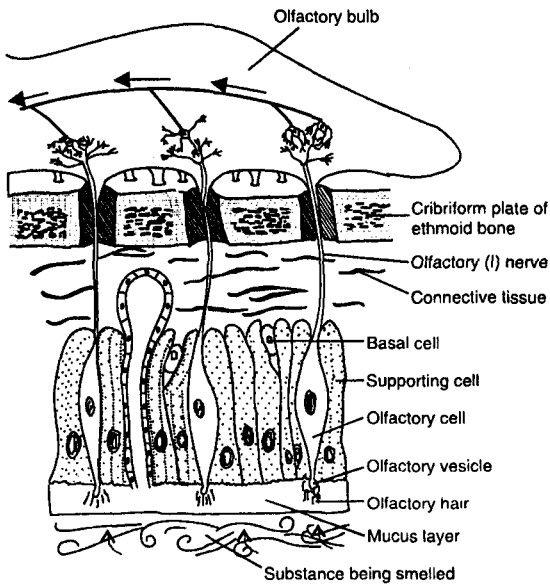

Fig. 25 (a) : Olfactory Receptors

The olfactory epithelium consist of following three types of cell-

1) Supporting cells.
2) Basal cells.
3) Bipolar nerve cells - These cells are concerned with smell.

Bipolar nerve cells are the receptors of sense of smell.

Dendrites of the bipolar nerve cells terminate in expanded olfactory vesicles.

Olfactory vesicles contain 6 to 8 granules and each granule give rise to hair like process called as olfactory end organ. Axons of the bipolar nerve cells form olfactory nerve. Olfactory nerve pierces the cribriform plate of ethmoid bone and enters the olfactory bulb.

Olfactory bulb consists of nerve cells called as mitral cells and tufted cells.

Mitral cells and tufted cells form network called as olfactory glomeruli.

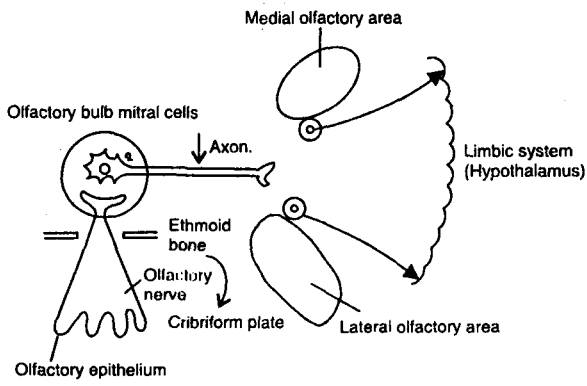

Fig. 25 (b) : Olfactory Pathway

Physiology of olfaction

1) The substances which remain in the gaseous state produce strong odors.

2) Odorous particles reach the olfactory area of the nose.
3) Particles dissolve in the fluid of the nose.
4) Particles stimulate bipolar nerve cells in the olfactory epithelium.
5) And impulse for smell is generated.
6) This impulse for smell is conducted by olfactory nerve and olfactory tract to cerebral cortex.

1st order neuron of olfactory tract: First order neuron of olfactory pathway begins from bipolar nerve cells of nasal epithelium. It extends up to olfactory bulb. The axons of bipolar nerve cells unite to form olfactory nerve.

2nd order neuron of olfactory pathway: Axon of olfactory nerve synapses with dendrites of mitral and tufted cells of olfactory bulb and from here starts 2nd order neuron. Axons of mitral and tufted cells form olfactory tract.

Olfactory tract consist of -

1) Medial olfactory area of temporal lobe.
2) Lateral olfactory area of temporal lobe of cerebral cortex.

Medial olfactory area is situated anterior to hypothalamus & lateral olfactory area consists of pyriform and prepyriform lobe of cerebral cortex.

From lateral olfactory area signals are transmitted to limbic system and hippocampus.

Hippocampus region is concerned with selection of food, for e.g. aversion of particular food after nausea, vomiting.

Clinical application

Sense of taste and smell are correlated each other. Smell of food can stimulate appetite and can increase salivation Hence in common cold, due to blocking of nose, person can not smell the food and hence don't feel like eating. However taste sensations are completely normal. Loss of sense of smell is called anosmia.

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4) Auditory Pathway (Pathway of Sound)

(Shabdagrahana Marga)

Parts of Ear - These are three:

1) External Ear
2) Middle Ear
3) Internal Ear

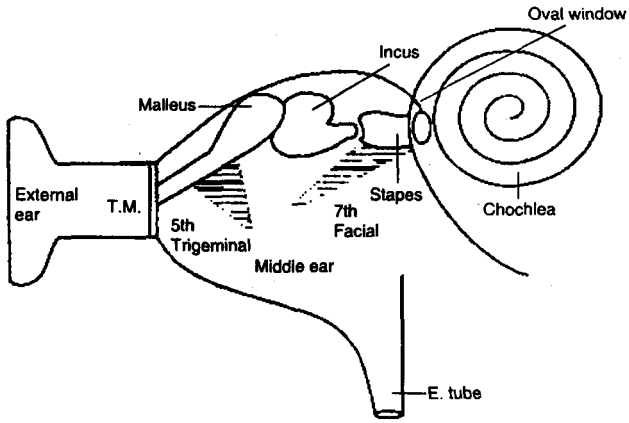


Fig. 26 : Parts of Ear

External Ear

Parts: 1) The auricle (Pinna), 2) Helix, 3) Lobule and 4) External auditory canal.

The auricle (Pinna) is a cartilaginous outer structure of the ear. Rim of the pinna is called as helix. Inferior portion of the pinna is called lobule.

External auditory canal is a 2.5 cm. long curved tube external auditory canal contains few hair and ceruminous gland.

Tympanic Membrane: It is a thin semi transparent partition of fibrous connective tissue between external auditory canal and middle ear.

Middle Ear

Posterior wall of middle ear communicates with mastoid air

cells through mastoid antrum. The anterior wall of middle ear contains an opening that leads to auditory tube (eustachian tube). One end of auditory tube is connected with nasopharynx.

Extending across the middle ear is three small bones viz -1) Malleus (2) Incus (3) Stapes. These bones are also called as ossicles.

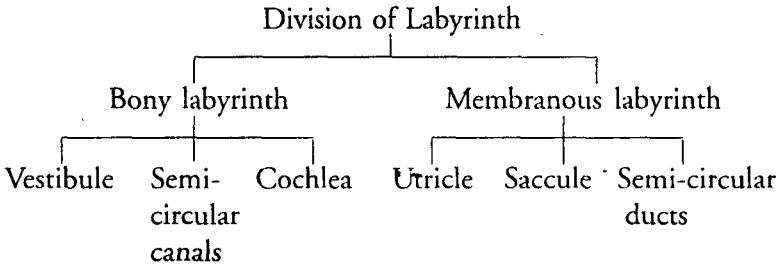
Oval window - It is present in the footplate of stapes.

Round window- Round shaped opening below the oval window is called round window. Round window is enclosed with secondary tympanic membrane. Two skeletal muscles are attached to ossicles.

1) Tensor tympani, 2) Stapedius muscle.

Internal Ear

Internal ear is also called as labyrinth.



Bony labyrinth is lined with periosteum.

Perilymph - Fluid in the bony labyrinth is called as perilymph. It surrounds membranous labyrinth.

Membranous labyrinth in the vestibule consist of two sacs -

1) Utricle 2) Saccule which are concerned with equilibrium.

Endolymph - Fluid in the membranous labyrinth is called as endolymph.

Ampulla - Enlarged end of semicircular canal is called ampulla.

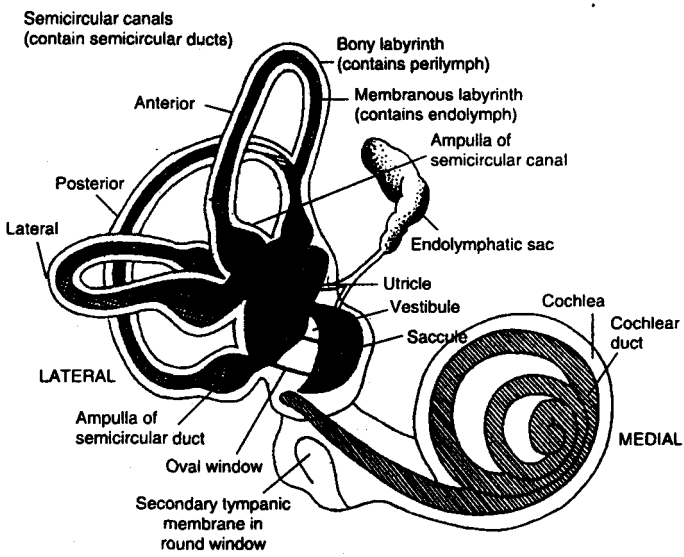


Fig 27 (a) : The Right Internal Ear

Semicircular duct - It is a part of membranous labyrinth inside the semicircular canal. These ducts are connected with utricle and saccule.

Cochlea - Cochlea is a coiled tube. Cochlea consist of - i) 3 cavities or tubes and ii) 2 membranes.

Helicotrema - Apex of the cochlea is called as Helicotrema.

Modiolus - It is the center of the cochlea.

Cavities or tubes of cochlea are:
1) Scala vestibule 2) Scala media 3) Scala tympani.

Membranes of cochlea are:
1) Vestibular membrane 2) Basilar membrane

Vestibular membrane separates scala vestibule & scala media from each other.

Basilar membrane - It is between scala media and scala tympani.

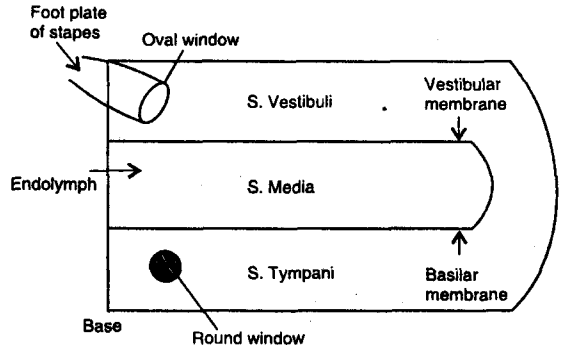


Fig. 27 (b) : Cavities (tubes) and membranes of cochlea

Characteristics of basilar membrane:

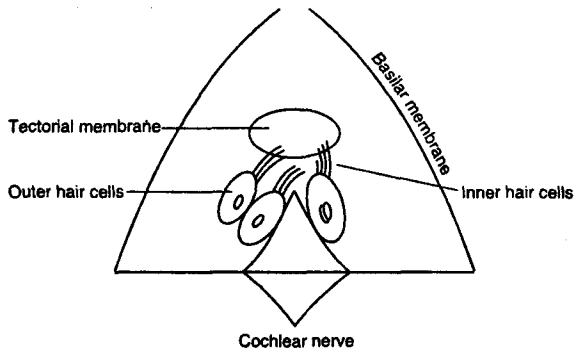


Fig. 27 (c) : Organ of Corti

1) Surface of basilar membrane consist of auditory receptors called as organ of corti.
2) Receptors on the basilar membrane generate the auditory nerve impulse.
3) Place principle - Basilar membrane can identify the specific pitch of sound. This is called place principle.
4) On the basilar membrane sound wave frequencies are coded from 20 Hz to 20000 Hz.
5) Organ of corti consists of hair cells.
Inner hair cells are arranged in single row.
Outer hair cells are arranged in three rows.

Total 16000 hair cells are present on basilar membrane.

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Tectorial membrane - It is a flexible gelatinous membrane. This membrane is in contact with hair cells. Hair cells rub against tectorial membrane and auditory impulse is generated.

Clinical importance of hair cells

Exposure to loud sounds, roaring sounds can damage hair cells and causes deafness.

Hair bundle - Hair bundle is present at the tip of each hair cell.

Stereocilia - Hair bundle consist of 30-100 stereocilia. These are long hair like microvilli which are arranged in rows, and they extend into endolymph.

Cell bodies of sensory neurons are located in the organ of corti.

Inner hair cells synapse with sensory neurons in the cochlear nerve.

Outer hair cells synapse with motor neurons in the cochlear nerve.

Physiology of Hearing

1) Sound waves travels from pinna to external auditory canal.
2) Sound waves attack tympanic membrane.

Low frequency sound - Slow vibrations of tympanic membrane.

High frequency sound - Rapid vibrations of tympanic membrane.

3) Vibrations are picked up by malleus, incus and stapes.
4) Stepes push the oval window in and out.
5) Round window bulges into middle ear.
6) Pressure in the endolymph also increases.
7) Basilar membrane then starts vibrating.

8) Due to vibrations in basilar membrane hair cells on the basilar membrane are stimulated.
9) Hair cells rub against tectorial membrane and hence auditory nerve impulse is generated, which is transferred to cochlear branch of vestibulo cochlear (VIII nerve).

Auditory pathway consist of 3 neurons, these neurons are:
1st order neuron - from organ of corti to pons.
2nd order neuron - from pons to thalamus.
3rd order neuron - from thalamus to temporal lobe of cerebral cortex.

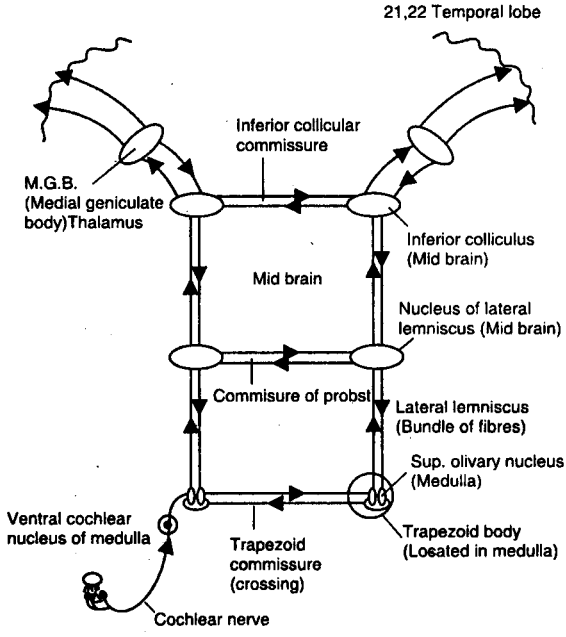

Fig. 28 : Auditory Pathway

<u>The Names of the stations and their places</u>

1) First order neurons in the cochlear branch of each VIII nerve terminate into cochlear nuclei medulla on the same side. For e.g.: 1st order neuron of right ear terminate into right cochlear nucleus of medulla.

2) Fibers of 2nd order neuron cross to the opposite side and pass to superior olivary nucleus in the medulla.

3) Some nerve fibers of 2nd order neuron pass to superior olivary nucleus of same side.

4) From both right and left cochlear nuclei and superior olivary nuclei fibers ascend to the inferior colliculus of mid brain.

5) Then fibers ascend to medial geniculate body (MGB) of thalamus.

6) From thalamus auditory signals project to the primary auditory area in the temporal lobe of cerebral cortex.

Important points

1) Auditory signals from both ears are transmitted through pathways of both sides of brain.
2) Crossing over of the fibers of the auditory pathway occurs at following 3 places, therefore sound coming from right side can be heard by left ear and vice versa.

The places of crossing over are as follows:

1) Trapezoid commeasure: Band of nerve fibers crossing to the superior olivary nucleus.
2) Commissure of Probst: Band of fibers crossing at lateral leminiscus in midbrain.
3) Inferior collicular commissure: Crossing of the nerve fibers at inferior colliculus in midbrain.

Auditory areas in cerebral cortex:

Auditory area in cerebral cortex lies in the temporal lobe of cerebral cortex.

Auditory areas in temporal lobe are 1) Primary auditory area (area 41, 42) & 2) Auditory association area or wernick's area determines if sound is speech, music or noise. This area also translates words into thoughts.

<u>Pathology</u>

Deafness

- Conductive deafness — Due to damage or defect in external
- Neural deafness — Organ of corti up to the temporal lobe

<u>Tests for hearing</u>

1) Rinne's test, 2) Weber's test, 3) Schwabach test, 4) Audiometry

<u>5) Pathway of Touch</u>

(Sparshagrhana Marga)

Sensation of touch is included in General Sense

<u>General Sense</u>

- Touch
  - Light touch
  - Discriminative touch
- Pain
- Pressure
- Heat/cold (Temperature)

Light touch and pressure touch are conducted by anterior spinothalamic tract. Pain and temperature are conducted by lateral spinothalamic tract. Discriminative touch, vibrations are conducted by posterior column pathway.

Posterior column pathway consist of

- 1) Tract of Goll (Fasciculus gracilis)
- 2) Tract of Burdach (Fasciculus cuneatus)

Conducts discriminative touch and vibrations

Anterior column pathway, lateral column pathway and

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posterior column pathway are called as ascending tracts. These tracts are sensory tracts that conduct various general senses to the cerebral cortex.

What is a sensation?

State of awareness of external or internal conditions or environment is called as sensation.

What is receptor?

Receptor picks up the stimulus of sensation. (Information of receptor is given in chapter No. 14)

In ascending tract 3 neurons are important:

1st order neuron: from receptor to spinal cord
2nd order neuron: from spinal cord to thalamus
3rd order neuron: from thalamus to cerebral cortex.

Pathway of Light touch and pressure
(Anterior Spinothalamic tract)

Anterior Spinothalamic tract conduct sensation of light touch and pressure.

1st order neuron - Stimulus is picked up by receptors of light touch and pressure.

Nerve fibers conducting light touch and pressure enter the spinal cord; **make synapses with posterior gray horn on the same side of cord.**

2nd order neuron - Axons of second order neuron crosses to the opposite side of spinal cord and become a part of anterior spinothalamic tract.

3rd order neuron - The axons of 2nd order neuron pass upward in postereo-lateral nucleus of thalamus. From thalamus nerve fibers of 3rd order neuron pass to somestetic (General) area of cerebral cortex.

Clinical Importance

Unilateral lesion of spinal cord cause loss of touch & pressure of opposite side.

Pathway of pain and temperature
(Lateral Spinothalamic tract)

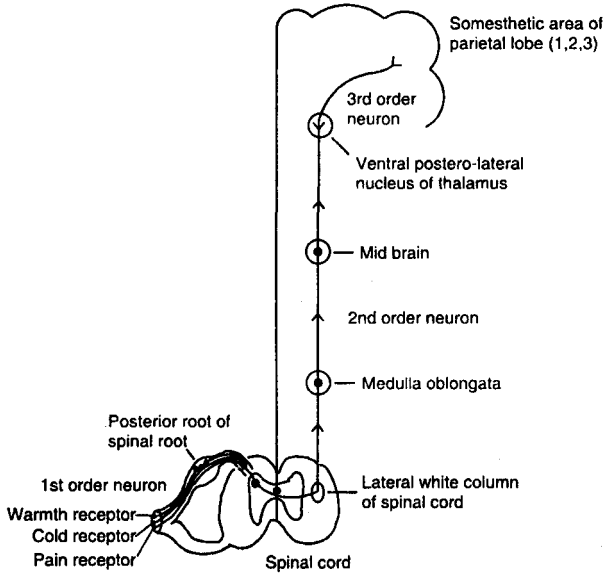

Fig. 29 : Lateral spinothalamic ascending tract conducting sensations for temperature and pain

Three neurons of this tract are the same as anterior spinothalamic pathway.

Lateral spinothalamic tract also cross in the spinal cord. Sensation of pain and degree of temperature is recognized by this tract. This tract terminates in the primary somesthetic area of parietal lobe of cerebral cortex.

Unilateral lesion of spinal cord causes loss of sense of pain and temperature of opposite side of the body.

Pathway for discriminative touch and vibrations
(Posterior column pathway)

1) Tract of Goll (Fasciculus gracilis) conducts sensation of discriminative touch and pressure.

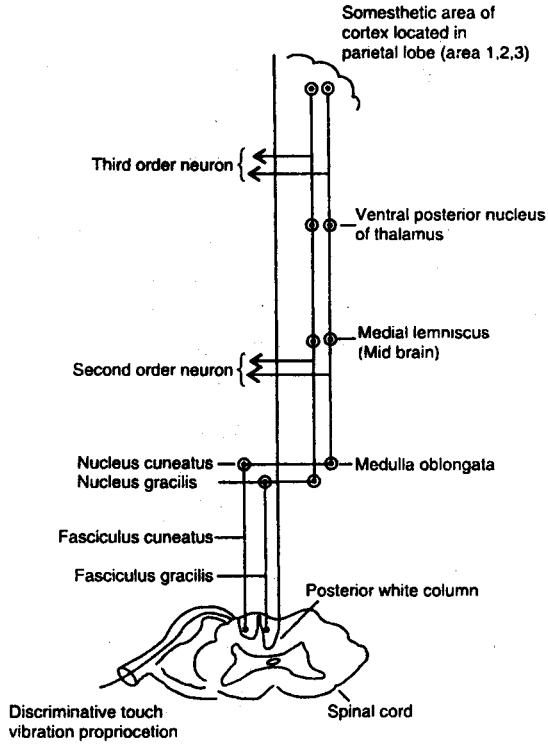

Fig. 30 : Posterior column pathway

2) It begins from posterior gray horn of sacral spinal cord.

3) This tract doesn't cross in the spinal cord.

4) But it directly passes up to the medulla.

5) Fibers terminate in nucleus gracilis of medulla.

6) In medulla 2nd order neuron begins.

7) Axons of 2nd order neuron travel through pons and midbrain.

8) They terminate in thalamus.

9) In thalamus 3rd order neuron begins.

10) This tract transmits signals to parietal lobe of cerebral cortex.

Tract of Burdach (Fasciculus Cuneatus)

This tact begins from the posterior gray horn of cervical spinal cord.

Its function and neuron are same as tract of Goll.

Functions of posterior column pathway

1) To determine fine, discriminative touch.
2) To determine exact location of touch.
3) To recognize difference in touch.
4) To recognize vibrations.
5) To recognize joint position (proprioception).

Unilateral lesion of spinal cord results in loss of functions of posterior column pathway, for e.g. failure to recognize size and shape of the body, inability to recognize discriminate touch of the same side of the body.

Lesion of right side of spinal cord results in loss of proprioception, touch on the same side of the body.

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Chapter 14

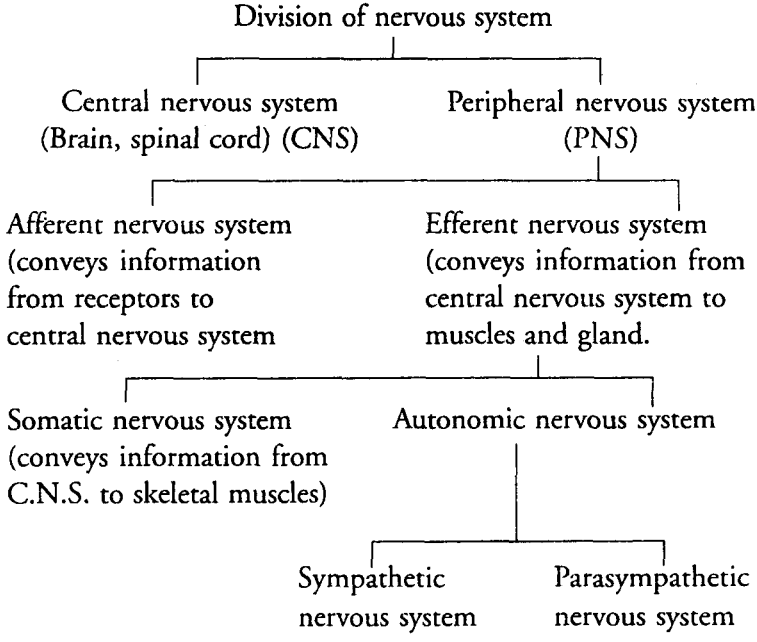
Nadi Sansthana

(Nervous System)

Nervous system transmits messages and correlate various body functions.

Nervous system controls homeostasis through impulses delivered via neurons.

Division of nervous system is shown in the following charts-



<u>Nervous Tissue</u>

Nervous system consist of 2 types of cells:

1) Neurons
2) Neuroglia are the 2 types of Nervous cells

Neurons : Structural and functional cells of nervous tissue.

Neurons conduct nerve impulses from one part of the body to another.

Components of Nerve Cell (Neuron)

Neuron consists of i) Cell body (ii) Dendrites (iii) Axon.

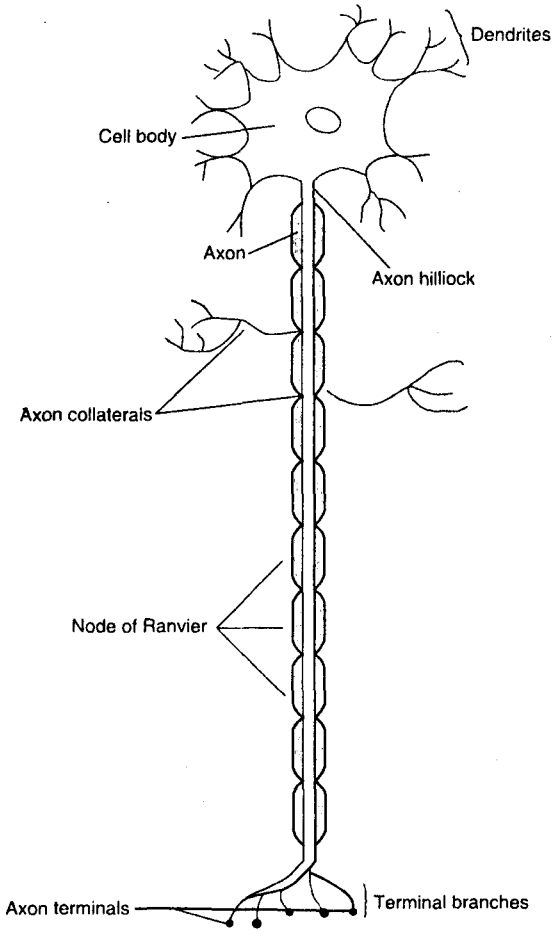


Fig 31 : A Digramatic Representation of a CNS Neuron

Cell body of Neuron

Cell body of neuron contains nucleus and it is surrounded by a granular cytoplasm.

Contents of the cytoplasm of cell body.

(1) Lysosmes 2) Mitochondria 3) Golgi complex 4) Lipofuscin 5) Nissl bodies 6) Neurofibrils.

Nissl's Bodies - It is a granular endoplasmic reticulum. Its function is protein synthesis and regeneration of peripheral nerve fibers.

Lipofuscin - These are yellowish brown granules which increase with age.

Neurofibrils - These are long, thin fibrils which transport nutrients.

Dendrites and Axons are cytoplasmic processes of neuron

Characters of Dendrites

Dendrites are highly branched and they are thick extension of cytoplasm of the cell body.

Function - to conduct nerve impulse towards the cell body.

A neuron has several dendrites.

Axon is a long thin process which originates from the cell body.

Characters of Axon

1) Long thin process 2) Originates from the cell body

Components of Axon

1) Axon Hillock - Small conical elevation from which axon originates from the cell body.
2) Axon contains mitochondria and neurofibrils.
3) Axon do not contain Nissl bodies hence it does not contain any protein synthesis.
4) Axoplasm- It is the cytoplasm of the axon.
5) Axolemma - It is a plasma membrane. Axoplasm is surrounded by Axolemma.
6) Axon collaterals - Side branches of axon are axon collaterals.

7) Axon terminals - The axon and its collaterals terminate by branching into fine filaments called as axon terminals.
8) Synaptic end bulbs - The distal ends of axon terminals are expanded into bulb like structures. These bulbs like structures are called as synaptic end bulbs.
9) Synaptic vesicles - Sacs present in synaptic end bulbs are called as synaptic vesicles. Synaptic vesicles store neurotransmitters.
10) Axon conducts nerve impulses away from the cell body to another neuron or muscle or gland.

Nerve Fiber

An axon along with its sheath is called as Nerve fiber.

Types of Nerve Fibers

- Myelinated nerve fibers
- Non-myelinated nerve fibers

1) Axon or the nerve fibers outside the CNS are surrounded by myelin sheath.
2) Axon or the nerve fibers in the CNS are without myelin sheath or also called as unmyelinated nerve fibers.
3) Axons of peripheral nervous system are myelinated.
4) Neurolemmocytes (Schwann cells) - These cells are located along the axon, these form myelin sheath.
5)Neurolemma - The peripheral nucleated cytoplasmic layer of the neurolemmocyte is called neurolemma.

Neurolemma is found only around the fibers of the peripheral nervous system.

Function of Neurolemma - Regeneration of injured axons and dendrites.

Types of the Neurons are as follows:

1) Multipolar neurons 2) Bipolar neurons 3) Unipolar neurons

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1) Multipolar neuron consists of many dendrites and one axon.

2) Bipolar neurons are few in numbers they are purely sensory e.g. of bipolar neurons are retina of eye, organ of hearing in the inner ear and olfactory epithelium in the upper part of nose.

3) Unipolar neuron have only one axon and one dendrite e.g. Neurons of posterior root ganglion of spinal nerves.

Functional classification of neurons

Sensory neurons (afferent neurons)	Motor neurons (efferent neurons)	Association neurons
Convey impulses from skin, muscles, joints to brain and spinal cord	Convey impulses from brain & spinal cord to muscles, glands or skin	Carry impulses from sensory to motor neuron

Nerves which lie outside the central nervous system belong to peripheral nervous system. The functional part of nerve is nerve fibers.

Classification of Nerve Fibers

1] General somatic afferent fibers: Conduct nerve impulse from the skin, muscles joints to the central nervous system.

2] General somatic efferent fibers: Conduct impulses from CNS to skeletal muscles.

3] General visceral afferent fibers: Conduct impulses from viscera & blood vessels to CNS.

4] General visceral efferent fibers: These types of nerve fibers are called as autonomic nerve fibers.

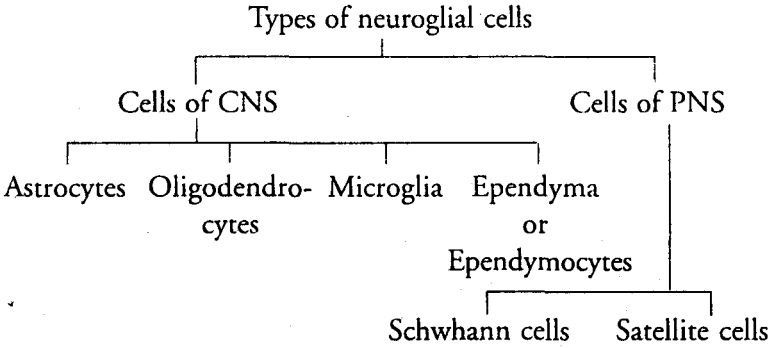
They control contractions of smooth & cardiac muscle & secretion of glands.

Characteristics of neurons

1] Ability of neurons is to generate & conduct impulse.
2] It has limited capacity of regeneration.

Neuroglial Cells

Neuroglial cells are supporting cells of nervous system.



Cells of CNS

1) Astrocytes - These cells look like stars. These cells support metabolic exchanges between neurons & capillaries in CNS. These cells release neurotransmitters.
2) Oligodendrites - They form myelin sheaths around axons in CNS. (Same function is carried out by Schwann cells in PNS).
3) Microglia - These cells have phagocytic action.
4) Ependyma - Epithelial cells, they assists in circulation of CSF.

Cells of PNS

5) Schwann cells - The function is same as oligodendrites.
6) Satellite cells - These are small cuboidal cells. These cells are found in para vertebral & peripheral ganglia function of these cells is same as satellite cells.

Regeneration of neurons

1) Neurons have limited capacity for regeneration.

2) Around six months of age, cell bodies of neurons loose their ability to reproduce.
3) A neuron destroyed is permanently lost.
4) Peripheral nerves have ability to regenerate.
5) Peripheral nerves are myelinated. Schwann cells regenerate myelin sheath.
6) Axons in the brain and spinal cord are myelinated by oligodendocyte but they do not assist regeneration.

Physiology of Central Nervous System

Parts of Central Nervous System are as follows:

Central nervous system consist of brain and spinal cord.

Parts of brain

1) Brain stem
2) Diencephalon
3) Cerebrum
4) Cerebellum

Brain stem consist of

- Medulla oblongata
- Pons
- Midbrain

Part of Diencephalon are

- Thalamus
- Hypothalamus

1) Forebrain consist of
   1) Cerebrum
   2) Thalamus
   3) Hypothalamus
2) Midbrain
3) Hindbrain consist of
   1) Pons
   2) Medulla oblongata
   3) Cerebellum

Functions of Medulla oblongata

Medulla oblongata is a continuation of upper portion of spinal cord.

Medulla oblongata consists of all ascending and descending tracts that communicate between spinal cord and various parts of brain. On the ventral side of medulla are two triangular structures called as pyramids.

Pyramids

Pyramids are composed of largest motor tracts that pass from brain to spinal cord. Just above the junction of medulla and spinal cord decussating of fibers takes place. Here most of the fibers in left pyramid cross to the right side and most of the fibers in the right pyramid cross to the left side of medulla. This crossing is called as decussation of pyramids. Therefore motor area of one side of cerebral cortex control muscular movements of opposite side after decussation, nerve fibers in the descending tracts pass in lateral fibers of medulla oblongata.

Dorsal side of Medulla oblongata

Dorsal side of medulla consists of two pairs of nuclei:

1) Nucleus gracilis.
2) Nucleus cuneatus.

These nuclei, receives sensory fibers from ascending tracts right and left fasciculus gracilis and fasciculus cuneatus, and relay sensory information to the opposite side of medulla.

Reflex centers in the Medulla oblongata are as follows -

1) Cardiac center - Regulates heart rate.
2) Medullary rhythmicity area - Adjusts the basic rhythm of breathing.
3) Vasomotor center - Regulates the diameter of blood vessels.

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4) Other reflex centers - Reflex center for swallowing, vomiting, coughing, sneezing and hiccup.
5) It gives origin to several pairs of cranial nerves.

The Medulla contains the nuclei of origin for following pairs of cranial nerves:

1) Vestibulo-cochlear nerve (VIII)
2) Glosso-pharyngeal nerves (IX)
3) Vagus nerves (X)
4) Accessory nerves (XI)
5) Hypoglossal nerves (XII)

Medulla is concerned with maintenance of equilibrium, postural changes and locomotion.

Effects of Medullary injury

1) Cranial nerve malfunctions on the same side of the body.
2) Paralysis and loss of sensation on the opposite side of the body.
3) Irregular respiratory rhythm.

Functions of Pons

Meaning of pons is bridge, because pons connects the spinal cord with the brain and parts of brain with each other.

1) Pons consists of two sets of fibers.
    1) Longitudinal fibers
    2) Transverse fibers.

Longitudinal fibers belong to the motor and sensory tracts that connect spinal cord medulla with the upper parts of the brain stem.

Transverse fibers are connected with the cerebellum.

2) Pons give rise to following pairs of cranial nerves:
    1) Trigeminal nerves (V)
    2) Abducent nerves (VI)

3) Facial nerves (VII)
4) Vestibular branch of Vestibulo-cochlear nerve

3) Pons controls breathing movements, pneumotaxic area and apneustic area. Pons together with medullary rhythmicity area control respiration.

Functions of Midbrain (Mesencephalon)

The midbrain or mesencephalon extends from the pons to the lower portion of the diencephalon. The cerebral aqueduct passes through the midbrain and connects the third ventricle above with the fourth ventricle below. Dorsal portion of midbrain is called as tectum and contains four rounded eminences which are called as-

1) Superior colliculi
2) Inferior colliculi

Superior colliculi serve as a reflex centers for movements of eyeballs and movements of head and neck in response to visual and other stimuli.

Function of inferior colliculi - It serves as reflex centers for movements of head and neck in response to auditory stimuli.

Red nucleus of Midbrain:

Fibers from cerebellum and cerebral cortex terminate in red nucleus. Red nucleus gives origin to descending rubrospinal tract, which is extrapyramidal tract.

Cranial nuclei in Midbrain:

Nuclei for occulomotor nerves (III) are present in the midbrain.

Functions of Diencephalon

Division of Diencephalon

Thalamus | Hypothalamus

Functions of Thalamus

1) All the special senses such as taste, touch, auditory and visual sense (except sense of smell i.e. olfactory sense) are carried in the thalamus. In other words, thalamus is a relay station for all the special centers except smell. From thalamus sensations are conveyed to cerebral cortex.

2) Thalamus acts as interpretation center for sensory impulses like pain, temperature, light, touch and pressure.

3) Anterior nucleus of thalamus is concerned with certain emotions and memory.

Hypothalamus

The hypothalamus is a small part located below thalamus.

Functions of hypothalamus

1) Information from external environment comes to the hypothalamus via afferent pathways.
2) Any change in physiological condition is brought to hypothalamus via afferent pathways.
3) Change in water concentration, hormone concentration, and change in body temperature is noticed by hypothalamus.
4) Hypothalamus controls autonomic nervous system.
5) Hypothalamus secretes regulatory/ inhibitory hormones.
6) Hypothalamus controls normal body temperature.
7) It regulates food intake.
8) Feeding center of hypothalamus is responsible for hunger sensation.
9) Satiety center is present in hypothalamus which gives feeling of satiety.
10) Thirst center is present in hypothalamus. Reduced extracellular fluid volume stimulates thirst center. This in turn produces thirst sensation.
11) Waking state and sleep patterns are maintained by hypothalamus.

12) It maintains biological rhythm.
13) It also maintains sexual behavior.

Functions of Cerebrum

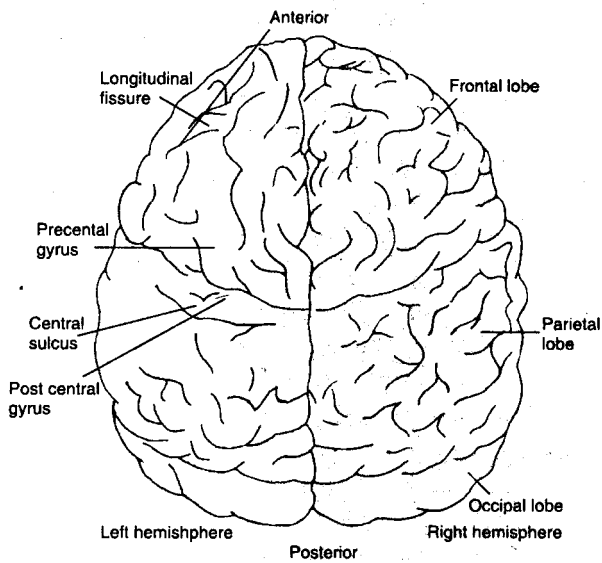

Fig. 32 : Superior view of the brain

The cerebrum is the largest part of the brain. The surface of cerebrum is called as cortex. It contains gyri, fissures and sulci. Cerebral cortex is made up of gray matter while cerebral white matter is situated below the cortex of cerebrum.

Cerebral cortex contains billions of nerve cell bodies. Gray matter is non myelinated nervous tissue and white matter is a myelinated nervous tissue. Cerebrum is divided into two equal halves called as hemisphere.

Division of Cerebrum

1) Right hemisphere 2) Left hemisphere

Right and left hemispheres are connected internally by

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bundle of transverse fibers called as corpus collosum. It is made up of white matter.

Protection and coverings of Brain

The brain is protected by cranial bones. Brain is covered by 3 meninges. The cranial meninges surround the brain and are continuous with spinal meninges.

The Cranial Meninges are:

1) Duramater - Outermost covering
2) Arachnoid mater - Middle covering
3) Pia mater - Innermost covering

The cranial duramater consists of two layers. The outer layer is thick, which functions like periosteum. The inner layer is thin.

Cerebrospinal Fluid (C.S.F.)

The brain is further protected by cerebrospinal fluid.

Cerebrospinal fluid is formed in the choroid plexuses and circulates through the subarachnoid space, ventricles and central canal of spinal cord.

Function of CSF

1) CSF acts as a shock absorber.
2) Protects brain and spinal cord from trauma.

Volume of C.S.F. is 80 to 150 ml

C.S.F is clear colorless fluid, like water and contains proteins, glucose, urea, salts and some lymphocytes.

Blood Supply of Brain

Blood is supplied to the brain via cerebral arteries i.e. circle of Willis.

Brain is the most active organ of the body, hence brain requires continuous supply of oxygen. Lack of oxygen for more than six seconds can damage brain cells.

Brain is supplied with oxygen and glucose, continuously. Low glucose level may cause mental confusion, dizziness, loss of consciousness and convulsions.

Blood Brain Barrier (BBB) is a concept that explains passage of certain material from the blood into the brain. BBB protects brain cells from harmful substances. Trauma, inflammation, toxins can brake BBB and the substances which normally don't reach the brain, can reach brain and damage brain tissue.

Basal Ganglia (Cerebral Nuclei)

Basal ganglia are paired masses of gray matter. They are present in each hemisphere of cerebrum.

Corpus striatum is the largest basal ganglia in each cerebral hemisphere.

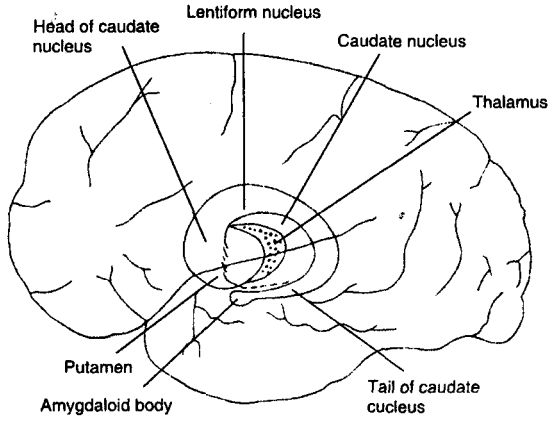

Fig. 34 (a) :

Division of Corpus striatum

- Caudate nucleus
- Lentiform nucleus
  - Putamen (lateral portion)
  - Globus pallidus (medial portion)

Other parts of Basal Ganglia are as follows:

1) Substantia nigra, the largest nucleus in the midbrain.
2) Subthalamic nucleus lies against internal capsule.
3) Red nucleus is a part of basal ganglia.

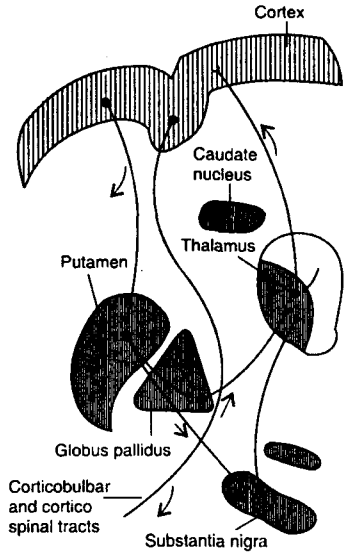

Fig. 34 (b) : Connection of cerebral nuclei with various parts of brain

Basal cell ganglia are connected to the cerebral cortex, thalamus, and hypothalamus.

Functions of Basal Ganglia

Caudate nucleus and putamen control large subconscious movements of skeletal muscles e.g. swinging of arms while walking. Damage to basal ganglia result in abnormal body movements.

Lobes of cerebrum

Each cerebral hemisphere is subdivided into four lobes. They are,

1) Frontal lobe
2) Parietal lobe

3) Temporal lobe
4) Occipital lobe

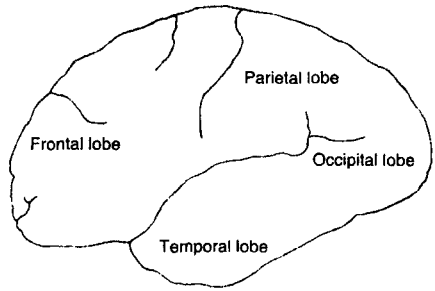

Fig 34 : Lobes of left cerebral hemisphere

White matter of Cerebrum

White matter of cerebrum is present below the cortex of cerebrum. It consists of myelinated axons.

Association fibers of white matter

These fibers connect and transmit nerve impulses between gyri in the same hemisphere.

Commissural fibers

Transmit impulses from the gyri in one cerebral hemisphere to the gyri in another hemisphere.

Projection Fibers

These fibers form ascending and descending tracts, e.g. internal capsule is type of projection fibre.

Limbic System

Certain parts of the cerebral hemispheres and diencephalons forms limbic system.

Functions of Limbic System

1) Limbic system is concerned with emotions, behavior pattern and memory.
2) Limbic system is concerned with pain and pleasure, anger, rage, fear, sorrow, sexual feeling and affection.

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3) Limbic system is called as visceral or emotional brain.

Functional areas of Cerebral cortex:

1) Functionally cerebral cortex is divided into
1) Sensory areas, 2) Motor areas, 3) Association areas

Functional areas are present in different lobes of cerebrum. These functional areas are numbered.

Sensory areas of Cerebral cortex:

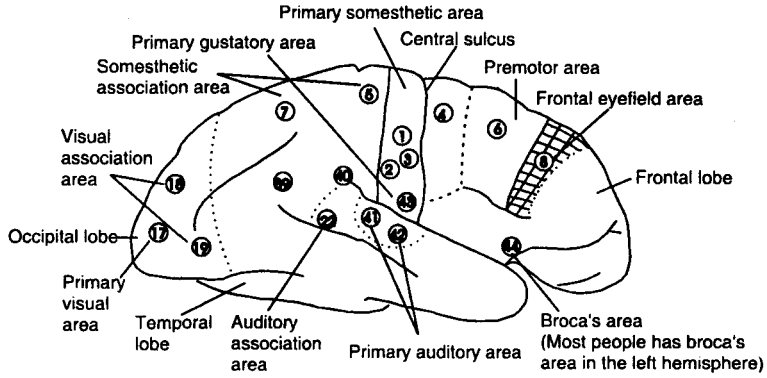

Fig. 36 : Sensory and motor areas located in right hemisphere (Brodmann's areas)

Sensory areas of cerebral cortex are as follows:

No.	*Sensory Areas*	*Area No.*
1	Primary somesthetic area or (General sensory area)	1,2,3
2	Somesthetic association area	5,7
	(Sensory association area)	
3	Primary visual area	17
4	Visual association area	18,19
5	Primary auditory area	41,42
6	Auditory association area (Wernick's area)	22
7	Primary gustatory area	43
8	Primary olfactory area	
9	Gnostic area	7,39,40

Motor areas of cerebral cortex

Sr. No.	*Areas*	*Area No.*
1	Premotor area	6
2	Frontal eye field area	8
3	Motor speech area (Broca's area)	44

Association areas of cerebral cortex:

The association region of the cortex occupies the greater portion of lateral surfaces of the occipital, parietal and temporal lobes.

Precise functions of sensory areas

1) Primary somesthetic area- This is also called as general sensory area.

2) Somesthetic association area.

Functions of primary somesthetic area

This area receives sensations from cutaneous, muscular and visceral receptors in various parts of body. Each point of this area receives sensation from specific parts of the body. Whole body is represented in this area. More the sensitive area, larger the space occupied by the area in this region for e.g. lips are sensitive than thorax. Therefore larger portion of sensory areas receives impulses from lips than from the thorax.

Important function of general sensory areas is to localize the points of the body where the sensation arises. But this area cannot identify the exact location of area, where the sensation arises.

Functions of somesthetic association areas

1) This area receives inputs from thalamus.
2) Its function is to integrate and interpret sensations.

This area can determine exact shape and texture of an object

without looking at it. This is then stored as memory of past experience. Therefore person can compare sensations with past experiences.

Functions of Primary visual area (area 17)

1) This area receives sensory impulses from the eyes.
2) This area interprets shape, color and movement of an object.

Functions of Visual association area (area 18, 19)

1) This area stores visual experiences
2) This area establishes present visual experiences with past one with recognition and evaluation of what is seen.

Functions of Primary auditory area (areas 41, 42)

1) This area interprets pitch and rhythm of sound.

Functions of Auditory association area (area 22)

1) This area determines whether sound is speech, music or noise.
2) This area converts words into thoughts.

Functions of Primary gustatory area (area 43)

1) This area interprets sensations related to taste.

Functions of Primary olfactory area

This area is related to smell.

Gnostic area or Wernicke's area (areas 5,7,39,40)

1) Meaning of gnosis is knowledge. This area receives knowledge from all association areas e.g. from taste and smell areas and from thalamus.
2) This area integrates sensory interpretations from all parts of brain.
3) By receiving such inputs from all parts of brain, a common thought is formed.

Sensory area and lobes of cerebrum

	Areas	*Lobes*
1	General sensory area (areas 1, 2, 3)	Parietal lobe
2	Somesthetic association area (areas 5,7)	
3	Primary visual area (area 17)	Occipital lobe
4	Visual association are (area 18,19)	
5	Primary auditory area (areas 41, 42,)	Temporal lobe
6	Auditory association area (area 22)	
7	Primary gustatory area (area 43)	Parietal lobe
8	Gnostic area (areas 5, 7, 39, 40)	Located among somesthetic visual, auditory association area.
9	Primary olfactory area	Temporal lobe

Motor area of cerebral cortex

	Areas	*Lobes*
1	Primary motor area (area 4)	Precentral gyrus of frontal lobe
2	Premotor area (area 6)	Anterior to the primary motor area in frontal lobe.
3	Frontal eye field area (area 8)	Frontal lobe.
4	Broca's area (area 44)	Located in frontal lobe superior to the lateral cerebral sulcus.

Functions of Motor area

1) The Primary motor area (area 4) control specific group of muscles those results in muscular contraction of opposite side of the body.

2) The frontal eye field area (area 8) - This area controls voluntary scanning movements of the eyes for e.g. searching for a word in book.

3) Functions of Broca's area (area 44) - Converts thoughts into speech. The production of speech occurs in Broca's speech area, which is located in the left frontal lobe.

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Functions of association areas

Association areas are related to memory, reasoning, intelligence and emotions.

Brain Lateralization

1) The two hemispheres of the brain are not exactly symmetrical.

2) For numerical, scientific skills left hemisphere is important.

Right hemisphere is important for musical, artistic awareness.

Electroencephalogram (EEG)

Brain waves generated by the cerebral cortex can be recorded. This record of cerebral activity is called as EEG.

Types of brain waves : 4 types of waves are observed in EEG. These waves are:

1) Alpha, 2) Beta, 3) Theta, 4) Delta

Alpha waves are found in people who are awake and in resting stage. These waves disappear during sleep. Beta waves indicates active nervous system. Theta waves occur in children and in adults and it shows stress. Delta waves are found in children in awaken stage, however this indicates brain damage in adults. These waves are also found during deep sleep in adults.

Cranial nerves

Twelve pairs of cranial nerves arise from the brain.

Name and functions of cranial nerves

1	Olfactory (I) sensory	Sensory function : Smell
2	Optic (II) Sensory	Sensory function : Vision
3	Oculomoter (III) mixed primarily motor	Motor function-Movement of eyelid, eyeball, constriction of pupil accommodation of lens for near vision. Sensory function - Muscle sense

4	Trochlear nerve (IV) mixed - primarily motor	Motor function : Movement of eyeball Sensory function : Muscle sense
5	Trigeminal nerve (V) mixed	Motor function : Chewing Sensory function: Conveys sensations for touch, pain, temperature from face, plate, pharynx and skin over face.
6	Abducens nerve (VI) mixed-primarily motor	Motor function : Movement of eyeball Sensory function: Muscle sense.
7	Facial nerve (VII) mixed nerve	Motor function: Facial expression secretion of saliva and tears. Sensory function : Muscle sense
8	Vestibulo-cochlear (VIII) nerve- Sensory nerve	Functions of cochlear nerve : Conveys impulses related to hearing Functions of vestibular nerve: related to equilibrium
9	Glossopharyngeal nerve (IX) mixed nerve	Motor function -Salivary secretion Sensory function: -Taste and regulation of blood pressure.
10	Vagus nerve (X) mixed nerve	Motor function - Visceral muscle movements. Sensory function -Convey sensations from muscles supplied.
11	Accessory nerve (XI) mixed primarily motor nerve	Motor functions - Control swallowing movements, controls movements of head. Sensory function - Muscle sense.
12	Hypoglossal (XII) mixed primarily motor nerve	Motor functions -Movement of tongue during speech and swallowing Sensory function - Muscle sense.

Cerebellum

Cerebellum is situated in the inferior and posterior part of

the cranial cavity. Cerebrum is posterior to the medulla and pons and cerebellum lies below the occipital lobes of cerebrum. Cerebellum is a motor organ.

Functions of cerebellum

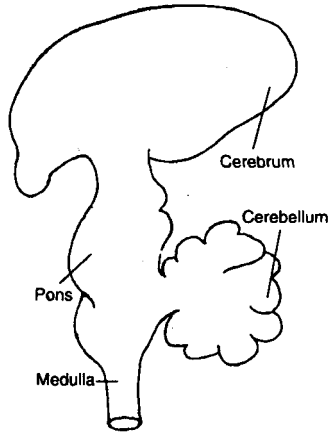

Fig. 37 : Anatomical position of cerebellum

1) Cerebellum co-ordinates subconscious movements of skeletal muscles.
2) Maintains body equilibrium.
3) Maintains normal muscle tone. Damage to the cerebellum is characterized by disturbances of gait and severe dizziness, which indicates loss of co-ordination in skeletal muscle movements and loss of equilibrium.

Neurotransmitters in the brain

1) Acetylcholine (Ach) - leads to excitation.
2) Serotonin (5 HT) - leads to excitation also involved in inducing sleep, temperature control and control of mood.
3) Gamma amino butyric acid (GABA) - leads to inhibition of brain activity.
4) Leads to inhibition of spinal cord.
5) Dopamine (DA) - Related to emotions and subconscious movements of skeletal muscles.

6) Glutaminic acid and aspartic acid- Causes excitation in brain.
7) Norepinephrine (NE) - Related to moods emotions and dreaming.

Definitions of Neural Tissue

White Matter -White matter is composed to myelinated processes of neurons. Due to myelin sheath, color of this neural matter gets white color.

Gray matter- The gray matter of the nervous system contains 1) Nerve cell bodies. 2) Dendrites or bundles of non-myelinated axons. 3) Neuroglia nerve - This is a bundle of fibers, located outside the central nervous system. This may be axons or dendrites.

Nucleus (Nuclei) -Nucleus is a mass of nerve cell bodies and dendrites in the central nervous system.

Gray matter is formed of nerve cell bodies

Physiological aspect of spinal cord: The spinal cord is located in vertebral column.

Length of the adult spinal cord: 42-45cm.

Circumference of the spinal cord: 2.54 inches.

Coverings of spinal cord: Spinal cord is protected by coverings, these coverings are also called as meninges.

These Meninges are:

1) Outer spinal covering is dura mater.
2) The middle covering is arachnoid mater and
3) Inner covering is pia mater.

Epidural space - This is the space between dura mater and the wall of vertebral column space is called as epidura space. The epidural space inferior to the second lumbar vertebra is the site for giving anesthetic block for child birth.

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Subarachnoid space - The space between arachnoid and pia mater is called as subarachnoid space. Cerebrospinal fluid circulates in this space. For giving spinal anesthesia, lumber puncture is done between third and fourth lumber vertebra, & anesthesia is given in subarachnoid space. The spinal cord is segmented. There are 31 segments of spinal cord. Each spinal segment gives rise to pairs of spinal nerves.

Study of cross section of spinal cord: Spinal cord consist of gray and white matter

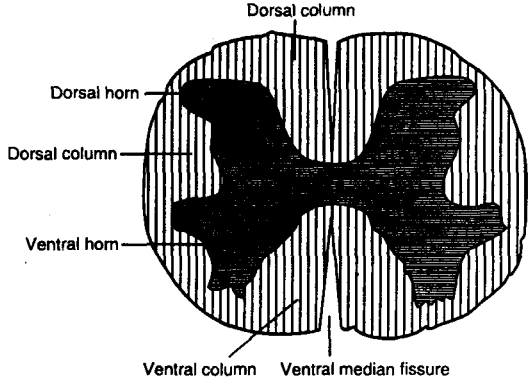

Fig. 37 : Transverse section of spinal cord

Gray matter of spinal cord

1) Gray matter of spinal cord occupies inner part of the spinal cord.

2) Shape of gray matter of spinal cord has a shape of English alphabet H.

3) Gray mater consists of nerve cell bodies of spinal cord.

4) The cross bar of the H is formed by the gray commeasure.

5) Central canal is a small space in the center of the gray commeasure. Central canal is continuous with the fourth ventricle of the medulla. Central canal contains cerebro spinal fluid. The upright portions of the Gray matter (H) are divided into -

1) Anterior (ventral) gray horns.
2) Posterior (dorsal) gray horns.
3) The region between anterior and posterior gray horns are called as lateral gray horns. Lateral gray horns are present in thoracic, upper lumbar and sacral segments of cord.

White matter of the spinal cord

White matter of spinal cord occupies outer portion of the cord. The white matter is formed of sensory and motor tracts of the spinal cord. White matter is divided into:

1) Anterior (ventral) white columns.
2) Posterior (dorsal) white columns.
3) Lateral white columns.

White columns consist of ascending and descending tracts.

Ascending tracts: These tracts consist of sensory axons. Ascending tracts of the spinal cord conduct sensory impulses upward towards brain.

Descending tracts: These tracts consist of motor axons. They run downward from the brain to periphery.

Functions of spinal cord

1) Spinal cord conveys sensory nerve impulses from periphery to brain.
2) Spinal cord conveys motor impulses from brain to periphery.
3) Spinal cord function as a reflex center.
4) The 31 pairs of spinal nerves arise from spinal segments.
5) The ventral rami of spinal nerves (except T2, T11) form nerve plexuses e.g. cervical plexus, lumbar plexus and sacral plexus.
6) All spinal nerves (except C1) innervate specific skin segments called as dermatomes.

Functions of dermatomes: Knowledge of dermatomes help physician to diagnose affected segment of spinal cord.

Ascending tracts of spinal cord

Ascending spinal tracts convey sensory impulses from periphery to the brain.

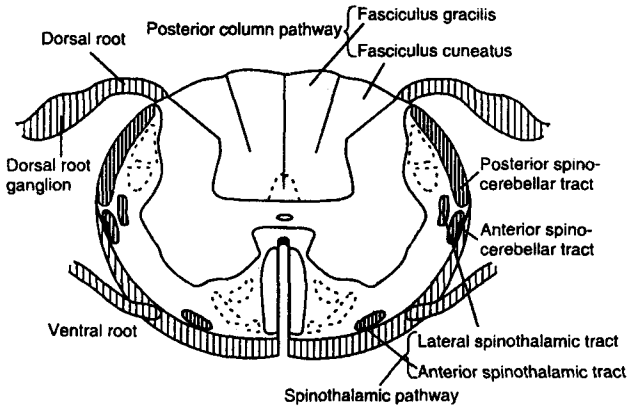

Fig. 39 : Ascending sensory tracts in the spinal cord

Names of ascending tracts:

1) Anterior spinothalamic tract.
2) Lateral spinothalamic tract.
3) Posterior spinothalamic tracts.
   i) Fasciculus gracilis.
   ii) Fasciculus cuneatus.
4) Posterior spinocerebellar tract.
5) Anterior spinocerebellar tract.

Name of the tract indicates -

1) Location of the tract in the spinal cord
2) Origin of the tract
3) Termination of the tract.

For example - Anterior spinothalamic tract is located in anterior white column of spinal cord & this tract terminates in thalamus, hence called as anterior spinothalamic tract.

Lateral spinothalamic tract is located in lateral white column

of the spinal cord & it terminates in Thalamus. Posterior spinothalamic tract is located in posterior white column terminates in medulla oblongata.

Sensory impulses from thalamus or medulla are conveyed to cerebral cortex.

Anterior and posterior spinocerebellar tracts are located in the lateral white column of spinal cord. Spinocerebellar tracts are terminated in cerebellum.

Functions of spinocerebellar tract

To convey nerve impulses regarding muscle and joint, movements to cerebellum and to maintain body posture and muscle tone.

Descending (Motor) tracts

Descending or motor tracts convey motor impulses from brain to the periphery.

Types of descending tracts

Descending tracts

Pyramidal tracts (arise from cerebral cortex)

Extra pyramidal tracts (arise from mid bran medulla or pones.)

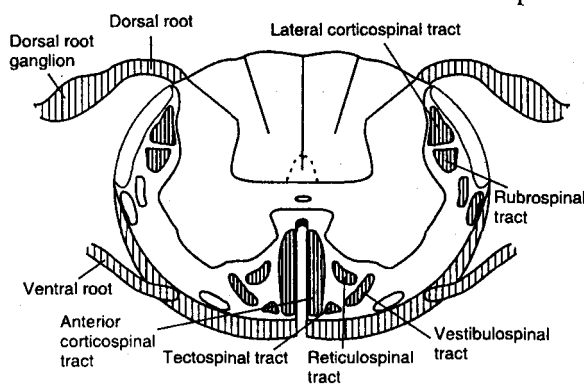

Fig. 40 : Descending motor tracts in the spinal cord

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Names of descending pyramidal tracts

1) Lateral corticospinal tract
2) Anterior (ventral) corticospinal tract

Names of Extra pyramidal tracts

1) Rubrospinal tract
2) Tectospinal tract
3) Vestibulospinal tract
4) Lateral reticulospinal tract
5) Anterior reticulospinal tract.

Rubrospinal and Tectospinal extra pyramidal tracts have origin in mid brain

1) Vestibulospinal and lateral reticulospinal tract have origin in Medulla oblongata
2) Anterior reticulospinal tract arise from Pons.
3) Lateral corticospinal crosses in medulla.
4) Anterior corticospinal crosses to spinal cord.
5) Rubrospinal crosses to opposite side of spinal cord.
6) Tectospinal crosses to opposite side of spinal cord.

Crossed pyramidal and extra pyramidal tracts control opposite side of the body remaining uncrossed pyramidal tracts controls same side of the body.

Functions of descending tracts

1) Controls skeletal muscles of opposite side of the body.
2) Co-ordinate discrete movements.
3) Co-ordinate movements of axial skeleton.

Functions of Extra pyramidal tracts

1) Rubrospinal tract controls flexor muscle tone.
2) Tectospinal tract controls movements of head in response to visual and auditory stimuli.
3) Vestibulospinal tract maintains equilibrium.
4) Extra pyramidal tracts control complex movements of body e.g. movements of hand and legs while walking.

Reflex center

Spinal cord serves as a center for reflex action.

Definition of reflex

Reflexes are fast responses to certain stimuli (changes) in the internal or external environment.

Types of reflexes

Somatic	Autonomic (Visceral)
Related to skeletal muscle contraction	Related to heart rate, respiration, defecation, digestion vomiting etc.

Division Somatic reflexes

Superficial reflexes	Deep reflexes

Components of reflex arc are

1) Sensory receptor 2) Sensory neuron 3) Reflex center 4) Motor neuron 5) Effector

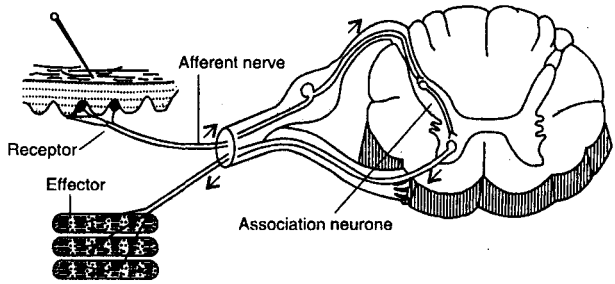

Fig. 41 (a) : Reflex arc

Receptor receives the stimulus & conveys to the reflex center by sensory nerve. In the reflex center, incoming sensory impulse generates an outgoing motor impulse. In the center, the impulse may be inhibited, transmitted or rerouted. Motor neuron transmits the impulse generated by the sensory or association neuron to the effector organ. Effector is the organ of the body that responds to the motor nerve

impulse. Reflexes that result in the contraction of skeletal muscles are called as somatic reflexes. Reflexes carried out only by spinal cord are called as spinal reflexes.

Definition of sensation

State of awareness of external or internal conditions is called as sensation.

Factors responsible for awareness of sensation are as follows: i) Stimulation, ii) conversion of stimulus to impulse, iii) conduction of impulse & iv) translation of impulse in the brain are the four factors which are required for awareness of sensation. Nerve impulse is conducted along the ascending tract via spinal cord to cerebrum.

Types and Location of receptors

- Exteroceptors are present on the surface of the body.
- Visceroceptors are located in the blood vessels & viscera.
- Proprioceptors are present on the muscles, tendons, joints internal ear.

Type of proprioceptors

Proprioceptors provides information about body position and movement.

Types:

1) Muscle spindles - present in skeletal muscles
2) Tendon organs - present at tendomuscular junctions
3) Joint kinesthetic receptors - present around joints

Functions of Receptors

Name of receptors	*Function*
Exteroceptor	Transmits sensations of hearing taste, touch, pressure, temperature etc.
Viseroceptors	Transmits sensations of pain, pressure, hunger, thirst, fatigue, etc.
Proprioceptors	Transmits sensation regarding body position, movement, equilibrium.

Receptors are further labeled on the basis of type of sensation they received.

Name of receptor	*Stimulus detected*
Thermoreceptors	Temperature
Nociceptors	Detect pain
Photoreceptors	Detect light on retina
Chemoreceptors	Detect taste, smell, oxygen of carbon dioxide level in blood.

Physiology of Sensory Pathways

Sensory pathways conveys information of sensations from receptors on one side of the body to the opposite side of the spinal cord or medulla & then to primary somesthetic area of the cerebral cortex. Sensory pathways are also called as ascending tracts which ascend from receptors up to the brain.

There are two general sensory pathways which conduct sensations from receptors to brain via spinal cord. They are as listed below:

1) Posterior column pathway &
2) Spinothalamic pathway

Functions of Posterior Column Pathway

Posterior column pathway conducts impulses related to proprioception (awareness of position of body & direction of movement), discriminative touch (the ability to recognize the exact location of stimulation) & vibrations.

Functions of Spinothalamic Pathway

1) Lateral spinothalamic pathway conducts impulses for pain & temperature.

2) Anterior column pathway conducts impulses for light touch & pressure. There are three neurons in the sensory pathways:

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i) The first order neuron of posterior column pathway connects receptors with the spinal cord.

ii) The second order neuron extends from posterior root ganglion of spinal cord which passes from medulla upward to thalamus. The cell body of the second order neuron is located in the nuclei cuneatus or gracilis of the medulla. Before passing to thalamus axons of the second order neuron crosses to opposite side & terminate in thalamus.

iii) From thalamus axons of third order neuron begins which terminate in the primary somesthetic area of parietal cortex of cerebrum. In this way posterior column pathway ascends from spinal cord, medulla, and thalamus & terminate in the cerebral cortex.

Axons of second order neuron of posterior column pathway which has cell body in the nuclei cuneatus is called as 'fasciculus gracilis', while which has cell body in the nuclei gracilis is called as 'fasciculus cuneatus'.

Spinothalamic pathways (lateral & anterior) also have three neurons. Spinothalamic pathway conducts impulses from receptors to cerebral cortex. Lateral spinothalamic tract conducts impulses for pain & temperature from nociceptors & from thermoreceptors to spinal cord. In the spinal cord second order neuron crosses opposite side of spinal cord. Here the axons conducting impulses of pain & temperature are arranged laterally therefore called as lateral column pathway. Axons of second order neuron pass from brain stem to thalamus. Thalamus is the site of conscious recognition of pain & temperature. Then from thalamus third order neuron terminate in cerebral cortex.

3rd order neuron starts from thalamus & terminate in cerebral cortex.

Anterior spinothalamic tract, Lateral spinothalamic tract, Posterior spinothalamic tract are the ascending tracts.

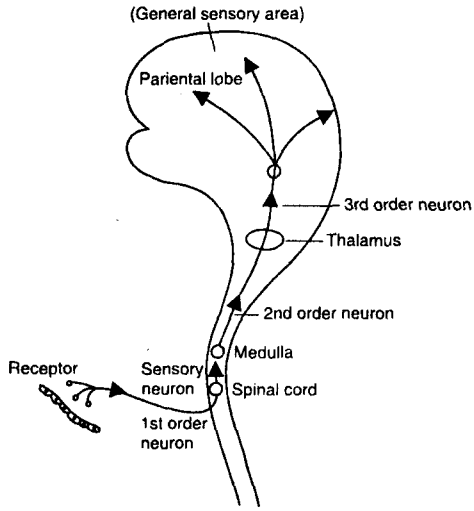

Fig. 40 (b) : Neuron levels in the sensory system

1) Afferent or sensory nerve fibers conduct various types of sensations (for e.g. pain, temp, pressure etc.) from body.
2) For the sensations to conduct, stimulus is picked up by receptors.
3) Receptor convert stimulus to nerve impulse.
4) Sensory nerve fibers conduct nerve impulse to spinal cord.
5) In the spinal cord sensory nerve fibers carrying same type of sensations come together to form ascending tracts.
6) Ascending tracts travels in the upward direction from spinal cord to thalamus.
7) From thalamus nerve impulse is transmitted to cerebral cortex.

Physiology of Motor Pathway

Descending tracts conduct motor impulses from cerebrum to the different parts of the body.

Pyramidal tracts (those arising from cerebral cortex) are :

1) Lateral corticospinal tract
2) Anterior corticospinal tract
3) Corticobulbar tract.

Extra pyramidal tract

1) Rubrospinal 2) Tectospinal tract
3) Vestibulospinal 4) Lateral reticulospinal
4) Anterior reticulospinal

(Functions of pyramidal & extra pyramidal tracts are enumerated under the functions of spinal cord).

Motor pathways consist of two neurons - 1) Upper motor neuron & 2) Lower motor neuron. Axons of upper motor neuron extend from motor cortex of cerebrum & spinal cord. Lower motor neuron extends from the spinal cord to muscle fibers.

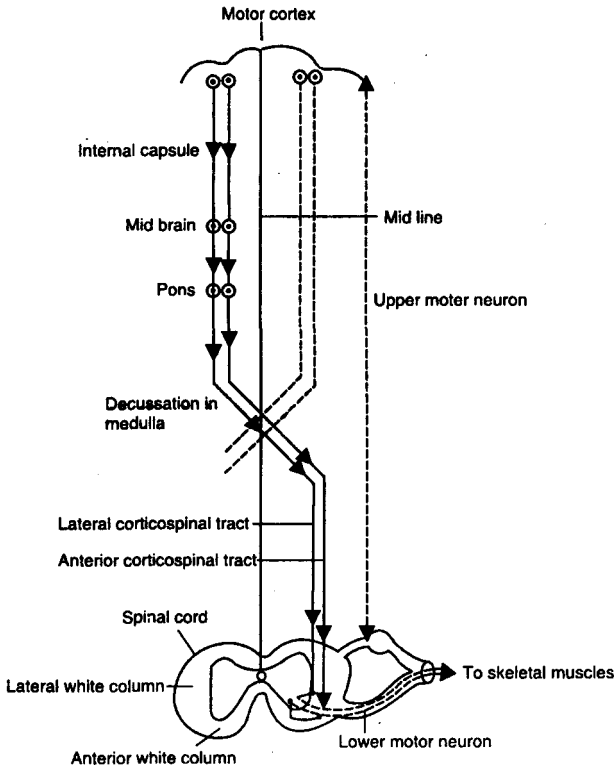

Fig. 40 (c) : Anterior and lateral corticospinal tract (pyramidal descending tract)

The lateral corticospinal tract begins in the motor cortex & descends through internal capsule & midbrain & then to same side of pons. About 85 % of the axons of upper motor neuron cross in medulla. After crossing these axons descends through lateral white column of spinal cord. Therefore right side of motor cortex control muscles of left side and vice versa. Axons of upper motor neuron synapses with anterior horn cells of lower motor neuron & axons of lower motor neuron leave the spinal cord through ventral root of spinal nerves at all levels of spinal cord. The lower motor neuron terminates in skeletal muscles.

The axons of upper motor neuron of anterior corticospinal tract descend from cortex, but don't cross in medulla but cross in the spinal cord. Therefore anterior corticospinal tract is an uncrossed pyramidal (motor) tract.

Axons of corticobulbar tracts extend from cerebral cortex & terminate in the nuclei of cranial nerves.

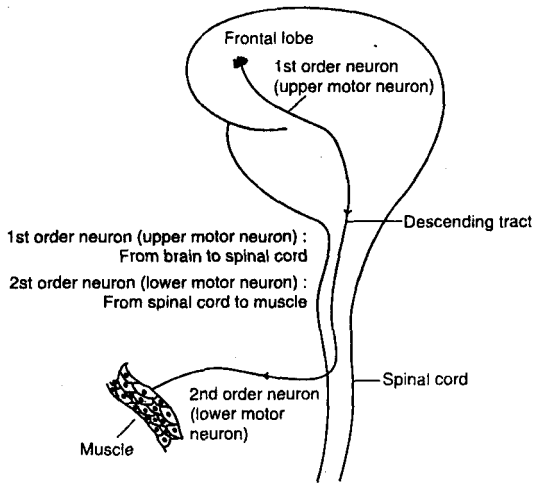

Fig. 40 (d) : Neuron levels in the motor system

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Clinical importance of upper motor neuron & lower motor neuron

Damage of lower motor neuron results in flaccid paralysis while that of upper motor neuron results in spastic paralysis.

Physiology of Autonomic Nervous System

The part of the nervous system that regulates the activities of

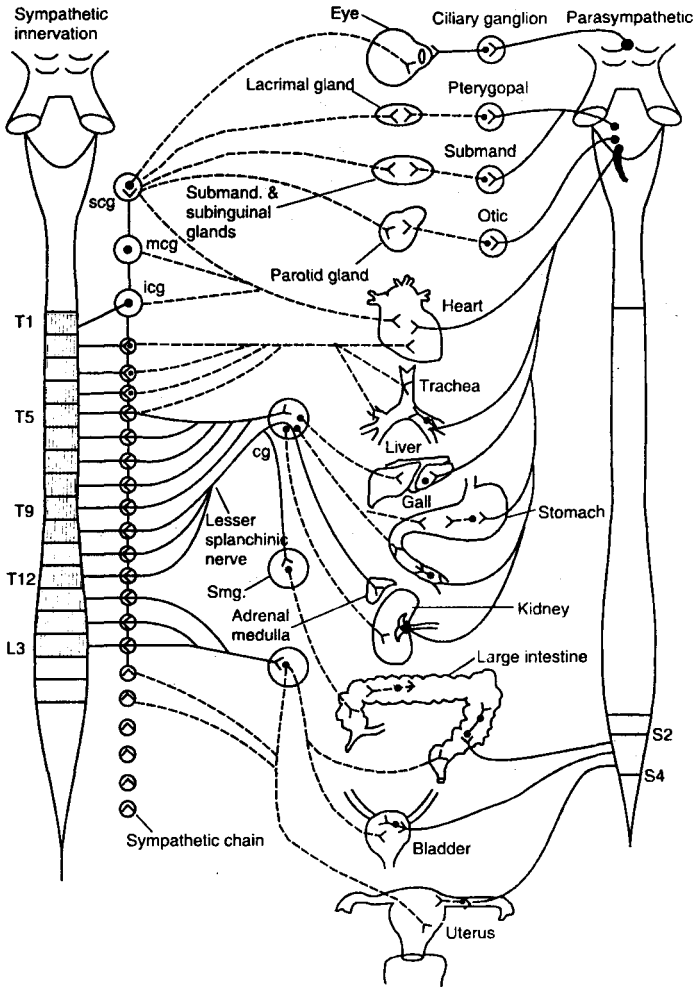

Fig. 42 (a) : Organization of Autonomic nervous system

smooth muscles, cardiac muscles & gland is called as Autonomic nervous system (A.N.S.)

1) Sympathetic nervous system
2) Parasympathetic nervous system are the divisions of ANS.

Sympathetic nervous system is also called as thoracolumber system because axons of neurons of sympathetic system have their cell bodies located in the lateral gray horns of the 12 thoracic segments & first 2 or 3 lumber segments of the spinal cord, therefore sympathetic outflow is called as Thoraco-lumber out flow.

Parasympathetic outflow is derived from the nuclei of cranial nerves III, VII, IX & X in the brain stem & in the lateral horn cells of sacral segments of spinal cord hence called as Craniosacral outflow.

In the autonomic ganglia synapses between preganglionic & postganglionic fibers take place. There are two types of sympathetic ganglia. Sympathetic ganglia are:

1) Para-vertebral ganglia &
2) Pre-vertebral ganglia

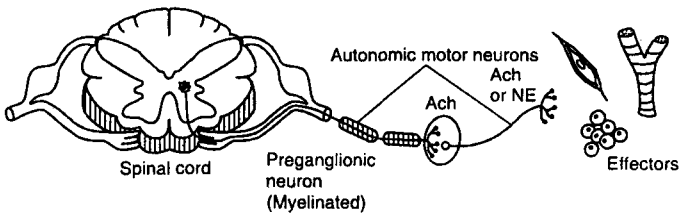

Fig. 42 (b) : Autonomic nervous system

Para-vertebral ganglia:

They are present on either side of the vertebral column in the form of chain. These ganglia are aggregated nerve cells. There are 3 cervical ganglia, 11-12 thoracic ganglia, 4-5 lumber ganglia & 4-5 sacral ganglia.

Pre-vertebral ganglia

These ganglia are present near large abdominal arteries. They are:

1) Superior mesenteric ganglion
2) Inferior mesenteric ganglion &
3) Celiac ganglion

Preganglionic nerve fibers of sympathetic system extends from lateral horn cells of thoracic or lumber segments of spinal cord up to pre-vertabral ganglia or para-vertebral ganglia. Postganglionic nerve fibers extend from ganglia & terminate in the organ or gland.

Parasympathetic Nervous system

Parasympathetic nervous system is also called as craniosacral nervous system.

Origin

Cranial parasympathetic outflow - This emerges from brain stem and passes along with four cranial nerves.

Parasympathetic fibers emerging from brainstem pass along with following cranial nerves:

1) Oculomotor nerve (III)
2) Facial nerve (VII)
3) Glossopharyngeal nerve (IX)
4) Vagus nerve (X)

Parasympathetic ganglia

Parasympathetic ganglia are also called as terminal ganglia. These ganglia are as follows:

1) Ciliary ganglia - It is lateral to each optic nerve.
2) Pterygopalatine ganglia - It is lateral to sphenopalatine foramen.
3) Submandibular ganglia - It is near duct of submandibular salivary gland.
4) Otic ganglia - It is inferior to each foramen ovale.

Parasympathetic receptors

1) Muscarinic receptors
2) Nicotinic receptors

Difference between sympathetic and parasympathetic nervous system

Sympathetic nervous system	*Parasympathetic nervous system*
1) Thoraco-lumber outflow.	1) Cranio-sacral outflow.
2) Preganglionic fibers are longer	2) Preganglionic fibers are short.
3) Ganglia are present on either side of vertebral column.	3) Ganglia are present.
4) Preganglionic fibers are cholinergic, post ganglionic fibers are adrenergic.	4) All pre and post ganglionic are cholinergic.
5) Action is widespread	5) Action or responses are restricted.
6) Concerned with energy expenditure	6) Concerned with energy restoration.
7) Heart rate & BP is increased	7) Heart rate & BP is decreased
8) Peristaltic movements are reduced.	8) Peristalsis increases.
9) Inhibits secretion of digestive enzymes and insulin.	9) Promotes secretion of digestive enzymes and insulin.
10) Increases blood sugar level.	10) Decreases blood sugar level.
11) Physiological responses are called fight or fright responses.	11) Conserve and restores body energy.

Autonomic Neurotransmitters

Autonomic nerve fibers release neurotransmitter at synapses and near organs.

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Autonomic neurotransmitters

Acetylcholine (ACH) Noradrenalin (NA)

On the basis of the type of neurotransmitter released at the synapses, autonomic nerve fibers are divided into:

1) Cholinergic nerve fibers release ACH &

2) Adrenergic nerve fibers release NA.

Cholinergic nerve fiber

1) All sympathetic and parasympathetic preganglionic nerve fibers are cholinergic.

2) All parasympathetic preganglionic nerve fibers are cholinergic fibers as they release ACH.

Adrenergic nerve fibers

Most of the sympathetic post-ganglionic fibers release NA; hence they are called as adrenergic nerve fibers.

Autonomic receptor

Neurotransmitter interacts with receptors which are present on the surface of the organs.

Sympathetic receptors -

1) Alpha receptors - excitatory in action.

2) Beta receptors - inhibitory in action exception is receptors on heart muscles which stimulate heart rate.

ANS is an energy conserver while PNS is an energy savour system. ANS increases heart rate, B.P, respiration, while PNS reduces heart rate, B.P and promotes digestion by stimulating digestive enzymes.

Chart showing action of Autonomic Nervous System on various organs

Organ	*Sympathetic receptor*	*Effect of sympathetic stimulation*	*Effect of para-sympathetic stimulation*
Heart	Beta	Heart rate increases	Coronary arteries dilatation.
		Heart rate decreases,	Constriction of coronary arteries.
Bronchioles	Beta	Dilatation	Constriction
Stomach & intestines	Beta Alpha	Decreases motility Increases motility	and tone and tone
Gastric glands		Inhibits secretions.	Increases secretions.
Pancreas	Beta Alpha	Inhibits secretion of enzymes and insulin. Promotes secretion of enzymes and insulin.	
Lacrymal glands	-	-	Stimulates secretion.
Eye	Alpha	Dilatation of pupil	-
Fat cell	Alpha	Lypolysis	-
Kidney	Beta	Urine volume decreases	No effect
Bladder	Beta Alpha	Relaxation of muscular wall.	Contraction of muscular wall.

YOGA

'तत्र शरीरं नाम चेतनाधिष्ठानभूतं पञ्चमहाभूतविकारसमुदायात्मकं समयोगवाहि' । (Cha.Sha. 6/4)

'युज-युज्यते' ।

Etymology

Word Yoga is derived from the verb root 'yuj'.

Yoga means union.

Yoga is union of self with God or Supreme Being. The aim of Yoga is mainly to achieve the liberation. Yoga teaches us how to control mind and senses from the various attractions.

'योगस्तु चित्तवृत्तिः निरोधः' । (Yogadarshan 1/2)

But Yogic science does not neglect the importance of maintaining health because-

'समत्वं योग उच्यते' । (Geeta 2/48)

Ayurveda is a science of life and longevity.

Yoga is the science of linking the individual self with the universal self.

Both Yoga and Ayurveda aims at developing balance at physical, mental, emotional and spiritual levels of human being.

According to Ayurveda body and mind are interconnected.

'सत्त्वमात्मा शरीरं च त्रयमेतत् त्रिदण्डवत्' । (Cha.Su. 1/46)

'शरीरं सत्त्वसंज्ञं च व्याधीनामाश्रयो मतः ।
तथा सुखानाम्' । (Cha.Su. 1/55)

Sattva (mind), atma (soul) and sharir (body) are tripod of life. Sattva (mind) and body are equally affected by disorders (vyadhi).

With the help of yogic science control over mind, senses and body can be developed. Hyper indulgence and wrong indulgence of subjects by respective senses is the basic cause of disease.

'कालार्थकर्मणां योगो हीनमिथ्यातिमात्रकः ।
सम्यग्योगश्च विज्ञेयो रोगारोग्यैककारणम्' ॥ (Ash.Hru.Su. 1/19)

With the help of yoga, control over mind - senses - and body can be achieved and wrong indulgence of objects can be

prevented. Patanjali is the author of Patanjali Sutra which is basic text on Yoga.

Ashtanga Yoga of Patanjali

There are eight aspects of Yoga described by Patanjali. Yoga practitioner should follow these eight aspects of Yoga:

Ashtanga Yoga are:

'तत्र अहिंसा सत्य अस्तेयं ब्रह्मचर्य अपरिग्रह यमा:' । (Yogasutra 2/31)

1) Yama - Yama means social code of conduct which must be followed by Yoga practitioner.

Non-violence, truthfulness, non-stealing, control of sexual energy, forgiveness, fortitude, mercy and purity are the rules called as Yama.

'शौच संतोष तप स्वाध्याय ईश्वरप्रणिधानानि नियमा:' । (Yogsutra 2/32)

2) Niyama - Niyama means rules of self discipline.
Contentment, faith, charity, control of mind, chanting of mantras, devotion to god and observation of vows.

'स्थिरसुखमासनम्' । (Yoga.Su. 2/46)

3) Asana - Asana means different postures. Eighty four postures have been described in Ashtanga Yoga. Practice of asanas makes body and mind stable and flexible.
4) Pranayama - This is the 4th aspect of yoga. Pranayama means control over respiration, prana and mind.

'स्वविषयासम्प्रयोगे चित्तस्वरूपानुकारइवेन्द्रियाणां प्रत्याहार:' ।
(Yoga.Su. 2/54)

5) Pratyahara- Pratyahara means to take away. Pratyahara is a method for withdrawal of the mind from the sense organs.

'तत्र एकरुपता ध्यानम्' ।

6) Dhyana - Meditation and concentration of mind is the state of Dhyana.

'तत्र देशबंध चित्तस्य धारणा' । (Yoga.Sutra 3/1)

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7) Dharana - Dharana means focusing the mind for concentration.

तदेवार्थमात्रनिर्भासंस्वरूपशून्यमि व समाधि:' । (Yoga.Su. 3/3)

8) Samadhi - Samadhi is the last stage of Yoga which is very difficult to achieve. It is a prolonged stage of Dhyana and in this one gets true, eternal happiness. Mind become unaware of body and surrounding in stage of samadhi.

The person, who wants to achieve eternal happiness through Samadhi, should learn to follow these eight aspects of Yoga.

Concept of Yogic Nadis

Science of Yoga has described various minute and gross channels or nadis. According to Yoga, nadis are very fine structures and are spread all over the body. These nadis are compared to the rays of sun. As sun rays spreads from the Sun in all directions in the same way these nadis are spread in the body.

According to Yogashikhopanishada synonym of Sushumna is brahmanadi.

According to science of yoga, there are 720000 nadis in the body. Some Yoga text books have mentioned that there are 3,50,000 nadis in the body. These nadis are often compared to nerves.

According to Ayurveda the human body is composed of body, mind, senses and soul.

The three main nadis are spread around vertebral column and the other nadis are all over the body. The main three nadis are- 1) Ida, 2) Pingala and 3) Sushumna.

Sushumna

'कन्दमध्ये स्थिता नाड़ी सुषुम्ना सुप्रतिष्ठिता' ।

(Trishikhabrahminopanishad 68-70)

Sushumna is the central nadi which arise from the base of

sacrum (muladhara) and goes in upward direction up to the Brahmarandhra of head.

From Sushumna thread like fibers originates, these tracts (nadis) are like a power house.

'मूलाधारादाब्रह्मरंध्रपर्यंत सुषुम्ना सूर्याभा। तन्मध्ये तदित् कोटिसमा मृणाल-तंतुसूक्ष्मा कुण्डलिनी'। (Mandal Brahmanopnishad)

Kundalini dwells at the base of Sushumna. When Kundalini ascends to Sahasradhara chakra, one gets control over mind and reaches a stage of spiritual bliss. Sushumna is compared with paramashakti - super power - ascends and descends along the path of Sushumna.

Concept of Ida and Pingala Nadi

Ida and Pingala are present on either side of Sushumna. Ida controls left side of the body, while Pingala controls right side of the body.

Characteristic features of Ida and Pingala

'इडायां तु स्थित: चंद्र: पिगलायां च भास्कर:।
इडा वामे स्थिता भागे पिंगला दक्षिणा स्थिता'॥
(Shivaswarodaya, Yogachudamani. 12)

Ida nadi is dominated by moon. When Ida nadi is active it produces coolness in the body, the effect of Ida on the body is very calming. Ida controls left side of the body and it is whitish in color.

Pingala nadi has opposite action than that of Ida. It controls right side of the body and it is dominated by sun. Pingala nadi produces heat in the body and it is reddish in color.

Ida, Pingala and Sushumna are related to respiration.

'इडापिंगला सौषुम्ना: प्राणमार्गे च संस्थिता:।
सततं प्राणवहिन्य: सोमसूर्याग्निदेवता:'॥ (Yogchudamani 21/1/2)

According to science of Yoga during the process of respiration air enters through the nostrils but sometimes

breathing is done only by left nostril or sometimes only by right nostril. When left nostril is working Ida is active, and when breathing is prominent through right nostril Pingala is active.

Sushumna balances both Ida & Pingala. The regular Yoga practitioner, who has conquered all eight aspects of yoga, is such person in whom the movement of prana is under control of only Sushumna.

'तासु सुषुम्नायां प्राणगति प्राणभृतांमध्ये सतां योगिनां एव भवति' ।

(Upanishad, Brahmayogitika)

Clinical application of Ida & Pingala Nadis:

Types of pranayama

- Suryabhedana pranayama
- Chandrabhedana pranayama

Suryabhedana pranayama: In this type of pranayama, person has to breathe in & out with right nostril, while left nostril is closed.

Chandrabhedana pranayama: In this type of pranayama, person breaths in & breaths out with left nostril, while right nostril is closed.

Effects of Suryabhedana pranayama

1) Suryabhedana pranayama produces heat in the body because Pingala nadi gets active.
2) It can reduce symptoms of increased kapha dosh.
3) It stimulates action of Pitta.
4) Suryabhedana pranayama is useful in the disorders like - i) shwasa (asthma), ii) cough (kasa), iii) sinusitis, iv) common cold and v) arthritis.

Effects of Chandrabhedana pranayama

1) Chandrabhedana pranayama produces coolness in the body.

2) This type of pranayama is useful to cure Pitta diseases e.g. i) daha (burning), ii) amlapitta (hyperacidity) and iii) fever (jwara).

Sushumna is considered as spinal cord. Ida & Pingala are considered as sympathetic trunks of ganglions, present on either side of spinal cord.

Sympathetic nervous system accelerates heart rate, blood sugar level, and blood pressure. Sympathetic nervous system is active during stress.

Pranayama releases stress and minimizes sympathetic stimulation by reducing mental & physical stress & therefore heart rate, blood pressure, blood sugar level can be brought under control by regular practicing of pranayama.

Shatchakra

In human body, places at which Ida & Pingala nadis meets together, these places are called Shatchakras. These chakras are controlling centers in the body. There are total six chakra & highest chakra - Sahasradhara - is situated in the brain.

1) Muladhara chakra
2) Swadhisthana chakra
3) Manipura chakra
4) Anahata chakra
5) Vishuddha chakra
6) Ajna chakra

The 7th chakra which is situated in the brain, which is the most potent chakra called as Sahasradhara or Sahasrara chakra.

Shatchakras are connected to nadis and Prana. While practicing pranayama; it is advised to concentrate the mind at various chakras. According to some experts these chakras are nerve plexuses.

The following table gives information regarding position of chakras in the body, and its relationship to particular mahabhuta, its beeja mantra. These chakras are compared to

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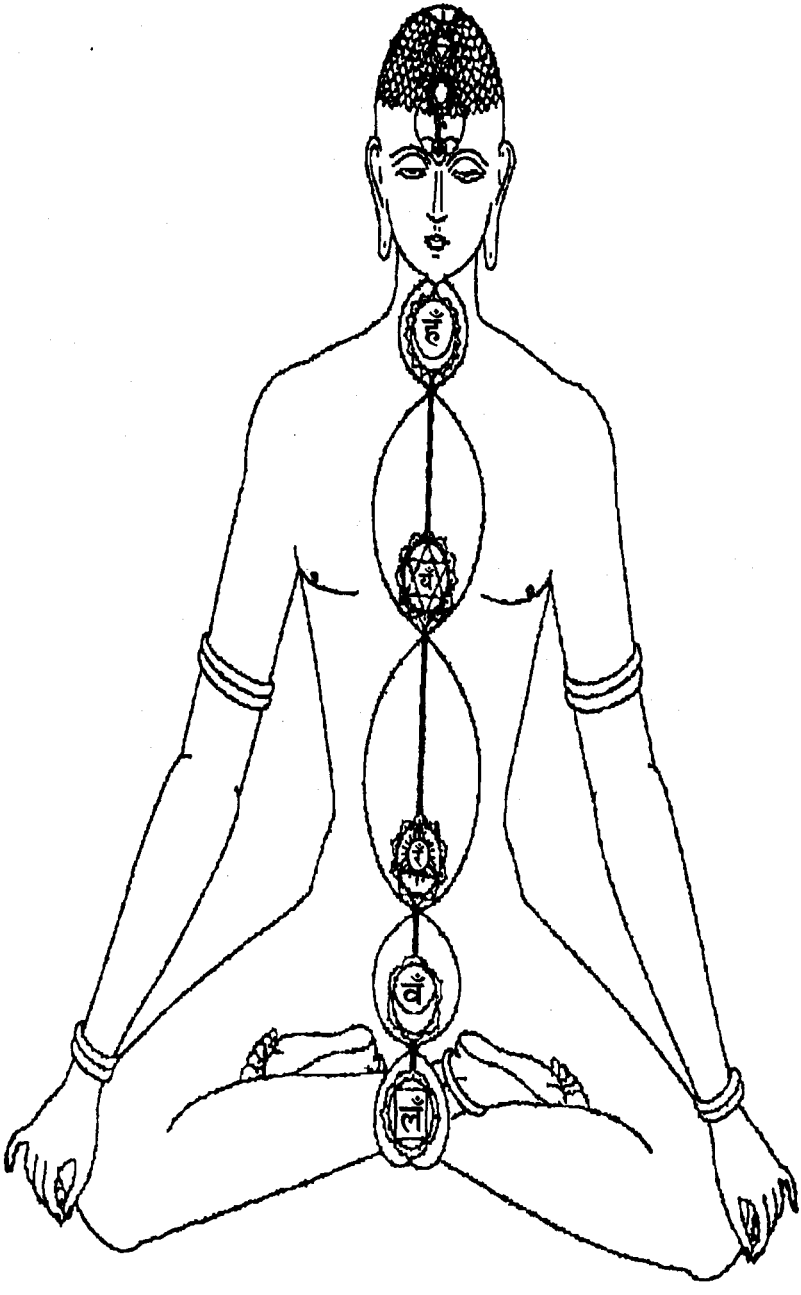

Fig 43 : Shat-chakra

lotus, and every chakra has particular number of petals which is also given in the table.

Chakra	*Position*	*Petals*	*Mantra*	*Mahabhuta*
Muladhara	Near rectum	4	Tram (त्रं)	Prithvi
Swadhishthana	Near penis	6	Vam (वं)	Jala
Manipur	Umbilicus	10	Ram (रं)	Teja
Anahata	Heart	12	Yam (यं)	Vayu
Vishuddha	Throat	16	Ham (हं)	Akasha
Ajna	Between eyebrows	2	Aum (ओं)	
Sahasradhara	Brain	1000		

Recent studies have tried to reveal relationship between shatchakras and anatomical organs. Study the following table to understand relationship between chakras and organs.

Shatchakra	*Organ*
Muladhara	Testes/ovary
Swadhishthana	Adrenals
Manipur	Pancreas
Anahata	Thymus gland
Vishuddha	Thyroid/ parathyroid gland
Ajna	Pituitary gland

Importance of relationship of organs and Shatchakras

Experts believes that while practicing pranayama, if mind is concentrated at particular chakra, then that may improve functioning of particular organs mentioned above.

This opinion requires more research of Shatchakras, nadis and pranayama. Yoga and Ayurveda are interdependent sciences, hence Ayurvedic students must try to learn and establish this relationship. For more detailed information you should read other books of Yoga e.g. Gherenda Samhita or Shiva Samhita etc.

Chapter 15

Mana-Atma-Nidra & Swapna

MANAS (MIND)

Mind is the topic of interest for all medical sciences. We can get elaborative description about the concept of mind in classic Ayurvedic literatures like Charaka Samhita, Sushruta Samhita. Understanding the concept of mind is important because, balanced state of mind contributes health.

'शरीरेन्द्रियसत्त्वात्मसंयोगो धारि जीवितम् ।
नित्यगश्चानुबन्धश्च पर्यायैरायुरुच्यते' ॥ (Cha.Su. 1/42)

Modern science has started to emphasize on the concept of mind and psychosomatic disorders in last century. However Ayurveda has realized importance of concept of mind in maintaining health of individual since thousands of years.

Mind, soul and body are the tripod on which life depends.

'सत्त्वमात्मा शरीरं च त्रयमेतत्त्रिदण्डवत्' । (Cha.Su. 1/46)

Five mahabhutas, mind, time and directions (dik) are the dravyasangraha.

'खादीन्यात्मा मनः कालो दिशश्च द्रव्यसंग्रहः' । (Cha.Su. 1/48)

Both body and mind are the sites pleasure and disorders.

'शरीरं सत्त्वसंज्ञं च व्याधीनामाश्रयो मतः ।
तथा सुखानां योगस्तु सुखानां कारणं समः' ॥ (Cha.Su. 1/55)

Importance of Mind

Mind is the seat of health (sukha) and disease (duhkha).

Synonyms of Mind

Mana, sattva, chetas, atindriya are the synonyms of mind.

'अतीन्द्रियं पुनर्मनः सत्त्वसंज्ञकं 'चेत' इत्याहुरेके' । (Cha.Su. 8/4)

Mind is called as atindriya because it transcends the sense objects.

Site of Mind

'आत्मा च सगुणश्चेतश्चिन्त्यं च हृदि संश्रितम्' । (Cha.Su. 30/5)

Heart and brain is the site of mind.

'वातपित्तश्लेष्मणां पुन: सर्वशरीरचराणां सर्वाणि स्रोतांस्ययनभूतानि तद्वदतीन्द्रियाणां पुन: सत्त्वादीनां केवलं चेतनावच्छरीरमयनभूतमधिष्ठानभूतं च' ।

(Cha.Vi. 5/6)

As Vata, Pitta, Kapha occupies whole body, mind also occupies the entire body.

'शिरस्त्वाल्वन्तरगते सर्वेंद्रिय परं मन:' । (Bhel samhita)

According to Bhela Samhita head is the seat of mind.

With the help of these references light can be thrown on the connection between body and mind.

Sukha and duhkha are the qualities of atma.

Mind is the mediator of soul and sense organs.

Mind is always conjugated with soul. But we think that its mind which experiences feeling of happiness or pain. Psychological disturbances like anger, rage can affect heart rate, and pulse rate. State of fear can lead to vasodilatation and sweating. These examples show interconnection between body and mind.

When mind is in the state of pleasure or when mind is in the state of health then this energetic state of mind reflects positively on the physiology of body. Stress, depression, anger, fear may lead to many disorders like insomnia, anorexia etc. and they affect the body by producing diseases like gastric ulcer, arthritis etc. Therefore these disorders are called as psychosomatic disorders.

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Characteristic of Mind

'लक्षणं मनसो ज्ञानस्याभावो भाव एव च।
सति ह्यात्मेन्द्रियार्थानां सन्निकर्षे न वर्तते' ॥ (Cha.Sha. 1/18-19)

When mind looses contact with sense organs then one can not perceive knowledge. When mind establishes the contact with sense organs, it can convey knowledge to soul. Mind is called as ubhayatmak as it is a mediator between sense organs and motor organs.

'उभयात्मकं मनः' ।

Mind is a stable nitya dravya and is always connected with soul when it is in balanced state.

Qualities of Mind

'अणुत्वमथ चैकत्वं द्वौ गुणौ मनसः स्मृतौ' । (Cha.Sha. 1/19)

Subtleness and oneness are the qualities of mind. Due to subtleness mind can move in the body very fast. Due to subtleness it conjugates with different sense organs to perceive knowledge rapidly.

Mind conjugates with sense organs so rapidly that visualization, hearing and perceiving the smell all these processes seems to occur at one time.

'वायुः पित्तं कफश्चोक्तः शारीरो दोषसङ्ग्रहः ।
मानसः पुनरुद्दिष्टो रजश्च तम एव च' ॥ (Cha.Su. 1/57)

'एव शब्देन सत्वाख्यगुणस्यादोषत्वमवधारयति, सत्वं ह्यविकारी' ।
(Chakrapani on Cha.Su. 1/57)

Rajas (action) and tamas (inertia) are the doshas of mind while sattva (intelligence) is the quality of mind.

Relationship between Sharira and Manas doshas:

'सत्त्वरजतमश्चेति त्रयो प्रोक्ता महागुणाः ।
वायु पित्तं कफश्चेति त्रयो दोषाः समासतः' ॥

'पवन रजोगुणमयः, पित्तं सत्वगुणोत्तरान् कफः तमोगुणाधिकः' ।
(Sharangdhar, Purvakhanda 5)

Sattva guna is predominantly related to Pitta dosha (although it has also relationship with vata and kapha), while rajo guna is related to vata dosha and tamo guna is related to kapha dosha.

Balance state of mind depends on sattva, rajas and tamas. Sattva guna stimulates mind towards the objects to acquire knowledge. Rajas motivates the mind towards objects. Tamas produces inertia in mind and gives necessary rest to the mind.

Due to excess of rajas quality, mind can become unstable and cannot concentrate on the objects. This lack of concentration of mind is called Amanaskatva.

'चिन्त्यं विचार्यमूह्यं च ध्येयं संकल्प्यमेव च ।
यत् किंचिन्मनसो ज्ञेयं तत्सर्वं ह्यर्थसंज्ञकम्' ॥ (Cha.Sha. 1/20)

Chintya, vicharya, uhya, dhyeya and sanklapa are the subjects of mind.

Subjects of Mind

Chintya - To think about the knowledge perceived
Vicharya - To establish logical sequence of the knowledge perceived by the sense organs.
Uhya - Analyzing capacity of mind
Dhyeya - Concentration on specific object
Sankalpa - Determination.

Proper thinking, analyzing the knowledge and concentration depends on the balanced state of sattva, rajas and tamas.

Functions of Mind

'इन्द्रियाभिग्रहः कर्म मनसः स्वस्य निग्रहः ।
ऊहो विचारश्च, ततः परं बुद्धिः प्रवर्तते' ॥ (Cha.Sha. 1/19)

Indriyabhigraha - Control over sense organs
Swanigraha - Self control
Uhya - Analysis
Vicharya - To think logically.

These are the functions of mind.

The sense organs can perceive their objects only when they are supported by mind. Chain of soul, mind and sense organs is essential for perception of knowledge and healthy mind has proper control over sense organs. When mind is balanced, sense organs don't get inclined towards improper harmful objects.

The right knowledge perceived is called as inputs.

Beneficial inputs are accepted by mind and motor organs (karmendriyas) are ordered accordingly. Intellect analyzes these inputs. Beneficial inputs are accepted by the mind and stored in the form of memory and are recalled at proper time.

Mind becomes very unstable due to rajas quality, but mind can control itself with the help of sattva guna. This self controlling capacity of mind is called as 'swanigraha'.

'असात्म्येन्द्रियार्थसंयोगः, प्रज्ञापराधः, परिणामश्चेति त्रयस्त्रिविधविकल्पा हेतवो विकाराणां.....' । (Cha.Su. 11/43)

Asatmyendriyartha-samyoga means excessive, improper and perverted indulgence of objects or non-indulgence of objects and conjunction of sense organs with improper objects. Improper time - parinama and prajnaparadha are the causes of disorders.

Mind is responsible for proper or improper indulgence of object.

Relationship of Mind with Vata dosha

There is a strong bonding between mind and Vata dosha. While stating function of vayu, Charaka says that vata dosha controls mind. It also stimulates mind towards objects.

'नियन्ता प्रणेता च मनसः' । (Cha.Su. 11/)

Relationship between Prana vayu and Mind

Specially Prana vayu and Udana vayu co-ordinate functions of mind.

Functions of Prana Vayu

'उर: कण्ठचरो बुद्धिहृदयेंद्रियचित्तधृक्' । (Ash.Hru.Su. 12/4)

Prana vayu controls functioning of five senses, and controls the functioning of mind. Prana vayu is also responsible for co-ordination between dhee, dhriti and smriti.

Prana vayu establishes the chain between sense organs, mind and soul.

Functions of Udana vayu

'वाक्प्रवृत्ति प्रयत्न उर्जा बलवर्ण स्मृति क्रिय:' ॥ (Ash.Hru.Su. 12/5)

Knowledge is stored in the form of memory and these inputs are recalled at proper time. This function of udan vayu is very much important for maintenance of health. Harmful inputs are rejected by the mind. But its harmfulness is stored in the form of memory, and are recalled at proper time.

Intellectual error is the basic cause of disorders, and memory is the important aspect of mind as it can avoid prajna-paradha. Therefore Prana and Udana vayu play important role in maintaining health.

Sadhak Pitta and Mind

'बुद्धिमेधाभिमानादयैरभिप्रेतार्थसाधनात् ।
साधकं हृदगतं पित्तम्' ॥ (Ash.Hru.Su. 12/13,14)

Heart is the site of Sadhak pitta. Heart is also the site of mind. Intellectual functions of mind are also supported by Sadhak pitta. Medha is the important aspect of intelligence.

'ग्रंथादिधारण शक्ती: मेधा' । (Chakrapani on Cha. Vi. 4/8)

Grasping capacity of an individual is called as medha and this depends on Sadhak pitta.

Psycho-somatic Relationship

Mind and body are interdependent. Sattva, rajo and tamo guans of mind are related to Pitta, Vata and Kapha dosha

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respectively. Tridoshas and trigunas can affect each other. Vriddhi or kshaya of tridoshas will affect trigunas and vice versa. Therefore health of body and mind must be maintained with proper food and exercise.

Ashtanga Yoga is helpful to maintain balanced state of mind and body. Yama and Niyama of Ashtanga yoga is useful for maintaining peace of mind. Asanas can keep body fit and flexible and state of health can be achieved with Ashtanga yoga.

ATMA (SOUL)

Etymology

'अत–सातत्यगमने' ।

Soul is immortal and eternal.

Synonyms - Atma, sarvaga, paramatma, ateendriya, bee-jadhatu, antaratma, vashi, bejadharma, indriyatma, anadi, purusha, vishwakarma, nityapurusha, ishwara, nirvikara are the synonyms of atma.

'खादीन्यात्मा मनः कालो दिशश्च द्रव्यसंग्रहः' । (Cha.Su. 1/48)

Atma is a Karana dravya. Atma is the supreme power of the human beings.

From the definition of life (ayu) we can realize importance of soul.

'शरीरेन्द्रियसत्त्वात्मसंयोगो धारि जीवितम् ।
नित्यगश्चानुबन्धश्च पर्यायैरायुरुच्यते' ॥ (Cha.Su. 1/42)

Ayu (life) is a combination of body, sense organs, mind and soul.

'तत्र शरीरं नाम चेतनाधिष्ठानभूतं पञ्चमहाभूतविकारसमुदायात्मकं समयोग-वाहि' । (Cha.Sha. 6/4)

Body is with soul and is the seat of all diseases as well as mahabhutas.

'सत्त्वमात्मा शरीरं च त्रयमेतत्त्रिदण्डवत्' । (Cha.Su. 1/46)

Mind, soul and body makes a tripod on which the living body stands.

'खादयश्चेतना षष्ठा धातव: पुरुष: स्मृत:' । (Cha.Sha. 1/16)

Purusha is made up of panchamahabhuta and soul.

The following facts can be inferred on the basis of various verses mentioned above. These facts are:

1) Human body is a combination of panchamahabhuta and soul.
2) Soul is the supreme active principle of the body.
3) Soul is the sign of life.

Substances in the universe are divided on the basis of existence of soul.

'सेन्द्रियं चेतनं द्रव्यं, निरिन्द्रियमचेतनम्' । (Cha.Su. 1/48)

Substances (dravya) with soul are called as 'sendriya' dravya.

Substances without soul are called as 'nirindriya' dravyas.

'पञ्चमहाभूतशरीरिसमवाय: पुरुष: इति; स एष कर्मपुरुष: चिकित्साधिकृत:' ।। (Su.Sha. 1/21)

Ayurveda is a clinical science and main object of Ayurveda is to maintain health and to cure disorders. Treatment of disorders can be successful only on living human body not on dead one. Physician is concerned with human body which is made up of panchamahabhuta and soul. Therefore physician must possess knowledge of soul.

Significance of Soul

'शरीरं हि गते तस्मिन् शून्यागारमचेतनम् ।
पञ्चभूतावशेषत्वात् पञ्चत्वं गतमुच्यते' ।। (Cha.Sha. 1/44)

Soul is the conscious principle (chaitanya) of body. When soul leaves the body, body is converted to a lifeless vacant house. Signs of life are not seen in the dead person.

Characteristics of soul

'निर्विकार: परस्त्वात्मा सत्त्वभूतगुणेन्द्रियै: ।
चैतन्ये कारणं नित्यो द्रष्टा पश्यति हि क्रिया:' ॥ (Cha.Su. 1/56)

Soul is devoid of all feelings. Soul perceives knowledge only when it conjugates with mind and qualities of mahabhuta. It is an immortal principle.

'निष्क्रियं च स्वतन्त्रं च वशिनं सर्वगं विभुम् ।
वदन्त्यात्मानमात्मज्ञा: क्षेत्रज्ञं साक्षिणं तथा' ॥ (Cha.Sha. 1/5)

Soul is inactive,
Soul is independent,
Soul is omnipotent,
Soul is omnipresent
Soul is the knower of the body and
Soul is the witness to all actions.

Atma Lakshanas

The signs of soul in the body are signs of life. These signs are absent in dead person. The signs of soul are as follows:

'प्राणापानौ निमेषाद्या जीवनं मनसो गति: ।
इन्द्रियान्तरसंचार: प्रेरणं धारणं च यत् ॥
देशान्तरगति: स्वप्ने पञ्चत्वग्रहणं तथा ।
दृष्टस्य दक्षिणेनाक्ष्णा सव्येनावगमस्तथा ॥
इच्छा द्वेष: सुखं दु:खं प्रयत्नश्चेतना धृति: ।
बुद्धि: स्मृतिरहङ्कारो लिङ्गानि परमात्मन:' ॥ (Cha.Sha. 1/70-72)

Respiration (pranapan),
Movements of eyelids (unmesh-nimesha),
Physiological activities of dosha, dhatu, mala (jeevana),
Rapid conjunction of mind with organs (indriyantara sanchara),
Motivation of sense organs towards objects. (prerana and dharana),
Experiencing of migration to another place or country in dreams (deshantara gati),

Perception of same object by two eyes.

Desire, aversion, happiness, misery, will, consciousness, control, intelligence, ego, memory are the signs of soul in the body. These signs are absent in dead person.

'शुक्रशोणितजीवसंयोगे तु खलु कुक्षिगते गर्भसंज्ञा भवति' ।(Cha.Sha. 4/5)

Garbha is a product of union of shukra (sperm) and artava (ovum) and soul. Due to existence of soul fetus has feelings of happiness, misery, aversion etc. Good or bad behavior of pregnant woman can affect garbha or fetus.

Therefore pregnant woman should follow code of conduct advised in Ayurveda.

Immediately after birth the very first sign of life is respiration and at the time of death ceasing of respiration is the sign of death. In old age desire, aversion gradually goes on decreasing. In this way sign of soul are applicable from the embryonic life to birth and from birth to death.

Shodasha kala purusha

'तस्य (पुरुषस्य) सुखदुःखे इच्छाद्वेषौ प्रयत्नः प्राणापानौ उन्मेषानिमेषौ बुद्धिः मनः संकल्पो विचारणा स्मृतिः विज्ञानम् अध्यवसायो विषयोपलब्धिश्च गुणाः' ।

(S. Sha. 1/17)

Sushruta has described sixteen attributes of soul which are called as shodasha kala, which are same as Atma lakshanas mentioned in Charak samhita.

Soul is inactive, immortal but due to desire it all the time, conjugates with mind to receive knowledge. Conjugation of soul and mind is the cause of pain or misery:

Principle of Yoga is to stabilize mind alongwith soul and to withdraw five sense organs from over indulgence of their objects. With the practice of Yoga and pranayama one can get control over mind and sense organs and cannot get affected by various attractions around him. Stabilized mind

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and soul can achieve state of moksha. To achieve liberation is a hard task, but one can maintains health by following Ashtanga Yoga. When person achieves liberation, he is not affected by happiness or misery. Liberation is the final step of Yoga but to live better life, one should stay away from attractions and have proper knowledge of soul, mind and sense organs.

NIDRA (SLEEP)

'त्रय उपस्तम्भा इति—आहारः, स्वप्नो, ब्रह्मचर्यमिति' । (Cha.Su. 11/35)

Food (ahara), sleep (nidra) and celibacy (bramhacharya) are three pillars of life. Sleep is as important as food, therefore we must know concept of sleep in Ayurveda.

Physiology of Sleep

'यदा तु मनसि क्लान्ते कर्मात्मानः क्लमान्वितः ।
विषयेभ्यो निवर्तन्ते तदा स्वपिति मानवः' ॥ (Cha.Su. 21/35)

1) Physical and mental fatigue is the main cause of sleep when mind and sense organs gets exhausted, then sense organs can not conjugate with their objects and this fatigue of mind and sense organs leads to sleep.

'हृदयं चेतनास्थानमुक्तं सुश्रुत! देहिनाम् ।
तमोऽभिभूते तस्मिंस्तु निद्रा विशति देहिनम् ॥
निद्राहेतुस्तमः सत्त्वं बोधने हेतुरुच्यते' ॥ (Su.Sha. 34/35)

2) Elevation of tamas quality and fatigue induces sleep. Heart and brain is the seat of mind. Sattva, rajas and tamas are qualities of mind. Tamas quality is responsible for sleep while rajas and sattva guna are responsible for awakening stage.

Benefits of Sleep

'निद्रायत्तं सुखं दुःखं पुष्टिः कार्श्यं बलाबलम् ।
वृषता क्लीबता ज्ञानमज्ञानं जीवितं न च' ॥ (Cha.Su. 21/36)

Happiness or misery, nourishment or malnourishment,

strength or weakness, potency or impotency, life or death and intellect depend on sleep. Therefore one should take proper sleep.

'निद्रानाशादंगमर्द शिरो गौरव जृंभिका: ।
जाडय ग्लानि कलमापत्ति: तंद्रा रोगाश्च वातजा:' ।।

Insomnia can lead to many disorders like body ache, heaviness in the head, yawning, weakness and drowsiness etc.

Sleep is a non suppressible urge. Urge of sleep should not be avoided and one should sleep at proper time.

Types of sleep

'तमोभवा श्लेष्मसमुद्भवा च मन:शरीरश्रमसम्भवा च ।
आगन्तुकी व्याध्यनुवर्तिनी च रात्री स्वभावप्रभवा च निद्रा ।।

(Cha.Su. 21/58)

Type of sleep	*Cause of sleep*
1) Tamobhava	Excess of Tamas quality
2) Shleshma-samudbhava	Excess of Kapha dosha
3) Sharira-manas-shrama-sambhava	Mental and physical fatigue
4) Agantuki	Adventitious
5) Vyadhi-anuvartini	Sequelae to diseases
6) Ratri-swabhava-prabhava	Occurring during night

Effect of sleep occurring in night

'रात्रिस्वभावप्रभवा मता या तां भूतधात्रीं प्रवदन्ति तज्ज्ञा:' ।

(Cha.Su. 21/59)

The normally occurring sleep in night is supporting, nourishing and hence it is called as Bhutadhatri.

'रात्रौ जागरणं रूक्षं.....' । (Cha.Su. 21/50)

Sleep is caused due to excess of kapha dosha and tamas. Sleeping only during night is healthier as it reduces tamas and heaviness of kapha dosha and produces dryness in the

body. Proper sleep at night creates lightness in the body and the person then becomes fresh and starts all the activities with good strength.

Day sleep (Diva-swap) is contraindicated but only in grishma ritu (summer season), day sleep is recommended.

Effect of Sleep during day time:

'.....स्निग्धं प्रस्वपनं दिवा' । (Cha.Su. 21/50)

Sleeping during day time removes dryness and creates oiliness in the body.

Excessive day sleep can produce various disorders in the body due to aggravation of Kapha e.g. obesity, rhinitis, cough, cold etc.

SLEEP

Sleep is that state of body in which cerebral activity slows down. There is reduction in sensory and motor activity hence reticular activating system (RAS) produces a state called as Sleep.

Requirement of Sleep

New born baby	-	16-20 hours
Children	-	12-14 hours
Adults	-	7-9 hours
Old age	-	5 hours.

Stages of Sleep

Non rapid eye movement (NREM) | Rapid eye movement (REM)

Non rapid eye movement sleep (NREM)

This type of sleep pattern consists of four stages.

In 1st stage - Respiration and pulse rate is regular and person can think during this stage.

2nd Stage- Stage of light sleep.

3rd stage - Stage of moderately deep sleep. Body temperature, B.P. decreases and there may be erection of penis.

4th Stage - Deep sleep occurs. It is very relaxed stage. Person may walk during this stage and there may be bed wetting by some children.

Rapid eye movement sleeps (REM)

1) Muscle tone is reduced
2) Reparation and pulse rate increases.
3) B.P. fluctuates.
4) Stage of dreaming

There is continues cycle of NREM and REM sleep stages throughout the night. In small children and infants REM sleep increases neuronal activity. This is useful for maturation of brain, as the individual grows REM sleep decreases.

Neurotransmitters and Sleep

Serotonin which is a neurotransmitter is required to induce sleep. Decreased level of serotonin produces insomnia i.e. lack of sleep or disturbed sleep.

DREAMS

'पूर्वदेहानुभूतांस्तु भूतात्मा स्वपतः प्रभुः ।
रजोयुक्तेन मनसा गृह्णात्यर्थान् शुभाशुभान्' ॥ (Su.Sha. 4/36)

During sleep sense organs can not perceive knowledge.

During sleep body is inactive but mind is still active. Mind in its state of activeness, with the help of rajas quality and memory, re-experiences the past events during the sleep. This re-experience of past events during sleep is called as dreams.

We can get information about dreams in Indriya-sthana of Charaka Samhita. Dreams are related to present, past and sometimes future events also.

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Nature of dreams depends on constitution

'वियति च गच्छति सम्भ्रमेण सुप्त:' । (Su.Sha. 4/65)

'.....सुप्ते शैलेद्रुमांस्ते गगनं च यान्ति' । (Ash.Hru.Sha. 3/88)

'सुप्त: सन् कनकपलाशकर्णिकारान् सम्पश्येदपि च हुताशविद्युदुल्का: ॥ (Su.Sha. 4/70)

'सुप्त: सन् सकमलहंसचक्रवाकान् सम्पश्येदपि च जलाशयान् मनोज्ञान् ॥ (Su.Sha. 4/73)

Constitution (Prakriti)	*Nature of dreams*
Vata	Dreams about flying in the sky climbing the tree, tracking.
Pitta	Dreams about gold, lightning, fire etc.
Kapha	Dreams about lotus, water, lakes, clouds etc.

Type of Dreams

'दृष्टं श्रुतानुभूतं च प्रार्थितं कल्पितं तथा ।
भाविकं दोषजं चैव स्वप्नं सप्तविधं विदु:' ॥ (Cha.Indriya. 5/43)

Types of dreams are as follows:

1) Drishta swapna - Dreams of visual experiences,
2) Shruta swapna - Dreams of auditory experiences,
3) Anubhuta swapna - Dreams of other experiences,
4) Prarthita swapna - Dreams of strong desire,
5) Kalpita swapna - Dreams of imagination,
6) Bhavika swapna - Dreams of future consequences,
7) Doshaja swapna - Dreams due to aggravation of doshas.

Chapter 16

Granthi Samsthana

(Endocrine Glands)

System that deals with ductless glands which secretes hormones directly in the blood is called as endocrine system.

Exocrine and endocrine are the two types of glands. Secretions of exocrine glands are conducted by ducts while secretions of endocrine glands are poured directly in the blood.

Hormones

Hormones are chemical substances.

Classification of Hormones

1) Amines, 2) Proteins and peptides and 3) Steroids.

1) Amine hormones are modified from the amino acid tyrosine.
2) Epinephrine and nor-epinephrine are secreted by amine hormones, which are in the medulla of suprarenal gland.
3) Proteins and Peptide hormones - These hormones consists of amino acids e.g. oxytocin, insulin are protein hormones protein peptide, and amine hormones are water soluble.
4) Steroid hormones - These hormones are derived from cholesterol e.g. aldosterone, cortisol, androgen etc. which are secreted by cortex of suprarenal gland.

Endocrine glands in the body

1) Pituitary gland (hypophysis)
2) Thyroid gland
3) Pancreas
4) Suprarenal gland (andrenalin gland)

5) Parathyroid gland
6) Ovaries
7) Testes
8) Thymus
9) Pineal body.

Role of hypothalamus in controlling hormonal secretions

1) Hypothalamus secretes chemicals which regulates hormonal secretions.

2) The chemicals secreted by hypothalamus are called as regulating hormones.

3) Regulatory hormones control the secretions of pituitary hormones.

4) Some hypothalamic secretions are called releasing hormones which stimulate the release of the hormone into the blood.

5) Hypothalamus also secretes inhibiting hormones which prevent the release of hormone.

Negative feed back mechanism : Hormonal secretions are controlled by negative feedback mechanism. For example low blood thyroxin level will stimulate hypothalamus to release thyroid stimulating hormone (TSH). This hormone stimulates anterior pituitary gland to secrete TSH. The increased TSH level in blood will stimulate thyroid gland to release more thyroxin in the blood.

Pituitary Gland (Hypophysis)

Pituitary gland is called as master gland and it is divided into:

Anterior lobe (Adeno hypophysis) and Posterior lobe (Neuro hypophysis).

Anterior lobe constitutes 75 percent of total weight of the gland. The posterior lobe is neurally connected to the hypothalamus.

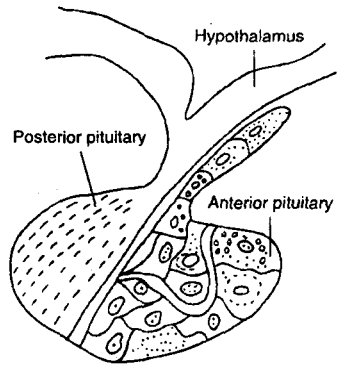

Fig. 44 : Pituitary gland

Hormones of Anterior Pituitary gland

1) Human Growth Hormone (HGH)
2) Thyroid Stimulating Hormone (TSH)
3) Adreno Corticotropic Hormone (ACTH)
4) Follicle Stimulating Hormone (FSH)
5) Luteinizing Hormone (LH)
6) Prolactin (PRL)
7) Melanocyte Stimulating Hormone (MSH)

Hormones of Posterior Pituitary gland

1) Antidiuretic hormone (ADH) or Vasopressin
2) Oxytocin (OT)

Functions of Human Growth Hormone (Somatotropin)

1) Growth hormone acts on skeleton.
2) Growth hormone acts on skeletal muscles.
3) Growth hormone enhances rate of bone growth by increasing number of osteogenic cells.
4) Growth hormone converts chondrocytes into osteogenic cells. These results in deposition of new bone (cells of cartilage are called as chondrocytes).
5) Due to action of growth hormone long bones grow in length.

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6) Epiphysial cartilage also grows in later period and fuses with shaft; hence in later life bones can't grow in length.
7) Growth hormone enhances protein synthesis.
8) Growth hormone enhances protein deposition in the tissue.
9) Growth hormone increases blood sugar level so it is called as diabetongenic hormone.
10) It increases cholesterol level in blood.
11) Growth hormone makes body to utilize fat instead of proteins hence body become lean. Factors that increases growth hormone level are as follows :

1) Protein deficiency
2) Hypoglycemia
3) Exercise
4) Excitement
5) Trauma
6) Deep sleep.

Role of hypothalamus in controlling growth hormone level

Hypothalamus secretes two hormones which control the secretion of growth hormone:

1) Growth hormone releasing hormone, stimulates secretion of growth hormone.
2) Growth hormone inhibiting hormone.

Disorders of Growth hormone

Dwarfism

Dwarfism is caused due to deficiency of growth hormone. In dwarfism body grows proportionally but rate of development is very slow.

Gigantism

Due to excess secretion growth hormone anterior pituitary

gland become excessively active and all body tissues including bones grow rapidly.

1) If this condition occurs before adolescence (approximately before the age of 12 to 14) then height of person increases abnormally, person becomes as tall as 6.5 feet.
2) The another symptom of gigantism is diabetes mellitus.

Acromegaly

If secretion of growth hormone increases (due to tumors), after adolescence, the condition is called as Acromegaly. In these patients bones of hand and feet become enlarged. Patients of acromegaly develop hunched back which is called as kyphosis. Soft tissue organs like tongue, liver and kidneys become enlarged.

Function of Thyroid stimulating hormone (TSH)

TSH controls the secretion of thyroid hormones of thyroid gland.

Control of secretion of TSH

Secretion of TSH is controlled by hypothalamus.

Hypothalamus secretes thyrotropin releasing hormone (TRH).

Function of Andrenocorticotropic hormone (ACTH)

Controls secretion of hormones of adrenal cortex, mainly cortisol secretion is controlled.

Control of secretion of ACTH

Hypothalamic hormone corticotropin releasing hormone (CRH) regulates secretion of ACTH.

Function of Follicle stimulating hormone (FSH)

1) In females FSH controls secretion of ovarian hormones and ovulation.

2) In males FSH controls spermatogenesis and control of

FSH by hypothalamic gonadotropin releasing hormone (GNRH)

Function of Luteinizing Hormone (LH)

1) In female along with FSH, stimulates ovulation and formation of corpus leteum.
2) In male LH stimulates secretion of testosterone.

LH is controlled by GnRH of Hypothalamus

Function of Prolactin (PRL)

Function

1) Promotes milk secretion in breasts.
2) In male it enhances secretion of testosterone.

Prolactin is related to secretion of milk, while oxytocin is concerned with ejaculation of milk from breast.

The suckling of nipples generates stimulus and these signals are transmitted to hypothalamus. Hypothalamus causes release of oxytocin by posterior lobe of pituitary gland oxytocin acts on myopthelial cells of breast to express milk out of breast and milk begins to flow this is called as milk letdown.

Control of Prolactin - Secretion of prolactin is controlled by hypothalamic prolactin inhibiting factor (PIF) and prolactin releasing factor (PRF). In males PIF is dominent.

Malanocyte stimulating hormone (MSH)

Function: It stimulates melanin production in the skin by melanocytes.

Control - Secretion of MSH is controlled by hypothalamus releasing and inhibiting factors (MRF & MIF).

Physiology of posterior pituitary gland

Neurohypophysis: Posterior pituitary gland is connected to the hypothalamus via nerves therefore also it is called as neurohypophysis.

Hormones of posterior pituitary

1) Vasopressin (Antidiuretic hormone ADH)
2) Oxytocin

Vasopressin and oxytocin are synthesized in hypothalamus and are transported to posterior pituitary. Prior to secretion these hormones are stored in hering bodies along the length of the axons of the posterior pituitary gland.

Functions of vasopressin (ADH)

1) Vasopressin is an antidiuretic hormone.
2) Action of vasopressin is seen on distal tubule and collecting tubules of kidney.
3) Vasopressin increases water re-absorption from the renal tubules and reduces urine flow.
4) ADH stimulates sodium reabsorption.
5) Vasopressin (ADH) is a vasoconstrictor.

Disorders of vasopressin (ADH)

Lack of vasopressin leads to a disorder called as diabetes insipidius.

1) In this disorder urine secreted is very dilute.
2) There is loss of water and dehydration due to loss of water.
3) Patient has to drink lots of water.

Functions of Oxytocin

1) Oxytocin stimulates contraction of pregnant uterus.
2) This hormone is partially responsible for causing baby's birth
3) Oxytocin is related to process of lactation.
4) Milk produced in the breast is expressed.

Thyroid Gland

Anatomical position of thyroid gland-

1) Located immediately below the larynx on each side of and anterior end of the trachea.

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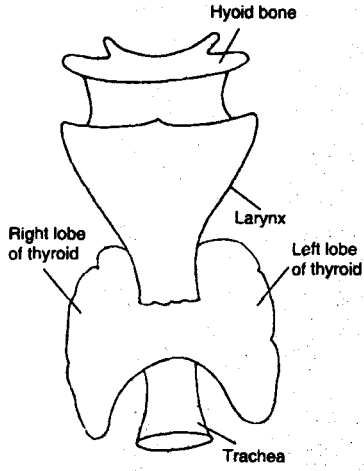


Fig. 45 : Thyroid gland

2) One of the largest endocrine gland.
3) Weight of the gland =15 to 20 grams in adult.

Hormones secreted by thyroid gland

1) Thyroxin (T4)
2) Tri-iodothyronine (T3)
3) Calcitonin

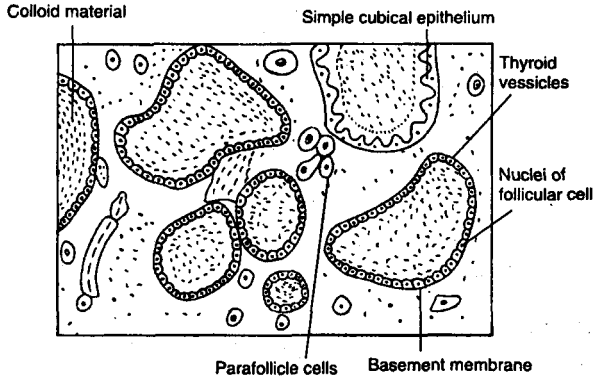


Fig. 46 : Thyroid gland (Transverse Section)

Follicles of thyroid gland are filled with a secretary substance called as colloid. This consists of thyroglobulin. Thyroglobulin contains hormones of thyroid gland.

Iodine is the Essential element required for formation of thyroxin. Every year 50 milligrams of iodine is required for the formation of thyroxin.

Special feature of thyroid gland

Thyroid gland is the only endocrine gland which can store large amount of thyroxin. Thyroid gland store thyroxin and supply the hormone to body for 2 to 3 months. Therefore deficiency of thyroxin hormone is observed after many months.

Physiological functions of Thyroid hormones
(Thyroxin, Tri-iodothyronine)

1) Thyroxin enhances growth and development of the brain during intrauterine life and in early childhood.
2) Thyroxin stimulates glycolysis (breakdown of glycogen to glucose).
3) Thyroxin enhances gluconeogenesis. (conversion of amino acids and fatty acids to glucose to yield energy).
4) Thyroxin specially has effect on fat breakdown.
5) Due to thyroxin due to rapid breakdown of fat, fatty acid levels in plasma increases.
6) Decreased thyroid hormone secretion increases blood cholesterol.
7) Body weight decreases.
8) Thyroxin increases action of digestive enzymes, enhances appetite.
9) Thyroxin hormone increases cardiac output blood pressure, pulse rate also increases.
10) Respiratory rate increases.
11) Gastro-intestinal motility increases.
12) Central nervous system become over active due to action of thyroxin. Therefore in hyperthyroidism patient gets anxiety; patient may become irritable due to stress and worry.

13) Excess thyroxin makes muscles weak due to excess protein breakdown.
14) In hyperthyroidism patient has difficulty to sleep due to tiredness. Deep sleep is a characteristic of hypothyroidism.
15) In women thyroxin deficiency causes menorrhagia and excess thyroxin causes oligomenorrhea.

Control of thyroxin secretion

1) TSH secreted by anterior pituitary control secretion of thyroid hormones by negative feed back mechanism
2) Hypothalamus secrets thyroxin releasing and inhibiting hormones which controls TSH levels and ultimately regulates thyroxin secretions.

Disorders of thyroid gland are:

1) Hyperthyroidism (Toxic Goiter, Thyrotoxicosis -Grave's disease)
2) Hypothyroidism - Myxoedema (in adults) and cretinism (in child).

Symptoms of Hyperthyroidism

1) Intolerance to heat.
2) Loss of weight
3) Diarrhea
4) Nervousness
5) Extreme fatigue
6) Insomnia (lack of sleep)
7) Tremors of hands
8) Oilgomenorrhea
9) High blood pressure
10) High basal metabolic rate.

Symptoms of Hypothyroidism

1) Weight gain
2) Deep sleep (patient can sleep for 12-14 hours)
3) Dullness, sluggishness
4) Increased blood cholesterol level.
5) Edema all over face and body.
6) Mentally retardation in children (cretinism).
7) Delayed mile stones in children in cretinism.

Goiter: Enlargement of thyroid gland is called as Goiter.

1) Lack of iodine leads to lack of synthesis of thyroxin.
2) Therefore by negative feed back mechanism level of thyroid stimulating hormone (TSH) increases.

Increased TSH stimulates thyroid gland to secrete large amount of thyroglobulin and gland grows larger and larger. This condition is called as Goiter. But due iodine deficiency there is no synthesis of thyroxin and tri-iodothyronine.

Functions of Calcitonin

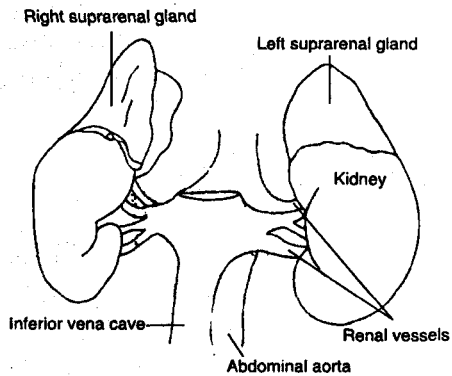
Calcitonin is a hormone secreted by thyroid gland.

1) Calcitonin enhances calcium absorption by bones.
2) Calcitonin regulates blood calcium level.
3) Calcitonin lowers blood calcium level and calcium is made available to the bones.

Control of calcitonin secretion

1) High blood calcium level stimulates calcitonin secretion.
2) Low calcium level inhibits calcitonin secretion (Normal blood calcium level is 9 - 10mg/ 100ml of blood).

Suprarenal gland (Adrenal gland)



Anatomical position of suprarenal glands (Adrenalin glands)

Fig. 47 : Suprarenal glands at the superior poles of the kidneys

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Anatomical Position: It is situated at the upper pole of two kidneys.

Parts of suprarenal gland are: Adrenal cortex and Adrenal Medulla.

Hormones secreted by suprarenal gland

Hormones of Cortex	*Hormones of Medulla*
1) Mineralocorticoids	1) Epinephrine (adrenalin)
2) Gluco-corticoids	2) Nor-epinephrine
3) Androgenic hormones	(Nor adrenalin)

Mineralocorticoids affects electrolytes (minerals) especially sodium and potassium level.

Gulcocorticoids have influence on blood glucose level.

Androgenic hormones act like male sex hormone.

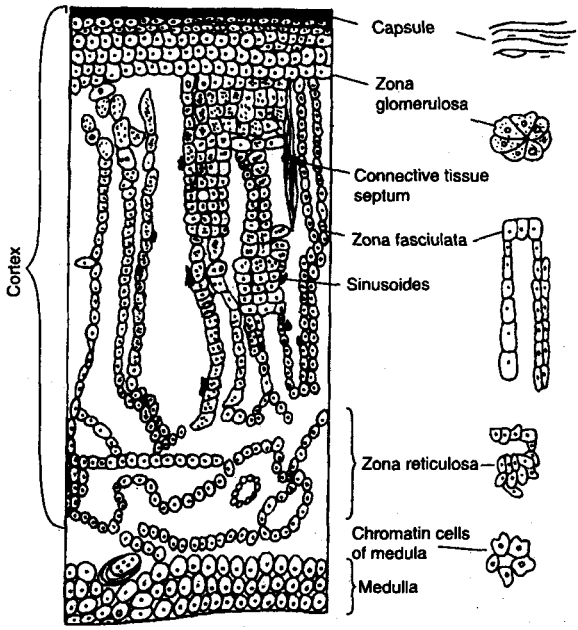

Fig. 48 : Histology of supra-renal gland (T.S.)

The zona glomerulosa secretes mineralocorticoids.

The zona fasciculata secretes glucocorticoids.

The zona reticulasis secretes sex androgens.

Mineralocorticoids

The most important hormone in this group is aldosterone.

Gulcocorticoids

1) The most potent hormone in this group is cortisol.
2) Corticosteroid is less potent than cortisol.

Functions of Mineralo-corticoids

1) Aldosterone acts on renal tubules.
2) Aldosterone increases renal tubular re-absorption of sodium in the body.
3) Aldosterone increases secretion of potassium.
4) Increase in aldosterone level causes hypokalemia and muscle weakness. High aldosterone increases potassium excretion in urine, hence potassium level in the blood reduces.
5) Deficiency of aldosterone leads to increased potassium ions in plasma causes cardiac toxicity, arrhythmias and heart failure.
6) Aldosterone enhances sodium absorption by the intestines.

Function of the Gulcocorticoids

Both Mineralo corticoids and Gulcocorticoids are life saving hormones.

1) Gulcocorticoids stimulates gluconeogenesis (Formation of glucose from proteins and fats).

2) Cortisol increases blood glucose level, it may lead to Adrenal diabetes.
3) Excess aldosterone can cause muscle weakness, because cortisol enhances protein breakdown, and reduces protein synthesis.

4) Excess cortisol causes fat deposition in chest and head regions of the body giving buffalo like appearance and rounded moon face.

5) Cortisol resists stress and inflammation.

Trauma Infection Intense heat or cold Surgery Chronic disease	Types of stress

All the conditions mentioned above leads to excess secretion of aldosteron.

6) Aldosterone is a strong anti-inflammatory agent, used in rheumatoid arthritis.
7) Aldosterone blocks inflammation in its early stage.
8) Cortisol suppresses the immune system cortisol reduces lymphocyte reproduction.
9) Cortisol resists allergic reactions.

Functions of adrenal androgens

Adrenal androgens are sex hormones. These hormones are continuously secreted by adrenal cortex.

Sex androgens acts like testosterone. Estrogen and progesterone are also secreted in minute quantity. Growth of axillary and pubic hair in female results from sex androgens especially in females.

In male, the quantity of this hormone is so less that the effects are very insignificant.

Functions of adrenal medulla

The cells of medulla which secretes hormones are called as chromaffin cells. These are innervated by sympathetic nerve fibers.

The secretion of medullary hormones is controlled by autonomic nervous system.

Hormones of adrenal medulla

1) Epinephrine
2) Nor-epinephrine (NE)

These hormones are called catecholamine.
These hormones are also life saving hormones.
These hormones are secreted when body is under stress. They increase heart rate.

Functions of adrenal hormones: They control blood pressure and respiratory rate. Rate of digestion gets lowered due to these hormones. These hormones elevate blood sugar level. Hypoglycemia stimulates secretion of these hormones.

Control of Mineralocorticoid secretion
(Aldosterone secretion)

1) Increased potassium level in plasma increases aldosterone secretion.
2) Increased sodium level in plasma decreases aldosterone secretion, so that less sodium will be reabsorbed.
3) In dehydration aldosterone level increases.

Control of Gluco-corticoid (Cortisol) secretion

ACTH (adreno-cortico tropic hormone) of anterior pituitary gland controls the secretion of cortisol, by negative feed back mechanism.

Control of Epinephrine and nor epinephrine

Sympathetic preganglionic neurons around chromaffin cells control the secretion of these hormones.

1. Hyperadrenalism (Cushing's syndrome) and
2. Hypoadrenalism (Addison's disease) is the disorder of suprarenal gland.

Symptoms of Addison's Disease

1) Loss of appetite
2) Weight loss

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3) Nausea and vomiting
4) Low blood pressure due to decreased sodium level in plasma.
5) Decreased cardiac output.

Symptoms of Cushing's syndrome:

1) Due to high gulcocorticoids, fat metabolism is disturbed.
2) Moon face, buffalo hump and pendulous abdomen due to excess fat deposition.
3) Poor wound healing.
4) Osteoporosis, weakness.
5) Hypotension
6) Diabetes.

Pheochromocytoma

These are the tumors of the chromaffin cells of adrenal medulla.

In these tumors there is hyper secretion of the epinephrine and nor epinephrine.

Symptoms

1) High blood pressure
2) High blood sugar level
3) Headache
4) Sweating
7) Nervousness
8) Vertigo
9) Poor digestion

Disorders of sex androgens

1) Excess secretion of sex androgens produces masculine effects in females.
2) Excess secretion of sex androgens in males, produces feminine characters.

Hormonal Functions of Testes

Testis is male reproductive organs which are located in scrotum. Testis also secretes hormones.

Hormones secreted by testes

1) Testosterone
2) Inhibin

Functions of Testosterone

Interstitial cells of Leydia secretes the hormone.

Testosterone -Testosterone is responsible for development of masculine characteristics in male body.

1) During fetal life also testes secretes small quantity of testosterone.
2) After birth for 10 weeks testosterone is secreted by testis.
3) But thereafter testis doesn't secrete testosterone during childhood up to the age of 10 to 13 years.
4) After the age of 10 to 13 years under the influence of F.S.H and LH of anterior pituitary, testis secretes testosterone.
5) In fetal life, male fetal testes secrets testosterone at 7th week of fetal life.
6) Fetal testosterone promotes development of penis, scrotum, prostate gland and seminal vesicles.
7) Fetal testosterone is responsible for the descent of testis during last 2 to 3 months of gestation.
8) After the age of 10 to 13 testosterone level increases.
9) Increased level of testosterone causes enlargement in the size of penis, scrotum and testes.
10) Testosterone is responsible for the development of secondary sex characteristics in males.
11) Testosterone stimulates spermatogenesis.
12) Testosterone causes growth of pubic and axillary hair.
13) It causes growth of hair on face, chest.

14) Testosterone inhibits growth of scalp hair
15) Due to testosterone larynx thickens, and voice changes and gets masculine voice.
16) Skin becomes thick due to effect of testosterone.
17) Testosterone promotes muscle development.
18) Bones become thicker and strong due to calcium deposition.
19) Testosterone acts especially on pelvic bones.
20) Testosterone stimulates erythropoisis.

Control of Testosterone secretion

Secretion of testosterone is controlled by following hormones:

1) Gonadotropin releasing hormone (GnRH) by the hypothalamus.
2) Follicle stimulating hormone (FSH) and Luteinizing hormone (LH) of anterior pituitary gland.

Function of Inhibin - It inhibits secretion of FSH to control spermatogenesis.

Hormonal Functions of ovaries

Ovaries are the organs of the female reproductive system.

Functions of ovaries are as follows:

1) Production and maturation of female gamete.
2) Secretion of hormones.

Hormones secreted by ovaries:

1) Estrogen	2) Progesterone
3) Relaxin	3) Inhibin

Functions of estrogen

1) Estrogen develops female reproductive structures especially endometrial lining of uterus.
2) Development of fallopian tube.
3) Under the influence of estrogen cuboidal epithelium of

vagina changes to stratified epithelium, which protects vagina from infections.
4) Estrogen plays important role in breast development.
5) Due to estrogen epiphysis of long bones unite with shaft and so length of bones cannot increases. This is the opposite action of estrogen than that of testosterone. Therefore height of females is less than males.
6) Estrogen promotes calcium deposition in bones.
7) After menopause, ovaries stops secreting estrogen, therefore after menopause, females suffer from osteoporosis.
8) Due to effect of estrogen skin of female become very soft and smooth.
9) Estrogen is essential for the growth of primordial follicles in ovaries.
10) Estrogen is essential for ovulation.

Function of Progesterone

1) After ovulation corpus leuteum secretes progesterone.
2) Progesterone promotes secretary changes in uterine endometrium after ovulation.
3) Progesterone reduces frequency and intensity of uterine contraction.
4) Progesterone stimulates secretion of mucosa of fallopian tubes. These secretions nourishes fertilized ovum.
5) Progesterone stimulates fat deposition in the breast. It also stimulates development of lobules and alveoli of breast.

Functions of Relaxin

Relaxin relaxes symphisis bubis and helps to dilate uterine cervix at the end of pregnancy.

Functions of Inhibin

Towards the end of menstrual cycle, inhibin prevents secretion of follicle stimulating hormone of anterior pituitary gland.

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Control of secretion of ovarian hormones

1) An increased level of estrogen and progesterone depresses secretion of F.S.H. and L.H. and vice versa.

2) Secretion of ovarian hormones is controlled by hypothalamus and naterior pituitary gland.

Pancreas

Pancreas is both endocrine and exocrine gland.

Exocrine portion of pancreas produces pancreatic juice. Endocrine portion of pancreas is called as Islets of Langerhans.

Islets of Langerhans consist of 3 types of cells:

1) Alpha cells - Secrete hormone glucagon
2) Beta cells - Secrete hormone Insulin
3) Delta cells - Secrete hormone somatostanin.

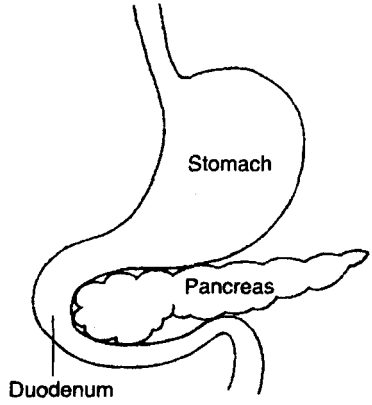

Fig. 49 (a) : Anatomical position of pancreas

Functions of Glucagon

1) Glucagon increases blood sugar level.
2) It accelerates gluconeogenesis.
3) Low blood sugar level stimulates secretion of glucagon.

Normal Blood sugar level (BSL)

Fasting blood sugar level is 60-110mg/ 100ml of blood. Postprandial (PP) sugar level is 110-180 mg/ 100ml of blood.

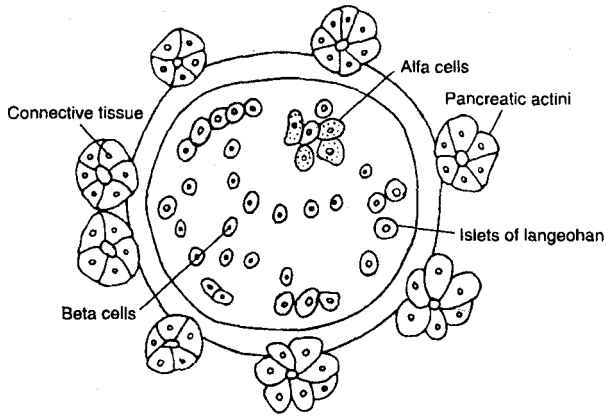

Fig. 49 (b) : Histology of pancreas showing islets of Langerhan

Function of Insulin

1) Insulin decreases blood sugar level.
2) Insulin enhances transport of glucose across the cell membrane.
3) Insulin maintain the normal blood sugar level in between the meals.
4) Insulin enhances fat deposition in adipose tissue.
5) Glucose can enter the cell only in presence of insulin then only cell can perform its physiological activities. High blood sugar level stimulates insulin secretion.

Disorder of Insulin

Hypo-secretion of insulin results in high blood sugar level, polyurea glycosuria, and excess eating (polyphagia). The disease in which insulin secretion decreases is called as diabetes mellitus. Somatostanin inhibits secretions of insulin and glucagon.

Parathyroid Gland

Anatomical position

Parathyroid gland is situated on the posterior surface of the lateral lobes of thyroid gland.

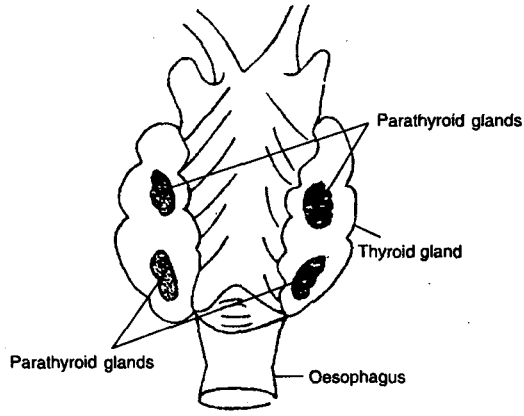

Fig. 50 : Parathyroid glands on the posterior aspect of thyroid glands : anatomical position

Parathyroid gland consists of two types of cell:

1) Chief cell (principal cell) -These cell secretes parathyroid hormone (PTH)
2) Oxyphil cell - Function of these cells is still obscure.

Functions of parathyroid hormones (PTH)

1) Parathyroid hormones elevate blood calcium level.
2) It leads to the activation of vitamin D.
3) PTH withdraws calcium from bones and blood calcium level is increased.
4) Due to this, PTH enhances osteoclastic activity which leads to bones destruction or osteoporosis.
5) PTH stimulates calcium re-absorption from kidneys and calcium is returned to blood.
6) PTH also removes phosphates from bones and phosphates are lost in urine.

Function of PTH and calcitonin are exactly opposite to each other.

Disorders of Parathyroid gland

Hyperparathyroidism | Hypoparathyroidism

Hyperparathyroidism:

Due to hyper activation of parathyroid gland it secretes large amount of PTH.

Due to elevated level of PTH, more calcium is absorbed from bones.

1) Hyperparathyroidism weakens the bony tissue.
2) Hyperparathyroidism withdraws more calcium from bones which lead to osteoporosis and osteitis fibrosa cystica (cavities in bones due to calcium loss).
3) Due to loss of calcium, bones may undergo spontaneous fractures.
4) High blood calcium level can cause kidney stones.

Hypoparathyroidism

Deficiency of PTH decreases blood calcium level. Low blood calcium level affects nervous system that leads to irritation, restlessness and muscle spasm or tetany.

Control of PTH secretion

1) High blood calcium level inhibits PTH secretion.
2) Low blood calcium level stimulated PTH secretion.

Thymus gland

Thymus gland is concerned with maturation of T lymphocytes.

Thymus plays important role in immunity. The hormones produced by thymus gland are:
1) Thymocin
2) Thymic humoral factor (THF)

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3) Thymopoietin

All the thymic hormones promote maturation of T lymphocytes.

Pineal gland

Pineal gland is attached to the roof of third ventricle of the brain. Hormones secreted by pineal gland are as follows:

1) Melatonin

This hormone may inhibit reproductive activities by resisting gonadotropic hormones. This hormone is produced during darkness.

2) Adrenoglomerulotropin hormone

It may stimulate secretion of hormone aldosterone.

Kidneys

The juxtaglomerular cell of the kidneys manufactures the hormone called as Erythropoietin. This hormone stimulates erythropoiesis.

Adipose tissue

Adipose tissue also secretes hormone. The hormone secreted by adipose tissue is called Leptin.

Leptin controls appetite

When person eats food, adipose tissue absorbs glucose and lipids and synthesizes triglycerides. At the same time, leptin is released in the blood by adipose tissue.

Leptin interacts with neurons in CNS these neurons are concerned with emotions and due to interaction with leptin they control appetite by producing sense of satiation and reduces appetite.