

## 6. The Evolution of the Musical Scales:

As already explained the consonant intervals make the passage from one note to other perfectly smooth and musical. The consonance has, therefore, played a great part in all the systems of music. However, it is also true that to widen the range of choice and to put greater vigour and strength in the expression of the ideas, musicians do use, in addition, dissonant notes also but then such notes are not allowed to last too long and at last are resolved into consonance.

A musical scale is a collection of such artistic steps, leading from the fundamental to its octave. As the physical consonance and dissonances was not at first truly known, it took a long time before the scale began to be constructed on really rational lines.

In the music of all the nations, the two unfailing characteristics are found, the rhythmic movement and the procedure by procedure development of notes by determinate degrees. To determine these degrees accurately is to construct a musical scale. As the octave was a mere repetition of the prime, the fifth alone was known to be a distinctly different yet a perfectly consonant interval. So the early artist used to get the additional notes by taking the direct or inverse fifth of the notes already known to them. On the European side, it was the famous Greek scientist Pythagoras who had first constructed the whole diatonic scale from the following series of fifths.

$$F \pm C \pm G \pm D \pm A \pm E \pm B$$

, arranged as the successive degrees of a scale.

(F,C,G,D,A,E & B are the name of the swaras Ma, Sa, Pa, Re, Dha, Ga & Ni respectively of Indian system as used in Western system of music)

The series may be written as below, with ratios as towards the key note or the fundamental.

C	D	E	F	G	A	B	C
1	9/8	81/64	4/3	3/2	27/16	243/128	2

The scale with intervals between the successive degrees might be written as

C	D	E	F	G	A	B	C
9/8	9/8	256/243	9/8	9/8	9/8	256/243	

Here though the law of formation is very simple the individual notes have nevertheless, an origin very distant from the fundamental note. The interval  $256/243$  repeating twice in the scale is not at all simple. **Hence Pythagoreans scale of fifths is essentially non harmonic in character.** Further in order to increase the musical resources, the ancient Greeks, like Hindus, used to derive by transposing six new scales by making each of the remaining six degrees of the scale of fifths, a fresh point of start for each successive scale (the Moorchanas).

The Pythagoras scale could not satisfy the requirements of harmony and also fell short of the requirements of melody even of those days. Also because of unequal and complex intervals the transposition was not possible without introducing large errors. So it was thought advisable to distribute the interval between the prime note and its octave equally among twelve notes. This is tempered scale so named because it tempers and slightly alters the character of the notes of the ideal scale. The successive notes of the tempered scale form a perfect geometrical progression and are separated from their neighbours by the same common interval, the mean-semitone. **The tempered scale has a simple law of formation and offers a special facility to fixed tones instruments of change of base at will, without changing the intermediate intervals. But with the exception of fundamental and its octave no other note of the tempered scale is truly consonant and melodies given by these notes are never perfect, much less perfect are the harmonies as the music played to equal temperament is bound to be always a little out of tune, it soon becomes insipid i.e. tasteless.**

**Theory of Structure of the Scales:** The object of all music being the production of pleasurable feeling in the mind of the listener, any rational explanation of the structure of the Scales on which the music is based must start with the hypothesis that the relationship subsisting amongst the notes constituting a Scale are capable of producing such feelings. The science of acoustics and experimental psychology has proved that only the relationships of consonance possess this property. There are indeed some dissonance relationships which play an important part in musical art. But as these relationships have no independent value of their own and must be related through consonant relationships in order to be acceptable, we must confine our attention to the consonant relationships only in our attempt to explain the structure of scales. We have seen that the consonant relationships are only six in number. In

order for a scale to be fit for being used in music, its notes must, therefore, be connected with each other by some one or more relationships.

The most spontaneous and easily appreciated consonant relationship is the descending fourth, which is a natural leap that the human voice takes in an affirmative sentence. A descending tetra chord may, therefore be considered as the earliest stage in the evolution of scales. The tetra chord of the Vedic Saman chants and that from which the Greek Doric Scale was formed, were both descending tetra chords. The consonant interval which comes next to the descending fourth as regard spontaneity is the ascending Fifth, which the human voice takes naturally in an interrogative sentence. So the ascending penta chord may be regarded as the second stage in development of scales. **The ascending tetra chord and the descending penta chord must have come as later developments.** *(This is the principle which has been used in finding the existence of inverse raagas discussed in the present work)*

**Basic Music Intervals:** All the scalic systems of the world were founded primarily on the above scientific basis consciously or unconsciously. Contrary to the opinion of the musicologists, the universal basic scale of unicentric tonality is common to all the musical systems of the world. Hence let us first determine the limit of basic musical intervals consisting of the consonance and the dissonances.

#### **History of Musical Scales in different civilizations:**

Thousands of years before Marine Messene (1636 A.D) discovered the natural law of harmonic series and law of vibrations, the Egyptian, the Sumerian, the Chinese, the Indian, the Greek, the Arabic and the Persian systems of music were arrived at solely by means of string lengths and the ear method.

All these systems were derived either from the cyclic, the equi-partitive, the auricular (pertaining to ear) or the divisive principles. They can now be tested for accuracy against the modern harmonic laws of acoustics. All these systems had obtained the same results, namely the universal basic scale.

The Indian Shruti system of Bharata was so far supposed to be a vaguely descriptive and indeterminate ear method without any ratios or measurements. Having evolved an algebraic formula, the Indian system may be called as based on Algebraic method.

#### **Pancham or Quintal Age:**

Chronologically speaking, the use of quintal interval Swayambhu Pancham came first, for in the recorded history; this innate consonance of the Fifth was first

used by man to construct his scale degrees. This is called Buddhist Period, the Pancham or the quintal age.

In China the legendary Ling Lun (C-2700 BC) is reported to have cut twelve Bamboo pipes in to a chain of ascending Fifths by cutting each successive pipe  $\frac{2}{3}$  in length of the previous one. The series of the first five positive fifths, he thus obtained consists of Sa, Pa, Re, Dha, Ga. This cycle of five fifths, arranged in scalar order, resulted in consistent Chinese tradition consisting of the practical Major-pentatonic scale corresponding to Indian Bhoop; Sa, Re, Ga, Pa Dha.

**According to an ancient Greek tradition, the earlier Egyptian bow shaped harp, seen in reliefs and painting of 3<sup>rd</sup> millennium BC- the same as the Sumerian harp or that of Indus Valley civilization, was tuned in falling Fourths to a descending Minor pentatonic Sa, DhaK, Pa, GaK, Ri. (DhaK-komal Dha, GaK-Komal Ga)**

**The Generating Centre:** The musical interval of Fifth in relation to a given fixed note can be either a positive Fifth or negative Fifth. These contrasting Fifths are governed by the prime number 3 in the numerator and the denominator respectively.

Thus if 'Sa', be the generating centre, representing unity, the active and passive fifth on the two sides of the centre will be (Pa) & (Ma) respectively.

Fig 1: The centre and the opposite Fifths:

Ma	Sa	Pa
$\frac{2}{3}$	1	$\frac{3}{2}$

**Ascending Tartivra Fifths:** The next step taken by man, to extend the above skeletal frame to a 7 note quintant series, was to continue the positive series of tartivra fifths thus intensifying progressively the higher powers of 3 in the numerator namely 3, 9, 27, 81 and 243.

This extended quintant series of five positive Fifths above the centre of unity 'Sa' with just one negative fifth 'Ma' is shown below in the form of continuous ascending series of 7 degrees. The notes are indicated by the initial consonants.

Fig 2:

Ma	Sa	Pa	Re	Dha	Ga	Ni
3	1	3	9	27	81	243

Later in the Past Buddhist period which is referred as Tartian Age the above last three quintal notes the tartivra Dha, Ga, Ni were substituted by the more

consonant tertian Tivra notes. **The improvement was made possible through the use of the Swayambhu Gandhar the discovery of which was first made in India in 5<sup>th</sup> century B.C.**

### **The Upright Quintal Scale:**

The rearrangement of the above quintal series of Fifths provided the Indian type of upright diatonic scale, a rough precursor model of the future perfect scale to come. The universal Basic Saptak (Ma Grama of Bharata) the rearranged quintal notes, represented by initial consonants, are given below with their respective ratios. This is called the upright quintal scale.

Fig 3: The Upright Quintal Scale Ascending

S	Re	Ga	Ma	Pa	Dha	Ni
1	9/8	81/64	4/3	3/2	27/16	243/128

### **Descending Atikomal Fifths:**

While the upright Quintal Scale was being evolved in the Quintal Age, the Greeks were constructing a descending Quintal scale by extending downwards the negative series of Atikomal fifths, thus intensifying progressively the higher powers of 3 in the denominator, namely 3, 9, 27, 81, 243.

This extended Quintal series of five negative fifths below the Central unity Sa, with just one positive fifth Pa, is shown below in the form of continuous descending series of 7 degrees.

Fig 4: Descending degrees of Fifths.

Rek	Dhak	Gak	Nik	Ma	Sa	Pa
243	81	27	9	3	1	3

Note: Later in the past Buddhist period, i.e. in the Tartian Age, the above mentioned last three quintal notes, the Atikomal Gak, Dhak & Rek were substituted by more consonant tertian komal notes. This improvement was made possible by the discovery of Swayambhu Gandhar in India in 5<sup>th</sup> century BC.

### **The upturned Pythagorean Scale:**

The rearrangement of the above quintal series of fifths provided the Greek type of upturned diatonic scale, a rough precursor model of the future upturned scale, which the Greeks somehow failed to perfect. The rearranged quintal notes, represented by initial consonants are given below with their respective ratios, the **sequence of**

**intervals being the exact reversal of the upright quintal scale.** This can be called upturned quintal scale.

Fig.5: The upturned quintal scale

S	NiK	Dhak	Pa	Ma	Gak	Rek
1	8/9	64/81	3/4	2/3	16/27	128/243

**The Swayambhu(Lo; H) Gandhar Age;**

The epochal (highly significant) discovery of Swayambhu Gandhar in India in 5<sup>th</sup> century BC, introduced a new tertian Tivra Gandhar as a subsidiary positive centre which immediately rendered consonant with the last three dissonant tartivra notes Dha, Ga Ni in the series given in Figure (2).

The last three, harsh-quintal notes were substituted by concordant tertian notes governed by multiple of 5 in the numerator, each tertian tivra note being a Didymian comma (çek k Jfr) lower than the corresponding Quintal tartivra note. In the illustration given below the new Tertian Tivra Notes are marked with a comma in the bottom of the letter, to distinguish them from the old high quintal tartivra notes.

The following illustration show the old series in juxta position with the new series, where in the new low Tertian constituents are substituted for the three old high Quintals.

(Fig.6) The old and the new ascending series.

Old Series

Ma	Sa	Pa	Re	Dha	Ga	Ni
3	1	3	9	27	81	243

New Series

Ma	Sa	Pa	Re	Dha1	Ga1	Ni
3	1	3	9	5	5	15
3 Tivra Notes						

**The Negative Gandhar or Komal Dhaivata(dley /6r):**

Similarly the Komal Dhaivata, the negative counter part of the positive Swayambhu Gandhar introduced a new Tertian Komal Dhaivata as a subsidiary negative centre which immediately rendered consonant the last three dissonant atikomal notes Gak, Dhak & Rek in the series given in Fig.4.

The last three harsh Quintal notes were substituted by concordant Tertian notes governed by multiples of 5 in the denominator, each Tertian komal note being a Didymian Comma (çekk Jfr) higher than the corresponding Quintal Atikomal note.

In the illustration given below, the new Tertian komal notes are marked with a comma at the top of the letter, to distinguish them from the old low Quintal Atikomal notes.

The following illustration shows the old series in juxta position with the new series; whereas the three new higher tertian constituents are substituted for the old low quintals.

(Fig 7) The old and the news descending series;

Old Series

Rik	Dak	Gak	Nik	Ma	Sa	Pa
243	81	27	9	3	1	3

New Series

Rik	Dha1k	Gak	Nik	Ma	Sa	Pa
15	5	5	9	3	1	3

Collecting the scale degrees of the main generating centres ‘Sa’ and those of the two subsidiary centres formed by the positive Gandhar ‘Ga1’ and the negative Gandhar ‘Dh1k’ we get the essential constituents of the ascending and the descending series. These are the elements that make up the upright Universal basic scale and the Upturned Basic Scale.

(Fig.8) One main and two subsidiary centers.

Nik	Ma	Sa	Pa	Re	Dha1	Ga1	Ni1	Re1k	Dha1K	Ga1K
9	3	1	3	9	5	5	15	15	5	5

### **The universal Basic scale**

Ma Grama of Bharata (5<sup>th</sup>, 4<sup>th</sup> cent B.C.)

We now come to the greatest Indian event in the world history of music as a sequel to the epochal Indian discovery of Swayambhu Gandhar. Bharata in his

Natya Shastra finally formulated the Ma-Grama the only perfect scale based on rational consonances. He thus provided what is called the universal basic scale of uncentric tonality, about 2000 years before Zarlino advocated superiority of this scale in Europe in 1558 AD. This 4000 years old 7 note Basic scale of Bharata has since not been and cannot possibly be improved upon.

Zarlino had called it the Natural Scale, a term that is not quite adequate. Describing the Sa-Grama as being more symmetrical in the two Tetra chords, Bharata seem to uphold its sequence which is actually an imperfect double scale of bi-centric tonality. Sa Grama, because it is symmetrical, falls short of universal basic scale just by one comma. It has two tonic centres. Its first half is a Sa scale & the second half is Pa scale.

**Fig.9 'Ma Grama' – The universal Basic scale and 'Sa Grama' compared**

	S	R	G	M	P	D1	N1	S
Ma Grama, Unicentric, non symmetrical, tivra D1	1	9/8	5/4	4/3	3/2	5/3	15/8	2
	S	R	G1	M	P	D	N1	S
Sa Grama, Bicentric symmetrical tartivra D	1	9/8	5/4	4/3	3/2	27/16	15/8	2

### **Fundamentality of Basic intervals – The Four-Fold Rule**

For testing the fundamentality of basic intervals the four-fold rule method is used. The first five harmonies provide two facts of Acoustics from Sadja: Sa-Pa & Sa-Ga and two other facts from Pancham: Pa-Sa & Pa-Ga1. The four fold rule consists of these four facts of Acoustics namely the Major Third, the Perfect Fourth, the Perfect Fifth and the Perfect Sixth. The fourfold rule when applied upwards to a low note and its Fifth above produces the Universal Basic Scale. But if applied downwards to a high note & its Fifth below produces the Upturned Greek Dorian.

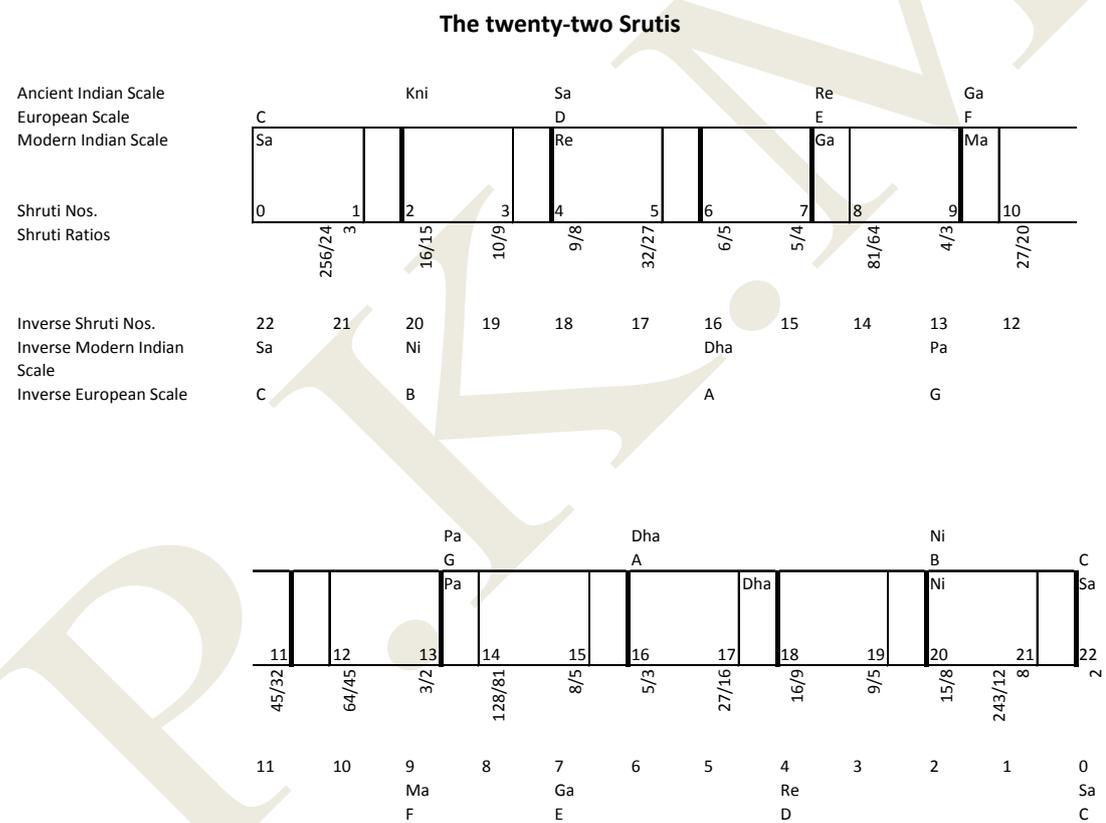
### **Musical Scales used in India ('Ma', 'Sa' & 'Ga' Gramas):**

#### **Model or harmonic Division of the scale:**

Hindu desi music is essentially model, which means that the relations of sounds on which the musical structure is built are calculated in relations to a

permanent note, the tonic. This does not mean that the relations between the sounds other than the tonics are not considered, but that each note is established first according to its relations to the fixed tonic and not as in case of cycle of fifth, by any permutation of the basic note. The model structure can then be compared to the proportional division of a straight line and no longer the periodical movement of a spiral. According to the symbolism of numbers those proportional divisions are connected with certain ideas, certain forms and certain emotions.

2. All the notes obtained in the harmonic system are distinct from those of the cyclic system which is based on different data. In this scale, according to the distinctions of ancient treatises, corroborated by the practice of present traditional musicians, the place of twenty two shrutis is thus as given below



(The full scale diagram of the above is also available in the Appendix)

In Indian music one octave is divided into twenty two shrutis or microtonal intervals. Both Bharata and Sarangdeva assigned a proper name to each shruti and both of them put these shrutis into five broad Jatis or classes. It is on account of this classification that some critics think that with Bharata or Sarangdeva, all shrutis were not equal and there were sharp and double sharp, flats and double flats even among the shrutis, the

middle one being the normal interval. Bharta and other ancient writers have mentioned 3 basic scales or Gramas namely Sadja, Madhyama & Gandhara Gramas respectively. According to them Gandhara Grama is meant for celestial beings and owing to their limited aural and vocal capacity mortals are unfit to handle it. Human being could, therefore, use the remaining two viz the Shadja and the Madhyama Grama. There scales as given by them are as follows

Shadja Grama                      C<sub>3</sub> D<sub>2</sub> E<sub>b4</sub> F<sub>4</sub> G<sub>3</sub> A<sub>2</sub> B<sub>b4</sub> C

Madhyama Grama                C<sub>3</sub> D<sub>2</sub> E<sub>b4</sub> F<sub>3</sub> G<sub>4</sub> A<sub>2</sub> B<sub>b4</sub> C

(The shruti intervals between the neighbouring notes are indicated by arithmetic numbers and the total number of shrutis is twenty two in both.)

As will be seen the Madhyama Grama differs from the Sadja Grama only in its fifth. The fifth of Shadja Grama is a true fifth while that of Madhyama Grama is one shruti lower.

As per the detail clues given by Bharata the shruti interval obtained are as under:

C-C	= 22	Shrutis or an interval of	2/1
C-G	= 13	Shrutis or an interval of	3/2
C-F	= 9	shrutis or an interval of	4/3
C-E	= 7	shrutis or an interval of	5/4
C-E <sub>b</sub>	= 5	shrutis or an interval of	32/27
E <sub>b</sub> -F	= 4	shrutis or an interval of	9/8
F-G	= 4	shrutis or an interval of	9/8
B <sub>b</sub> -C	= 4	shrutis or an interval of	9/8
C-D	= 3	shrutis or an interval of	10/9
G-A	= 4	shrutis or an interval of	9/8
D-E <sub>b</sub>	= 2	shrutis or an interval of	16/15
A-B <sub>b</sub>	= 4	shrutis or an interval of	9/8

In Sadja Grama G-A is 3 shrutis i.e 10/9 and in the Madhyama Grama G<sup>1</sup>-A is four shrutis i.e 9/8. Thus G<sup>1</sup>-G is 9/8 divided by 10/9 = 81/80 and having known this once the whole shruti theory becomes known.

Thus the notes of the two Gramas may now be rearranged and written as

<b>Sadja Grama:</b>	C	D	E <sub>b</sub>	F	G	A	B <sub>b</sub>	C
	240	266 2/3	284 4/9	320	360	405	426 2/3	480

<b>Madhyama</b>	C	D	E <sub>b</sub>	F	G	A	B <sub>b</sub>	C
<b>Gramas:</b>	240	266 2/3	284 4/9	320	355 5/9	400	426 2/3	480

Also by shifting the tonic from one note to other of the Gramic scale, seven different model scales or moorchanas are obtained from each Grama which together develop nineteen different variations of what are popularly known as the seven notes of musical scales. These therefore appear to be nineteen notes referred by Sarangdeva in his Sangeet Ratnakar as being the ones in one octave, from which two more drop down further, as notes which happen to be at an interval of one shruti are dissonant and therefore inadmissible in music.

Thus there are twenty two shrutis but seventeen different musically useful sounds in one octave and these seventeen notes are classed under seven broad names indicating the seven notes of the basic scales.

**Consonants being the consonants all over the world**, it is no wonder if there is found a close similarity between Indian & Western scales. In Europe there are two scales Major mode and the Minor mode which form the backbone of the music of the west. The closest and the simplest relationship of tones is reached in the major mode as all its notes are but constituents of the compound tone of the tonic or its fifth, above or below. The major mode is built up of three major chords.

	3←-----3←-----3								
Notes	C	D	E	F	G	A	B	C	(d)
Index number	24	27	30	32	36	40	45	48	(54)
of frequency	1-----→1-----→1			2-----→2-----→2					

The first major chord is indicated by 1, the second by 2 and the last by 3. The arrow supplied to the figures indicates the point of start and direction of application in each case. Similarly the Minor scale consists of three minor chords.

	3←-----3←-----3								
Notes	C	D	E <sub>b</sub>	F	G	A <sub>b</sub>	B <sub>b</sub>	C	(d)
Index number	24	27	28.8	32	36	38.4	43.2	48	(54)
of frequency	1-----→1-----→1			2-----→2-----→2					

It should be remembered in both these scales that the principle of tonality is fully observed as all the tones are connected by simple relationship of the chief note, the tonic as also between themselves.

Similarly, if a particular scale is put forward as the suddha or natural scale of Indian music one should prove that the scale is the result of truly scientific practices and does not rest on the mere caprice (mood, whims). The shruti scale as put forward by present exponents cannot satisfy this expectation as one is not sure if the Veena (based on which the swara of the scales have been established) of today is exactly like the Veena(oh ~~kk~~) of ancient days.

In these circumstances some are tempted to adopt the Major scale of the West as the basic scale of Indian Music. However such a step is too bold and moreover it is unnecessary as it is possible to trace the evolution of the scale of Indian music, firstly by critical analysis of the popular or the folk forms of recitation and songs in general and secondly by considering a simple but a very important practice common to both the ancient and the modern system of Indian Music.

#### **Bharata Suddha Scale of Sa-Grama:**

The following chart will show how Bharata has distributed the seven swaras among twenty two shrutis.

1	2	3	4	5	6	7	8	9	10	11		
Ni			4Sa		3Ri		2Ga					
	12	13	14	15	16	17	18	19	20	21	22	
		4Ma				4Pa			3Dha		2Ni	
Swara		4Sa	3Ri	2Ga	4Ma	4Pa	3Dha	2Ni				
Sh No.		4	7	9	13	17	20	22				

The intervals of 4 shrutis are the major tone, the interval of 3 shrutis is the minor tone and the interval of the 2 shrutis is the semi tone.

Each swara become manifest on its last shruti, when the swaras stand on their proper shrutis they are called suddha swaras. The above scale of 4 3 2 4 4 3 2 intervals is called the Suddha Scale of Sadja (Sa) Grama.