

An Overview of Sanskrit Historical Phonology

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Common Abbreviations

A number of abbreviations are used throughout the historical phonology section. We have listed them here for reference and convenience.

AV	Atharvaveda
BMAC	Bactria-Margiana Archeological Complex, Oxus civilization
ie	Indo-European
IIr	Indo-Iranian
lith	lithuanian
MIA	Middle Indo-Aryan
MPers	Middle Persian
MWD	Monier-Williams Dictionary
NIA	New Indo-Aryan
OAv	Old Avestan, Early Avestan
ocs	Old Church Slavonic, старославянский
OIA	Old Indo-Aryan
OPers	Old Persian
OPruss	Old Prussian
PIE	Proto-Indo-European
PIIr	Proto-Indo-Iranian
psl	Proto-Slavic, праславянский
RV	Rigveda
skt	Sanskrit
Toch	Tocharian
ukr	Ukrainian
YAv	Young Avestan, Late Avestan

References are given throughout the text in parenthesis with the author's name to identify the entry in the references at the end. If multiple references exist for the same author the date of publication follows the author's name, as Beekes-1988 vs. Beekes-1995, Ringe-2006 vs. Ringe-2013. In the case of A.A.Macdonell we have used the abbreviation "Mac" to refer to his "Vedic Grammar" and "MacStud" to refer to his "Vedic grammar for students." Whitney's "Sanskrit Grammar" is referred to simply by "Wh".

A. Proto-indo-european (PIE) phonology.

The phonology of proto-indo-european (PIE) is recovered by reconstruction from modern indo-european (ie) languages, attested early ie languages, borrowings into and from language groups and place names. As such no presentation of ie phonology can be definitive and final, rather represents a best fit to available data.

Assigning a time frame and dates to linguistic events is even more tenuous, albeit tempting. Extrapolations are made from language attestations of known date and time using relative chronology and any available archeologic and genetic data. As such the PIE language system can be conceptualized as existing between the 6th and 4th millenia BCE -- spanning early, middle and late stages.

Indo-european reconstruction is a hugely consuming undertaking that may never achieve a final or

definitive result, since there is far too much missing information in the form of the early history of the languages that are attested and indeed in the form of lost cultures and language systems themselves. Reconstructed middle and late PIE represents a synthesis of comparative historical data from all the attested ie languages. Choosing a later stage reduces the scope of data incorporated - e.g., recovering proto-indo-iranian has great benefits to understanding and correlating avestan and sanskrit, but reduces the contribution of other ie languages. Choosing an earlier, pre-indo-european stage increases uncertainty without adding insight, unless it can bring in new information as by the nostratic model.

The main benefit of reconstructing PIE and incorporating data from all the ie languages is to enable an understanding of the processes in the individual indo-european daughter languages. An optimally reconstructed PIE system serves as a template for the understanding of the structure and properties of an individual modern ie language.

The accuracy of recovery of early forms diminishes with time depth. On the other hand the various ie language systems converge with time depth. The data from sanskrit itself takes us well into the second millenium BCE. Of great benefit is the contribution of well attested avestan and the iranian language system that allows us to reconstruct an intermediate proto-indo-iranian (PIIr) stage, albeit with probable late PIE features, which takes us into the 3rd millennium BCE. To this extent, the contribution of other ie systems, like well attested greek, conservative balto-slavic, germanic and latin is mainly supplemental.

The PIIr system leaves a residual separation of one or two millenia from late PIE. For this segment it is necessary to incorporate as much data from the other ie daughter languages as possible to identify PIIr innovations and to elucidate vectors of change. In this sense, reconstructed late PIE affords for sanskrit a reference point (or area) or point of origin from which attested language resources (phonologic, accentologic, morphologic, syntactic, lexical) can be understood. Secondly this allows us to identify preserved archaic features, evolved inherited processes, innovations, and attrition of resources.

Prosody and accentuation are an important aspect of phonological development from PIE. The nature of PIE and sanskrit accent, its dynamics and development, are discussed in our section on accent. Out of necessity, a simplified discussion of accent and morpheme phonology is presented in this section.

For our purposes, we will not undertake indo-european reconstruction. An attempt to assign a time and place for ie language differentiation and phonological changes should be addressed separately from the study of language processes. Rather, in this section we will briefly present the PIE phonological system as a starting point for development into the PIIr and sanskrit systems.

A.1. PIE (late) phonological inventory.

PIE (late) phonological inventory.

vowels [+syll]

e e:	a a:	o o:	i u (ə)	ɾ	ŋ ɱ
ei ei:	ai ai:	oi oi:			
eu eu:	au au:	ou ou:			

consonants [-syll]

laryngeals (H)	h ₁	h ₂	h ₃			
labiovelar:	k ^w	g ^w	g ^{wh}			
velar:	k	g	g ^h			
palatal:	ĵ	ĝ	ĝ ^h	i [j]		
dental:	t	d	d ^h	l r	n	s (z)
labial:	p	b	b ^h	ɹ [w]	m	

In ie, the glides (i, i [j] ; u, ɹ [w]), liquids (ɾ (R) [+syll], r ; | (L) [+syll], l), and nasals (ŋ [+syll], n ; ɱ [+syll], m) -- collectively, the resonants -- functioned both as non-syllabic consonants and as syllabic vowels.

The schwa - ə - of earlier authors has generally been replaced by the laryngeals.

In the newer interpretation of stops, the voiced consonants represent a degree of lenition of the first consonant and are represented as unvoiced preglottal consonants, so: p 'p p^h, for instance. We preserve the older notation for simplicity.

(See: Fortson ch. 3, Meier-Brugger ch 2, pp. 70-139; Szemerényi ch. 4-6; Clackson ch 2-3; Beekes-1995 ch 11-12; Luraghi ch 2, Voyles ch 1, 7; Burrow pp.67-117 (sanskrit); Skjærvø pp.48-49 (avestan); Beekes-1988 p.70-103 (avestan); Tremblay p.23 (avestan))

The PIE phonological inventory above represents a reasonably widely supported model and serves as a modern starting point for a discussion of ie phonology. A cursory comparison of this inventory with working models from the early days of ie studies in the 19th century shows considerable progress. The experience from the original three languages used to formulate an understanding of the PIE system -- sanskrit, greek and latin -- has developed and has been put into more balanced context with the discovery of and experience with additional ie language systems. On many points the jury is clearly out. Indeed, due to the absence of early ie data and attestations of early ie languages, support for competing approaches -- such as the glottalic theory, variability in application of the laryngeal theory, and various schools of thought in India -- remains quite widespread. The reader can be referred to Mallory and Adams (Unit 3.4 "Reconstruction and Reality") for a discussion on the dimensions of this problem.

The inventory serves to represent discreet phonemes -- i.e., elements of phonological contrast -- even if some of their precise phonological features remain inconclusive. It is the phonological contrasts that are important. These phonemes offer a reasonable starting point in the trajectory of change into modern ie languages.

Please refer to "Appendix A. PIE phonemes and their ie reflexes" for an enumeration of PIE reflexes in modern ie languages.

Vowels.

PIE possessed five short and five long simple vowels, a, e, i, o, u. There is general agreement that *a, *e and *o belong, but some authors view *i and *u as vocalic glides [j] and [w]. Similarly, there is general agreement that *a:, *e:, and *o: belong, but some maintain that *i: and *u: represent a later contraction of *iH and *uH, where the loss of laryngeals is accompanied by compensatory lengthening.

In PIIr (sanskrit and avestan) the short and long *a, *e and *o develop into short and long *a respectively, that is, [a, e, o] -> [a] and [a:, e:, o:] -> [a:]. As a result of this unconditioned change the indoiranian system does not distinguish these three short and three long vowels. The phonological contrast of vowel length - short or long - is preserved, though. Both the short and long *i and *u continue into sanskrit. (The language is sanskrit, where not indicated.)

e.g.,

- *a *ghans- "goose" -> हंस- haMsa-
- *e *esti "is" -> a'sti, *nebhos "sky" -> नभस- nabhas-
- *o *oktō "eight" -> अष्ट aSTA
- *i *wid- "know" -> वि- vid-
- *u *rudhros "red" -> rudhira-, *sops "daughter-in-law" -> सुप्त snuSA
- *a: *mātēr "mother" -> मातृ- mAtar-
- *e: *h₃rēǵ-s "king" -> राजन्- rAjan- m., rāzar-, rāzan- n. "rule" (OAv)
*dhē- "put" -> धा- dhA-, dā- (avestan, OPers)
- *o: *gnō- "know" -> ज्ञा- jJA- (skt), zān-(OAv), xšnā- (OPers), знати (ocs)
*dō- "give" -> दा- dA-, dā- (avestan, OPers)
- *i: *wos -> "live" -> jlv-, *pī- "drink" -> पी- pA-, but पिबति pibati
- *u: *nūn "now" -> नूनम् nUna'm, nūram (OPers), nunc (latin), нынѣ (ocs)

If one includes the schwa - ə - into the group of simple vowels, then it's appreciated that its reflex in

indo-iranian is uniquely 'i' - in contrast to all other ie languages, e.g.,
 (*ph₂ters ->) *ph₂tēr -> पितृ- pita'r- "father", *steh₂- -> *sth₂-to'- -> sthi-ta'- (ppl.) "stood", etc.
 See below under "laryngeals."

Diphthongs.

The non-high vowels [a, e, o][high] combine with the glides (i, i [j] ; u, u [w]), to yield six PIE diphthongs:

[a, e, o] x [j, u] -> [*ai, *ei, *oi, *au, *eu, *ou]

e.g.,

- *ai *aidh- "burn" -> एध- edha- m. "fuel" (< indh-), edhata-m. "fire"
 *daiwēr "husband's brother" -> devara- m.; δαῖρ (gr), дѣверь (psl), дивер (ukr)
- *ei *ei-ti "goes" -> एति eti,
 *deiwos "god" -> देव- deva- m.
 *sneigh^w- "to snow" -> snihy (pass.) (< snih-), снѣгъ (ocs), sniegas (lith)
- *oi *toi "they" -> ते te,
 *woida "I know" -> veda (parasm.perf.ind.1st.sg) (< vid-), вѣдь (< вѣдѣти)(ocs)
- *au *sausos "dry" -> शोष- ZoSa- (< ZuS-), соухъ (ocs)
- *eu *eusō "I burn" -> ओषामि oSAmi (root: uS-),
 *leuk- "shine" -> rocate (root: ruc-), лоча (ocs)
- *ou *roudh- "red" -> vs, raudas (lith)
 *loukos "glade, clearing" -> loka- m. "place, free or open space" (in early sanskrit it is preceded by u-, so *louka- m.),
 *klounis "buttock" -> श्रोणी- ZroNI- f. "thigh, hips"

The combination of a long vowel + [j, u] is uncommon in PIE, (Fortson p. 61) arising by contraction or by induced lengthening (to long grade) of a root vowel. In later PIE long diphthongs arose by contraction involving laryngeals.

In PIIR (sanskrit and avestan) the unconditioned change of both short and long [*a, *e, *o] to short and long [a], respectively, also affects the diphthongs, so,

[*ai, *ei, *oi; *au, *eu, *ou] -> [ai; au] or later [e:, o:] (sanskrit)

That is, the development of the diphthongs in PIE correspondes to that of the independent vowels. (Szemerényi p. 42)

Monophthongization of these diphthongs typically follows. This occurs individually in the various post-PIE ie dialects or languages. By the time of attested languages these long diphthongs are generally shortened or monophthongized. (Szemerényi p. 42)

In PIIR as noted above the diphthongs merge to [ai; au] and generally persist in Old Iranian, but even in earliest Indic have begun their monophthongization to long vowels, [e:, o:].

In greek, the diphthongs are preserved in the classical period, although 'ou', still so written had become u:

In latin, by the first half of the second century BCE, [ei] > [i:], [oi] > [u:], with [ai] (written ae) and [au] surviving the classical period. (also Meier-Brugger p. 90)

In germanic, [ei] > [i:] at an early stage. In gothic [ai] > [ē], [au] > [ō]. In old high german, [ai] > [e:] before r, w, h, but [ai] > [ei] in other positions. And [au] > [o:] before h and dentals, but [au] > [ou] elsewhere.

In slavic [ei] > [i:], [ai, oi] > [e:], [au, eu, ou] > [u:]

In lithuanian, the diphthongs have been preserved to the present day.

Resonants.

As noted above, in PIE, the resonants -- that is, the glides (i, i [j] ; u, u [w]), liquids (r (R) [+syll], r ; l (L) [+syll], l), and nasals (ñ [+syll], n ; m [+syll], m) -- functioned both as non-syllabic consonants and as syllabic vowels. Indeed, the non-syllabic (consonantal) and syllabic (vocalic) forms may in PIE be

considered allophonic. For PIE designating these six phonemes as vocalic or consonantal is not necessary, but can be helpful. (Beekes-1988 p. 95)

The non-syllabic liquids and nasals are largely preserved, as

- *l *leuk- "shine" -> rocate (sanskrit), raocaiieiti (avestan)
*klewos *n-d^hg^{wh}itom "imperishable fame"
-> श्रवोऽक्षितम् Zravas akSitam (sanskrit) (but श्लोक- Zloka- "verse")
-> κλεος αφθιτον (greek) (Clackson p.180, 188)
- *r *pro "forward" -> pra (sanskrit), fra- (avestan)
- *m *men- "think" -> man- (sanskrit), manah- "mind" (avestan), мънѣти (ocs)
- *n *ne "not" -> na (sanskrit and avestan)

The non-syllabic glides [j̥ j̄], [w̥ w̄], as expected, underwent change much more frequently, with the [j̥ j̄] tending to weaken or disappear, and the [w̥ w̄] tending towards fricative [v] and [f]. Noteworthy is that in west germanic, including English, the [w̥ w̄] survived as [w].

- *j̥ [j̄] *jugom "yoke" -> yugam
*jud^h- "move" -> युध्- yudh- "fight", yūiḍiia- "fight" (YAv)
*h₂iu-h₁en- "having vital force" -> युवन्- yuvan- "youth" (skt), yuuānəm (YAv), юнь (ocs), юний (ukr), jaunās (lith), iuvenis (latin)
- *w [w̥] *ueǵh- "lead, convey in a vehicle" -> वह- vah-, vahati (sanskrit), vazaiti (avestan)
*wek^w- "speak" -> वच्- vac- (sanskrit), vācam (acc) (OAv), vocare (latin)
*uēsr̥- n. "spring" (Tremblay p. 125) -> वसन्त- vasan-ta- (sanskrit), vaŋri (YAv), bahar (iranian), весна (ocs), uēr (latin), var (old norse)
*uōs "you (gen.pl.)" -> [redacted] (acc.dat.gen.pl. [redacted] yUyam), vā (dat.gen.pl. OAv), vā (acc.pl. OAv), васъ (acc.gen.loc.pl. вы ocs)

The syllabic resonants are recognized by position between two non-syllabic consonants or at a word boundary (CRC, -CR, RC-).

In most ie languages these vocalic resonants are retained with the help of "prop vowels", such as germanic (*ul, *ur, *um, *un) and slavic (*il, *ir, *im, *in (or *ul, *ur, *um, *un)). Sanskrit, while retaining the syllabic liquids (vocalic ऋ R [r̥], ॠ L [l̥]), shows a process of gradually replacing them and the vocalic nasals with अ 'a'. By the time of attested vedic sanskrit, the vocalic nasals have been replaced by 'a', and in the development of prakrits from sanskrit the vocalic R (and L), too, are replaced with 'a'. In avestan, the vocalic [r̥] frequently corresponds to [əɾə] < [əɾ]+[ə], while in other (later) Iranian languages the reflex is [ir] or [ur]. (Skjærvø p.55, MacStud 15.1a)

- *l (L) *ul^wos "wolf" -> vRkas (ve[redacted]skt), vəhrka- (avestan)
*mldu- "soft" -> mRdu- "delicate, soft"
[redacted] "much, many" -> puru'- (sanskrit), paru- (O.Pers)
*p|h₁-no'- (ppl.) "filled" (< *pleh₁- "fill") -> पूर्ण- pUrna'- (ppl.) < pR- (pRN- pUr- pRR-)
-> pəɾənā (OAv) "fulfill, grant"
-> плънь (ocs), pilnas (lith)
- *r (R) *mr̥-to- "dead" -> mRta'- (sanskrit), mərəta- (avestan)
mRtyu'- m. "death" (sanskrit) -> maccu (prakrit, Pischel p. 63)
*krd- "heart" -> hRd- n., hRdaya- n. "heart"
but श्रद्धा- Zra'd-dhA- "putting one's heart in, trust" sanskrit)
-> zrd- (avestan)
-> сръдьце (ocs) (s^hr̥d̥-ce (psl.) < s^hr̥d̥-ko), širdis (lith)
-> cor cordis, cre[d]-do (latin), καρδ-ια (greek)
*g^wr̥h₂u- (*g^wr̥u-) "heavy" -> guru-, gravis (latin), kaurus (gothic) (Szemerényi p.51, Fortson p. 111))
- *m̥ *dék̥m "ten" -> da'Za- (sanskrit), dasa (avestan)
*g^wm̥tos- "ppl. come" -> [redacted]'- (root gam-)
*septm̥ "seven" -> sapta'-

*smo- "some(one)" -> sama- "any, every" (vedic); hama- "any" (avestan)
 *n̥ "non-" -> a- an- (sanskrit), negation prefix, in- (latin), un- (english)
 *n̥ -> possibly on- (psl) -> ж- (as ж-богъ ж-родъ) (ocs), у-богий, ви-родок (ukr), у-богий, у-род(-ец) (russ)
 but *ne (negation particle) -> na (skt), na (avest), не (ocs, ukr) replaced *n̥- as the general negation prefix in slavic, becoming не-

*m̥s "thought" -> mati- f. "prayer, thought" (root man-), maiti- (avestan)
 *m̥n̥₂u- *n̥u- "thin" -> tanu- (skt), тънъкъ (psl), тънъкъ (ocs), tenuis (latin)

Some earlier works also describe a variety of long syllabic resonant vowels, (*r̥H, *l̥H, *m̥H, *n̥H), but these are now understood as sequences of vowel + laryngeal -- as *r̥H, *l̥H, *m̥H, *n̥H -- whose vowel undergoes compensatory lengthening with loss of the consonantal laryngeal.

Consonants - stops.

The PIE consonant inventory consists of three series of velars (plain velars, palatal velars, labiovelars), one dental and one labial series -- each series having one voiceless, one voiced and one voiced-aspirated member (see Fortson pp.48-54). Velars are also referred to as gutturals and tectals. These series are deduced from cognate correspondence sets from the various indo-european languages in such a manner as to yield optimal compatibility with what is known of the phonology of all the ie languages. That the phonological features of a number of these phonemes continues to be investigated and debated is less important than their **phonological contrasts** -- i.e., the fact that they behave distinctly, as discreet phonemes. We consider their phonological distribution.

labiovelar:	k ^w	g ^w	g ^{wh}
velar:	k	g	g ^h
palatal:	k̂	ĝ	ĝ ^h
dental:	t	d	d ^h
labial:	p	b	b ^h


The need for three series of velars (gutturals) is at first confusing. To simplify the matter as much as possible and to avoid a very involved discussion as to the rationale, let us briefly outline the predicament. One needs to consider phonological change in all the ie languages. In the first of two groups of ie languages - the satem (from avestan) or central group, Indo-iranian, baltoslav, armenian - the velars form two groups, one inclined to palatization and spirantization to 's' or 'š' and the other tending to remain velar; in this group labiovelars correspond to plain velars. In the second group - the centum (from latin) or "western" group, greek, italoceltic, tocharian, germanic, hittite - palatalization does not occur, instead labiovelars undergo a distinct development while the plain and palatal velars are generally not distinguished. In short,

[k^w], [k, k̂] -> [k^w], [k] (centum group)
 [k^w, k], [k̂] -> [k], [k̂] (satem group)

This "three-dorsal" series approach undergoes repeated attempts to reduce it to a "two-dorsal" series (Clackson, p. 51-53, Beekes-1995 p.109-113). The realization that many velars remain unchanged in satem languages while a significant proportion of sibilants in the satem languages, when compared with correspondence sets from centum ie languages, have their origin in velar consonants leads one to observe the effects of a PIE **phonological contrast** between these two population of velars, referred to as plain and palatal velars. (Szemerényi p.60) In turn, numerous instances of satem language velars correspond to centum language labiovelars of the form 'qu' or 'k^w', while many correspond to centum language plain velars. This leads to the observation of yet another **phonological contrast** in the population of PIE velars, which based on the 'qu' structure in centum languages has become understood as 'k^w'. Interestingly, evidence from Luwian (a centum anatolian language) suggests a distinct outcome for each of the three velars (see examples below).

To help clarify the examples below, one should briefly note that in indo-iranian (and slavic), prior to the PIE vowel merger of [e, o, a] > [a], the merged labial and plain velars became palatalized before e, i and the semivowel y (i̯ [j]) (see Szemerényi p. 63). And as noted above the palatal velars in the satem group generally turned into sibilants like ['s', 'š'] or even affricates like [tʃ or ts].

labiovelars:

*k^w *kwi-, *kwo- "who, what" -> kuj "who" (Luwian), kuit "what" (hittite), quid (latin), hwæt "what" (Old Engl), kuse- "which" (tocharian), kas  dic, kō (avestan), kas "who" (lithuanian), кѣто, чѣто (OCS), kē "whom" (Albanian)

*kwe- "and" -> -que (latin), ca (Ilr)


*kwi- "atone" -> ci- "revenge, punish" (RV)

**kwoinā- "penalty" -> kaēnā (avestan), цѣна (ocs)


*penkwe "five" -> पञ्च (paJca), quinque (latin, <-pinque)

*kwelo-, *kwekwlo- "wheel" -> cakra'- n. (sanskrit), čaxra-(avestan), kokale (TochB) (Tremblay p. 134)

*g^w *neg^w-, *nog^w- "naked" -> nagna'-

*gwen- "woman" ->  f. (sanskrit); jaini- (avestan)

**gwh₃-uo- "living" -> jIva'- "living" (root जीव्- jlv-) (sanskrit), jIva (O.Pers)

*g^{wh} *g^{wh}er- "burn" -> gharma'- m. "heat" (sanskrit root  ghR- "shine, burn" (not ghR- "sprinkle") also ghRNa'- m. "heat", gareti (lithuanian), горѣти (ocs)

*g^{wh}en- "strike, kill" -> han- ghnanti (parasm.pres.ind.3rd.pl.) (sanskrit), jan- (avestan), kwen (hittite), genu- "drive" (lithuanian), гонити жену (act.pres.ind.1st.sg.) (ukrainian)

*h₁lŋg^{wh}-u'-, *h₁lŋg^{wh}-ro- -> raghu'- "quick, swift", laghu'- "light, low"

plain velars:


*k *ker- "cut" -> kars- "cut" (luwian), छिद् chid- "cut" (skt), σχιζω (greek), scindo (latin) (<*(s)ki(n)d-), цѣдити (ocs), цідити (ukr), чистъ (ocs), чистий (ukr)

*kes- "comb" -> kisa- "comb" (luwian), ke'sa- "hair" (sanskrit), коса (ocs, ukr)

*kreu- "bloody, raw flesh" -> kravis (sanskrit), крѣвь (ocs)

*g *yugom "yoke" -> yugam (skt), иго (ocs)

*g^h *steigh- "go" -> stigh- "go, stride", посигнѣти (ocs), устигати, стигнути (ukr)

*mighlā "mist" ->  a- m. "cloud", мъгло (ocs)

palatal velars:

*k̥ *k̥rd- "heart" -> hRd-, zart- (luwian)
-> hRdaya- n. "heart"

but श्रद्धा- Zra'd-dhA- "putting one's heart in, trust" sanskrit)

-> zrd- (avestan), сръдьце (ocs) (s^hr̥d̥-^{ce} (psl.) < s^hr̥d̥-ko),

-> cor cordis, cre[d]-do (latin), καρδ-ια (greek)

*h₁eḱ-u- -> *h₁eḱ-u-os "horse" -> asu-, azzu (luwian), *ekku- (hittite)

-> अश्व- aZva- m. (sanskrit), aspa (avestan)

-> equus (latin) (see deVaen p. 193, Tremblay p. 133, 142)

-> ašvienis "stallion" (lith)

*ōḱu- "fast" -> अशु- AZu'-, (*h₂eḱu- "sharp")

*h₂eḱmōn- (or *aḱm-) "1) stone, sharp; 2) ? heaven, cloud"

-> अशमन्- aZman- m. "stone, sharp; cloud" (sanskrit),

-> asman- "stone"(avestan), aSman (OPers)

-> akmuō "stone" (lith), камы "stone" (ocs) (note 'k')

-> ακμων "anvil" (greek)

(-> asman- "heaven" (OPruss) - uncertain)


*ḡ *h₃rēḡ-s "king"  राजन्- rAjan- m.

*ḡonu, *ḡenu  e" -> jAnu- n.

*eḡoh₂, *eḡh₂-ōm -> aha'm (sanskrit), azəm (avestan), азъ (ocs), aš (lith), es (armenian), uk (hittite), εγων (greek), ego (latin), ik (gothic)

*ḡ^h *ḡ^heu- "pour" -> hu- "worship, sacrifice", passive meaning hUyate, huta'- "poured out" (sanskrit), zaotar- "priest who pours oblation" (avestan), futuere (latin)

*ḡ^heīōm-, *ḡ^hime's-, "winter" (Tremblay p. 125)

*ḡ^heiḡm-, *ḡ^hiem- "winter, snow" -> gie-e-mi (hittite),  - (vedic), ziiā (avestan), зима

(ocs), žiema (lith), hiems (latin), χιων (greek), jiwn "snow" (armenian)

*h₂emĝh- (*anĝh^u-) "narrow" -> अङ्घ्र- aGh-, अंघ्र- aMh- "be narrow or distressing", अंघ्र- aMhu'- "narrow" (sanskrit), azah 𐬀𐬎𐬌 difficulty" (avestan), жъкъ (ocs) узкий (py)

From the examples above, it is noted that sanskrit in a number of instances, has a voiced aspirate, 'h', where the other ie languages retained a stop, usually a voiced stop, other examples being these:

(Szemerényi p. 66)

ha'nu- f. "jaw -- γεγυς (greek), gena (latin), kinnus (Goth) (see MWD)
aham "I" -- azam (avestan), азъ (ocs), εγω (greek), ego (latin), ik (gothic)
mahant- "great" -- μεγας (greek), magnus (latin)
duhitar- "daughter" -- dugədar (avestan)

Consonants of the dental and labial series are preserved and continued into sanskrit.

dentals:

*t *treyes "three" -> trayas; *pet- "fly, fall" -> pad-
*d *domos "house" -> dama- m.
*dh *dhumos "smoke" -> dhUma- m. "smoke, perfume"

labials:

*p *ped- "foot" -> pad- m.
*pek^w- "prepare food" -> पक्- pac-, paçaiti (avestan), пешти (ocs), пекти (ukr)
*b *belo- "strong" -> bala- n. "power, might"
*bend- "drip" -> bindu'- m. "droplet, spot" (see Tremblay p. 23)
*(H)a'blu- n. "apple" -> аблъко (ocs) (Tremblay pp.23, 129)
*bh *bher- "carry, bear" -> भृ- bhR-, baraiti (avestan)
*b^he'b^hros- "beaver" -> feber (latin), bebras (lithuanian), бобер (ukr) (Tremblay p. 131)

Mention should be made of the series of unvoiced aspirates seen in sanskrit, ख, च्, ठ्, थ्, फ्.

Although the series, *kh, *th, *ph, was included in the PIE inventory by Brugmann and other earlier authors, with the development of the laryngeal theory, these became viewed as arising from unvoiced stop + laryngeal, and occasionally from voiced stop + laryngeal. For PIE, the combination of unvoiced or voiced stop + h is viewed as **monophonematic** and is grouped with the voiced aspirates. Nonetheless, the existence of unvoiced aspirates in PIE has not been entirely excluded; instead their presence in sanskrit has acquired another explanation. (Szemerényi p. 69, 144). Notwithstanding the above, one cannot help but appreciate the relatively high frequency in sanskrit of 's' followed by a voiceless aspirate: e.g., (note reduplicated forms)

sphUrj- "rumble", pusphUrja (parasm.perf.ind.3rd.sg), pusphUrjiSa- (desid)
sthA- "stand, be", tasthau (parasm.perf.ind.3rd.sg), tiSThAsa- (desid)
skhal- "stumble", caskhAla (parasm.perf.ind.3rd.sg)
chid- "cut", cicheda (parasm.perf.ind.3rd.sg), cichitsa- (desid)
*ker- "cut" -> kars- "cut" (luwian), σχιζω (greek), scindo (latin) - (no 's' in luwian)
iS- "seek", yaj- "sacrifice", iSTa'- (passive past ppl for both iS- and yaj-)
-iSTha- (superlative morpheme)

Consonants - consonant clusters.

Consonant clusters in PIE often behave differently phonologically from their constituent members and ie correspondence sets suggest their special development. Two-consonant clusters are found in nearly all combinations. Three-consonant clusters are also observed, often word initially. In addition, the development of consonant clusters depends on whether the cluster is word-initial, word-internal or word-final. (Fortson p.58-60).

Consonant clusters in PIE exhibit a special development for sanskrit. Whereas individual PIE consonant clusters are reflected distinctly in ie languages, often simplified to single consonants, in sanskrit we observe क्त kS- as the product of convergent development from numerous PIE consonant clusters.

(discussed in B.5. Consonant Clusters)

Sanskrit often exhibits the cluster, क्ष- kS-, in places where greek and anatolian languages have their own cluster and where more modern ie languages have a single consonant. It's believed that these clusters originate from "thorn groups", often a dental (or even a dental-sibilant) followed by a velar, as the dental-velar sequence is preserved only in anatolian and tocharian.

e.g.,	ie	sanskrit	avestan	hittite	greek	latin	Tocharian A	
		*h ₂ rtkos-	RkSas-	m."bear"-	hartaggaš	αρτος	ursus -	
		*d ^h ǵhom-	kSam-	"earth"	zam-	in-zagan-	χθον	homo tkam
		*d ^h ǵ ^{wh} i-	kSi-	"stay"	-	-	φθι	si-tis

(Hittite [hartaggaš] is phonetically [hartkaš]. Fortson p. 59)

Consonants - sibilants (spirants, fricatives).

For PIE, **only one sibilant is reconstructed, voiceless 's'**. But *s may change to *z (an allophone) by assimilation before voiced consonants. (Meier-Brugger p.102, Szemerényi pp 51-52, Fortson p.55, Beekes-1995 p.134, Kobayashi p.105) No other sibilants have been convincingly reconstructed for PIE.

The sibilant *s is preserved intact in most ie languages, including sanskrit, as *sed- "sit" -> sad- "sit", sldati (parasm.pers.ind.1st.sg.) (sanskrit), sedēre (latin), сѣдѣти (ocs)
 *seǵ- -> सञ्ज्- सज्- saJj- saj- sajati "hang, attach" (skt), fra-hanjati "hang" (OPers), сѣгнѣти (ocs), сягати, сягнути (ukr).
 *seǵh- (*sǵh-) "win" -> sah- sahati "prevail" (sanskrit), sigu "victory" (OHG)
 *ue's- "wear, clothe" -> vas- (sanskrit), uēs-ta "he wears" (hittite), vestis "robe" (latin)
 *pis-to'- "crushed" -> पिष्- पिष्ट- piS- piSTa'- (ppl.) "crush" (sanskrit), pistus (latin), пьхати (ocs)

The sanskrit (and ocs) locative plural further illustrates the preserved sibilant, e.g., सूनुषु sUnu-Su, сынъхъ (ocs) and त्रिषु triSu' (mn.loc.sg), трѣхъ (ocs).

The voiced sibilant allophone too is for the most part preserved in ie languages, but undergoes further change in sanskrit (Kobayashi p. 49), as *misdho'- "reward" -> मीढ- mIDha (sanskrit), mižda- (avestan), мъзда (ocs), mizdo (Goth), μισθος (greek).

And if one considers the sanskrit root, निषद्- niSad- "be seated, sit down, rest upon", the word for "nest," a place for a bird to rest upon, the PIE word, *ni-sd-o- (zero grade root), shows the form, нѣздо, in ocs. But in vedic it has the form, नीड- nIDa'- m. So, *ni-sd-o- (PIE) -> *nizdo- (late PIE) -> *niždo- (PIIr) -> *nižda- (PIIr) -> नीड-/नीळ- nIDa- (sanskrit).

Sanskrit no longer has voiced sibilants (spirants) in its phonological inventory even by the vedic period. The formation of the imperative singular is instructive. The voicing (assimilation) of 's' to the ending -dhi would produce a 'z'. In most cases the loss of voiced sibilants [z, ʒ, ʒ] [з, ʒ, ж] occurred without a trace, but when 'a' preceded 'z', the loss is evidenced by the presence of 'e', which replaced 'az', as

e-dhi' < az-dhi' (as- "to be")
 de-hi' < daz-dhi' (dA- "to give"), note also the form da-dhi'
 मीढ- or मीळ- mIDhA- "reward" < *miždha-

When vowels other than 'a' preceded 'z', the 'z' disappeared after cerebralizing the following dental and lengthening the preceding vowel, so

a'-sto-Dhvam < a'-stozh-Dhvam < a'-stos-dhvam

The process: voiced assimilation of sibilant -> cerebralization of dental + assimilation of sibilant --> loss of sibilant + compensatory lengthening of vowel. (MacStud.15.2k, Kobayashi p. 105, Burrow pp. 94-96)

Considering that in the vedas there persists a metric timing slot where one would expect a voiced sibilant, it is conceivable, in the way of relative chronology, that voiced sibilants and jh persisted into the immediate prevedic period and that their loss occurs after the complete loss of laryngeals. (Kobayashi p. 50)

In their further development, however, the ie languages acquire additional sibilants from other sources, such as from epenthesis in dental geminates, consonant clusters and palatalization of velars.

Laryngeals.

A group of phonemes, referred to as laryngeals, are theorized to have existed in PIE. Although it is believed they are partially preserved in anatolian languages as the velar fricative, 'h', in hittite and luwian, they are not directly attested in any other ie language. Anatolian languages, in particular Hittite, provide the most compelling evidence for their existence. (Lehmann chaps 3, 12)

While their precise phonetic value is unclear, it is surmised that they represent fricatives or spirants (Luraghi p.66, Fortson p.58, Meier-Brugger p.106, Szemerényi p.128, 140). Recent work has attempted to assign a more precise value to these, such as: h_1 -- a simple [h] or glottal stop [ʔ]; h_2 -- a voiceless pharyngeal fricative [ħ] or [χ]; h_3 -- a voiced pharyngeal or velar fricative [ʕ] or [ʁ] (or even a labiovelar voiced fricative [ɣ^w]), among other possibilities. An understanding of the phonological properties of the laryngeals (the laryngeal theory) requires consideration of PIE root and syllabic structure, ablaut (vowel alternation) processes and the role of accentuation, which will be presented below. As the laryngeals are included in the PIE inventory, a preliminary description of what they are is useful here.

In the older literature the laryngeals are represented by the schwa (ə), often differentiated as $ə_1$, $ə_2$, $ə_3$. The unsubscripted symbols -- the 'H' and the schwa 'ə' -- are used for the general case of the laryngeal, when the laryngeal is not specified. Some investigators have proposed additional laryngeals, for instance, h_4 , which is distinguishable from h_2 only word-initially and only when there is a clear anatolian cognate (Mallory and Adams p.55).

In addition to their non-syllabic, consonantal role, the laryngeals may also function as syllabic, vocalic phonemes, much in analogy with the resonants -- (the glides (i, i̯ ; u, u̯), liquids (r, r̥ ; l, l̥), and nasals (ṛ, ṛ̥ ; ṁ, ṁ̥) -- discussed above. As for the resonants, the syllabic (vocalic) laryngeals may be considered vocalic allophones of the consonant laryngeals. (Kobayashi pp. 127-128, Lehmann 12.3, Gamkrelidze p. 202) When a laryngeal is located between two non-syllabic consonants it becomes syllabic, presumably with the help of a supporting vowel. In most ie languages, the vocalic laryngeals develop into 'a', but, importantly, into 'i' in sanskrit. In greek, it is believed that the proposed three different laryngeals develop into three different vowels. I.e., CHC > CVC. E.g.,

* h_1 *dh h_1 s- "sacred, religious" -> धिष्ण- dhiSaNa m. "1) praise, hymn, 2) intelligent, wise, 3) name of an evil being (AV)" (related to धिक् ?), धी- dhi- "perceive, think" (sanskrit), θεσ-φρατως "decreed by god" (greek)

[* h_1] -> [i] (sanskrit)

[* h_1] -> [e] (greek)

* h_2 *sth h_2 -to'- "stood" -> स्थित- sthita'- "stood" (sanskrit), στατως (greek)

*ph h_2 te'r- "father" -> पितृ- pita'r- m. (sanskrit), πατηρ (greek)

[* h_2] -> [i] (sanskrit)

[* h_2] -> [a] (greek)

* h_3 *e'-dh h_3 -to "he gave" -> adita (Atm.s-aorist.3rd.sg dA-, sanskrit), εδοτο (greek)

[* h_3] -> [i] (sanskrit)

[* h_3] -> [o] (greek)

Some authors, like Lindeman, explain the three different vowels in greek as innovation following the merger of vocalic laryngeals. (Kobayashi p. 129)

In greek, armenian and phrygian, a laryngeal preceding a consonant at the beginning of a word develops into a vowel, i.e., HC- > VC-, whereas in all other ie languages, including sanskrit, that laryngeal is simply lost, so HC- > C-.

Non-syllabic, consonantal laryngeals contributed to a number of processes, which need to be appreciated in the morphophonetic context of vowel alternation (ablaut), accentuation and syllabic and root structure. But for our purposes here we can at least categorize them.

The effect of **laryngeal coloring** refers to the change in a neighboring 'e'. This is an early to mid PIE effect of the laryngeals affecting all ie languages, and serves as one of the earliest instances of loss of laryngeal with compensatory change.

* h_1 e -> e *e h_1 -> e:

* h_2 e -> a *e h_2 -> a:

* h_3 e -> o *e h_3 -> o:

Laryngeal coloring with change in vowel quality at this early stage of PIE frequently takes place without loss of the laryngeal. The postulated presence of laryngeals (before their effects in laryngeal coloring) facilitates the reconstruction of PIE roots as CVC (see below). It should be noted that not all PIE instances of 'a' and 'o' owe their existence to this effect of the laryngeals on 'e'; rather, independent instances of 'a' and 'o' can be reconstructed without invoking laryngeals to account for them. (Luraghi p. 66)

Secondly, non-syllabic laryngeals next to a vowel could be lost. This process takes place much later than laryngeal coloring and is seen to be incomplete in anatolian languages, which actually preserve reflexes of consonantal laryngeals -- especially h_2 and h_3 -- in the form of the velar fricative, 'ħ' - e.g., * h_2ant - -> ħant- "forehead". The laryngeal, h_1 , is lost even in anatolian. The effects of consonantal laryngeals in sanskrit and old avestan are evidenced by hiatuses or glottal stops. (Fortson p.58) An example is provided by Clackson (p.58) by the sanskrit word वऱत- vAta- m. "wind", which in vedic hymns is consistently trisyllabic, as va-ata, suggesting a hiatus at the time of composition of the verse that represents the loss of a laryngeal, the reconstructed form being * h_2weh_1-nt -. The consonantal laryngeals are lost in all non-anatolian ie languages.

Laryngeals following a vowel either at the end of a word or before a consonant were lost with **compensatory lengthening** of the vowel, so -VH, -VHC- --> - \bar{V} , - $\bar{V}C$ -. E.g., pih_1-urh_2 "fat" (f.) --> पीवरी plvarī (sanskrit). (Fortson p.58) Fortson mentions an analogous process with the English word, "night", where the 'i' undergoes compensatory lengthening with the loss of pronunciation of 'gh'.

The process of loss of laryngeals with concomitant phonological (and morphological) effects took place over a considerable time period, and probably in stages, starting in early PIE and reaching completion only in the individual early ie languages, during and soon after their differentiation.

The reconstruction of laryngeals is currently widely accepted and it should be appreciated that they are lost in nearly every ie language branch in a similar stepwise manner, according to similar rules, but importantly with effects that are unique to each ie branch.

For a list of common reflexes of PIE phonemes in ie languages see Appendix A and the following: Clackson pp. 37-39 (Tables 2.5a-c), Mallory & Adams pp.464-465 (Appendix 1)

The Glottalic theory.

The PIE inventory as presented above is the version most widely supported by indo-europeanists. Nonetheless, alternatives continue to enjoy support. One of these is the glottalic theory. The glottalic theory was proposed by Gamkrelidze and Ivanov (see references section). Some significant work has been done on the basis of this theory and many studies are presented in the glottalic context. Hence a familiarity with this theory and its PIE inventory is needed to interpret and have access to this work.

Briefly, this theory suggested that the traditional plain voiceless stops of the traditional system are voiceless aspirates, the traditional voiced unaspirated stops are voiceless glottalized stops and the traditional voiced aspirates remain voiced aspirates, but that aspiration is not phonemic. I.e., the traditional series p - b - bh corresponds to ph - p' - bh. The following is adapted from Mallory and Adams (p. 53)

	Traditional			Glottalic		
labiovelar:	k^w	g^w	g^{wh}	$k^{h'o}$	k'^o	$g^{h'o}$
velar:	k	g	g^h	k^h	k'	g^h
palatal:	\hat{k}	\hat{g}	\hat{g}^h	\hat{k}^h	\hat{k}'	\hat{g}^h
dental:	t	d	d^h	t^h	t'	d^h
labial:	p	b	b^h	p^h	p'	b^h

Basic phonological contrasts are maintained; what is negotiated is the value of the phonological entities, which cannot be tested.

The points that are reiterated in refuting the glottalic theory are: that the assumption that there are no languages in the world with a phonological inventory with PIE properties has been refuted; there is no direct evidence in any ie language for the sounds proposed by this theory; and that the phoneme [b], albeit rare, probably did exist in PIE. (For further discussion and criticism see Fortson p. 54 and Salmons, the glottalic theory.)

Brugmann's PIE phonological inventory (1888).

We include Karl Brugmann's PIE inventory as published in 1888 for reference -- based on "the eight Indo-Germanic dialects."

(See vol 1, p. 19 in Brugmann, Karl. (transl by Joseph Wright). Elements of the comparative grammar of the indo-germanic languages. Vols 1-5. Trubner & Co., London, 1888-1895.)

vowels [+syll]

e e:	a a:	o o:	i i:	u u:	ə (schwa)	ɾ ɾ:	:
	ɳ ɳ:	ŋ ɳ:	ŋ ɳ:	ɳ ɳ:	(both long and short vocalic nasal vowels)		

consonants [-syll]

velar:	k	k ^h	g	g ^h		ŋ	
palatal:	ĉ	ĉ ^h	ǵ	ǵ ^h	i [j]	ñ	j
dental:	t	t ^h	d	d ^h	l r	n	s z
labial:	p	p ^h	b	b ^h	u [w]	m	v

Notes:

1. Unvoiced aspirates are part of Brugmann's PIE inventory.
2. Each vowel has a long and short form, including those derived from resonants.
3. Not only included are nasals of all articulations (velar, palatal, dental, labial) but too are their corresponding vocalic long and short forms.
4. Both voiced and unvoiced dental sibilants are present, but not palatal or velar sibilants
5. The palatal phoneme 'j' and consonantal 'v' are in the inventory.
6. Diphthongs are not included:
ei ei: ai ai: oi oi:
eu eu: au au: ou ou:
7. Laryngeals and labiovelars are not included:
laryngeals (H) h₁ h₂ h₃
labiovelar: k^w g^w g^{wh}

A.2. Phonological changes affecting the morpheme.

In this section we discuss phonological processes affecting the root and syllable that are also relevant to morphological change. Much as phonemes exhibit allophones, morphemes exhibit allomorphs. The various phonological changes affecting syllabic or morphemic structure are referred to as morphophonemics. Each language system possess rules affecting the distribution of its allomorphs. Affected by phonological change are root morphemes, inflectional morphemes and morphemes involved in word formation, i.e., prefixes and suffixes forming nominal and verbal stems. The main elements of this discussion are vowel alternations (ablaut), accent and laryngeals -- all affecting the structure of the syllable.

The root.

When reconstructing morphemes and words in PIE, one typically starts with the root, the unit that determines the semantic value of the word. In 1935, Benveniste, building on recent works by Cuny and Kurylowicz, proposed that the fundamental structure of all PIE roots was CVC (or CeC), as

*sed- "sit" -> sad- (sanskrit), had- (avestan), sedeo (latin), сѣд- (ocs), sit (english)

*bher- "carry" -> bhar- (sanskrit), bar- (avestan), бер- (ocs), φερω (greek), parām (toch B)

The root could be elaborated with the addition of resonants on either side of the vowel, the consonants could form consonant clusters and an 's' could precede the basic structure.

The PIE root was monosyllabic.

The ordering of phonemes in PIE roots conform to a scale of sonority in which the elements on either side of the vowel are arranged in decreasing sonority (Fortson p. 69, Szemerényi p. 98, 128, Clackson p.69, Kobayashi p. 22-23). That is, the most sonorous segment represents the nucleus of the syllable. Reconstructed structures such as TeHT- and TeRH- indicate the sonority placement of the laryngeals, so

stops (T) and 's' > laryngeals > *i, *u, *m, *n, *r, *l (resonants)

Accordingly, from the fundamental structure proposed by Benveniste,
CeC-

we obtain the structural formula for the PIE root as,

(S) (T) (R) e (R) (T/S),

where S = sibilant, T = consonant stop, R = resonant, e = vowel.

For comparison, vedic roots conform to the formula (see Witzel p.4),

prefixes +/- {(s) (C) (R) (e) (R) (C/s)} +/- suffixes,

where

C = consonant, including laryngeals H = h₁, h₂, h₃.

e = standard PIE vowel (it can change to o (> skt. a), e, o (> skt. A) or disappear to null.

R = resonants, the semi-vowels, y, r, l, v, m, n, which can also appear as i, R, L, u, a.

and 's' found at the beginning of roots is unstable and can disappear.

In the paper cited, this formula is used by Witzel to identify words of non-IE origin.

Roots reconstructed with laryngeals help to account for numerous instances that would not conform to the above formula, yielding roots that start and end with a vowel, for instance. Their reconstructed distribution in roots exhibits a certain regularity and their sonority between obstruents and resonants is consistent. (Kobayashi p. 128) Referring to the phenomenon of "laryngeal coloring" allows one to reconstruct a conforming root structure, so

dhA- "put" (sanskrit) <-- [*dhē] <-- *dheh₁- (CeC) (loss of laryngeal with comp. length.)

anta- m. "limit" (sanskrit) <-- [*ant-] <-- *h₂ent- (CeRC) (see above)

*h₂ant- -> hant- "forehead" (hittite), ante "before" (latin), end (english)

The majority of roots reconstructed with laryngeals have the forms, *CeH, *HeC-, *HReC- and -CeRH-.

(Fortson p.72). One should note that for sanskrit PIE roots ending in a laryngeal become सेट् (seT) roots and those without a laryngeal become अनिट् (aniT) roots (Meier-Brugger p. 108, Fortson p.72, Lehmann ch. 3), as

*b^he_uH- "be" -> भू- bhU- भवितुम् bhavitum (infinitive), भूत- bhUta'- (ppl.)

*_uemh₁- "vomit" -> vom- vomitum (infinitive), वाम्त- vAMta'- (ppl.)

*terh₂- (*trh₂-?) "cross over" -> [*tř-] -> tR- tartum taritum (infinitive forms), tRNa'- (ppl.)

Hittite cognates with preserved laryngeal forms are found for a number of sanskrit seT verbal roots, as

ša-an-ḥa-an-zi "he conquers" (hittite) vs. san- "gain" sanoti sAta'- (sanskrit)

Roots classified as -- aniT, seT -- are used in forming the past participle, gerundive, infinitive (and grdv -tavya), noun deriv. kartR- -tR, future -sya-, sigm-aorists, desid -sa-. (see Sanskrit Verb System)

The distribution of sanskrit sibilants continues to observe the sonority principle. This behavior is unique among the IE languages. The sibilant can occur at the syllable onset when it precedes a resonant (sonorant). The sibilant can follow a voiceless stop at syllable onset and precede a resonant (or vowel). A sibilant occurring before voiceless plosive is considered extrasyllabic or s-mobile. A sibilant can end a syllable (often as visarga). The hierarchy of the sonority scale is observed -- plosive < sibilant < resonant < glide < vowel -- and as presented above. (Kobayashi pp. 42, 182-183)

Roots may also undergo "extensions" and "enlargements" -- yielding stems of words (or new roots) that function independently, as

*dhugh₂tēr "daughter" -> duhitR- f. (sanskrit), dughdar (avestan), (duh- "to milk" + i + tR-)

and

*dey- "sky, god" (Benveniste reconstruction of an archaic root, Clackson p. 66)

+ -w- -> [*dey-w-] -> *deiw- -> dyau'- "sky", Zdeu's (greek), Sius (hittite)

+ -ew- -> [*dey-ew] -> *dyew- -> deva'- "god" (sanskrit), diēvas "god" (lith), deus (latin)

The zero grade of both roots, *dyew- and *deiw-, is *diw-; and the fluctuation of the full grade vowel ('e' in this example) is called schwe-be-ablaut (Clackson p.74). So when a root suffix of the form -eC is added to a root, CeC, the 'e' of the root is dropped yielding CCeC.

Roots of the CeC structure in PIE appear to be subject to additional constraints. (Salmons, p. 34) The attested combination of consonants (value of C) in a CeC root appear to be: both voiceless; voiceless + voiced; voiced + aspirate; both aspirate (note Grassman's Law). Unattested (prohibited?) combinations consist of these: both voiced; voiceless + aspirate. "Of comparatively recent origin...(in sanskrit as in

greek)," of course, is that a root cannot both begin and end with an aspirate. (Whitney 155a, Kobayashi p. 114).

Identification of the root can be done with greater certainty in sanskrit than with any other ie language, due to the antiquity of the language as well as its abundant attestation. In most instances, the root is readily separated from inflectional elements and those in turn are also easily discerned. This makes sanskrit indispensable for PIE reconstruction and for understanding the inherited structure of all ie languages.

Morphemic vowel alternations (Ablaut).

The gradation of vowels in sanskrit morphemes -- स्वर svara (zero grade) --> हुण guNa (full grade) --> वृद्धि vRddhi (lengthened grade) -- is intrinsic to the phonology and morphology of sanskrit. These vowel alternations -- also referred to as ablaut and apophonie -- are very productive in sanskrit and represent a morphological device that allows the morpheme to adapt dynamically in nominal declensions, verbal conjugations, word formation, and so on. Indeed vowel gradation is among the most characteristic phonological attributes of ie languages. It may seem obvious, but it is essential to appreciate that ablaut generates synchronic allomorphs that coexist in time in the language. This is unlike the proposed effects of laryngeals which generate diachronic, evolutionary changes over time.

Ablaut, the facility of morphemic vowel alternation as a morphological device, is similarly reconstructed for PIE. That is, it is believed to be a widespread facility in all early ie languages. All morphemes can be affected -- roots, inflections, suffixes, prefixes, etc. Furthermore, all later ie languages have inherited ablauted ie forms and these forms cannot be explained within the histories of the individual languages. (Szemerényi p. 83) These allomorphic forms evolve into lexical morphemes (perceived "roots" of modern languages) and grammatical morphemes in later ie languages.

At this point it is worth mentioning that sanskrit, being displaced from PIE by some two thousand years, while largely preserving ablaut as a morphological device, has likewise inherited from PIE a number of grammatical forms and lexical elements that are difficult to account for within the system of sanskrit itself.

In the gradation of vowels in sanskrit, of the three forms -- स्वर svara (zero grade) --> हुण guNa (full grade) --> वृद्धि vRddhi (lengthened grade) -- the svara (zero grade) is regarded as the basic form that gives rise to the next two forms through enhancement of the vowel. However, in ie studies it is the full grade -- the equivalent of sanskrit हुण guNa -- that is the basic form from which one derives the zero grade (स्वर svara) in weak forms, termed "quantitative ablaut," and the lengthened grades (वृद्धि vRddhi), termed "qualitative ablaut." (Szemerényi p.85) For PIE the following grades of vowel alternation (ablaut) are reconstructed (Fortson p.73):

full grade (e-grade for roots with 'e')	*sed- "sit"
zero grade	*sd- (as in ni-sd-o'-)
o-grade	*sod-
lengthened e-grade	*sēd-
lengthened o-grade	*sōd-

These root grades once formed in PIE, in turn, each potentially give rise to forms inherited by ie languages. (Gamkrelidze pp. 230-231) E.g.,

*h₂e'k-mōn- "stone, sharp"

*h₂e'k-[mōn] -> अश्मन्- a'Zman- "stone" (sanskrit), asman "heaven" (avestan)

*h₂k^h-eH- -> शा- ZA- शिशति ZiZAti "sharpen" (sanskrit), камы "stone" (ocs)

*kei- -> сѣръ "grey" (ocs) < *soir-; сѣдъ < *soid-

*k_ieH- -> श्याव- ZyAva'- "dark colored" (sanskrit), syāva (avestan), šēmas "blue" (lithuanian)

*uer- -> ερω < *uer-jo "I call" (greek)

*ur-eH -> ρημα "word", ρητωρ "speaker" (greek)

-> ? उरस्- u'ras- n. "chest" (sanskrit), उरी- url- (particle of agreement) उरीकृ- url-kR- "make a promise"

Accent and zero grade.

Accentology plays an important role in understanding developments in ie phonology and morphology. The accent in PIE is believed to have been mobile as it is in vedic sanskrit, ancient greek and some slavic languages. Please refer to our section on sanskrit accent for a more detailed discussion on the properties of accent itself, and refer to our sections on nouns and verbs for examples on the effects of accent on morphology and on nominal and verbal stem strength.

Word accent influences the distribution of allomorphs in PIE. That is, accentuation determines the vowel grade of a given syllable. In PIE the loss of accent is associated with the zero grade, mainly before, but also after the accented syllable. The effects of this **quantitative ablaut** is obvious in sanskrit.

Observe the effect of stress on the forms of the present indicative and optative indicative in sanskrit, the optative being formed by adding the ablauting suffix, *-iēh₁- / -ih₁-, to the present stem. Take the verbal root, *h₁es- > √as- "be", as an example:

	present indicative (active)			optative indicative (active)		
	sg	du	pl	sg	du	pl
1	a'smi	sva's	sma's	syA'm	syA'va	syA'ma
2	a'si	stha's	stha'	syA's	syA'tam	syA'ta
3	a'sti	sta's	sa'nti	syA't	syA'tAm	syu's

a'smi <- *e's-mi <- *h₁e's-mi; sa'nti <- *sa'nti <- h₁se'nti

The reconstructed PIE verb, *h₁es- "be" (Fortson pp.87, 96), shows the effect of accent on the root syllable, resulting in the zero-grade in the unaccented forms:

	present indicative			optative indicative		
	sg	du	pl	sg	du	pl
1	*h ₁ e's-mi	*h ₁ s-ve'-	*h ₁ s-me'-	*h ₁ s-iēh ₁ -m	*h ₁ s-ih ₁ -ve'-	*h ₁ s-ih ₁ -me'-
2	*h ₁ e's-si	*h ₁ s-the'-	*h ₁ s-te'	*h ₁ s-iēh ₁ -s	*h ₁ s-ih ₁ -the'-	*h ₁ s-ih ₁ -te'-
3	*h ₁ e's-ti	*h ₁ s-te'	*h ₁ se'nti	*h ₁ s-iēh ₁ -t	*h ₁ s-ih ₁ -the'-	*h ₁ s-ih ₁ -e'nt-

	Greek:		Hittite:	
	sg	pl	sg	pl
1	eimi'	esme'n	ēšmi	
2	eī, essi'	este'	ēši	
3	esti'	eisi', enti'	ēšzi	ašanzi

Latin (Schmalsteig p.108) also shows the effects from PIE times of accent on the morphology

1	sum < *es-o'm	sumus < *es-o'mos
2	es < *e's-es	estis < *es-ete[s]
3	est < *e's-et	sunt < *es-o'nt

For ocs the following forms obtain, noting the presence of 'e' in the unstressed syllables, except for the 3rd.pl. form:

	sg	du	pl
1	юсмь	юсвѣ	юсмѣ
2	юси	юста	юсте
3	юстѣ	юсте	сѣтъ

Noting the presence of 'e' in the dual and plural forms in unaccented position in the non-sanskrit languages, on the basis of this verb alone, one would might infer that the final weakening of the unaccented vowel would have taken place in proto-indo-iranian (PIIr). The reconstruction of PIE accented zero-grade forms, such as *u̯k^wos "wolf" and *h₂ft̥kos- "bear", suggesting their appearance in early PIE (before the zero grade), further complicates the timing of this process (Fortson p.74) Some roots and inflections,

moreover, show no ablauting forms, such as the verb, *b^huH- -> भू- bhU-. (Fortson p. 87)

By the time of Sanskrit the effect of accent on ablaut is no longer dynamic, that is, the presence of strong or weak stems in morphologic forms has been established as a result of accent effects in late PIE. Accordingly an appreciation of accent-ablaut processes in PIE are needed to account for the forms in Sanskrit.

A few more examples here.

√ङ्- √i- "go" - strong stem ए- e-, weak stem इ- i-

एमि e'mi <- h₁e'-mi, इमः ima's <- h₁i-me's (parasm.pres.ind.1st.sg.&pl.)

For the verb -

√svap- "sleep" - pres.stem svap-, weak stem sup-, sva'ptum (infinitive), supta'- (pass.past.ppl.) - the null grade is reconstructed simply by the loss of PIE 'e' (by the loss of 'a' in Sanskrit) -

*s_uep- "sleep" (full grade) -> *sup- (null grade) (Meier-Brugger p. 148)

One should mention that for the presentation or naming of Sanskrit roots one makes use of the full grade (गुण guNa grade) when the zero grade (स्वर svara grade) is not admitted by Sanskrit phonology, as

मन्- man- "think", not ma-, *men- (full grade) -> *mṅ- (null grade), *mṅta'- (ppl.)

गम्- gam- "go", not ga-, *g^wem- (full grade) -> *g^wm- (null grade), *g^wm̐ta'- (ppl.)

In short, accent - affects the grade of the nominal and verbal stem - determines the allomorph to be used. For many roots, loss of the accent results in the root appearing in the zero grade. For syllables with simple vowels in the full grade, the null grade represents loss of the vowel (syncope), for syllables with a long vowel, the null grade may develop a short vowel, a schwa - ə. (Szemerényi pl 112) In addition, if the formation of the null grade (by loss of the mid vowel) should result in a sequence of obstruents (with no intervening resonants) then a "schwa secundum" may be epenthesized. If the root contains liquids (r, l) or nasals (n, m), then in zero grade these become syllabic -- as (r (R) [+syll], l (L) [+syll]) and (ṅ [+syll], m [+syll]) -- and the schwa - ə is not epenthesized. (Kobayashi p. 18)

An important function of ablaut is inflection. Ferdinand de Saussure is credited with presenting (in 1878) a unifying morphological model for the present system of the athematic Sanskrit 5th, 7th and 9th verbal classes. (Fortson p.75, Clackson pp.54, 56, Meier-Brugger p. 108) His approach involves combining full grade-zero grade vowel alternations with his then newly proposed laryngeals.

Comparing युज्- yuj- "join" (7th class), युनज्- yuna'j- (strong stem), युञ्ज- yuJj- (weak stem)

and पू- pU- "cleanse" (9th class), पुनA'- (strong stem), पुनl- (weak stem);

parasm.pres.ind.3rd.sg.	pass.past.ppl	s-fut.3rd.sg.	infinitive
yuna'kti <- *yu-na'-k-ti	yukta'- <-*yuk-to'-	yokSyati <- *yeuk-syati	yoktum <- *yeuk-tum
punA'ti <- *pu-na'-H-ti	pUta'- <- *puH-to'-	paviSyati <- *peuH-syati	pavitum <- *peuH-tum

The 5th class shows an analogous ablaut process - e.g., श्रु- Zru- "hear"

ZRNoti <- *k̑|neu'-ti Zruta'- <- *k̑|u-to'- ZroSyati <- **k̑|eu-syati Zrotum <- *k̑|eu-tum

Classes 7 and 9 obtain the infixation, *-ne- -> -na- (*-neu- -> -no- for class 5). One should add that the 8th class is conjugated much as the 5th class in that the root already ending in 'n' adds 'u' in weak forms, and 'o' in strong forms. Thus with a single reconstruction four verbal Sanskrit classes can be understood together.

Another illustration obtains by examining the conjugation of the verbal root, *steh₂- > स्था- sthA- "stand, be". (Meier-Brugger p. 109)

PIE	intermediate	Sanskrit
*steh ₂ -	*sthaH-	sthA-
	*sthaHtum	sthAtum, (simple loss of H with compensatory lengthening)
	*tHsthaHti	tiSThati, (reduplicated syllable is zero grade)
*sth ₂ to'-	*sthHta'-	sthita'-, (unstressed syllable is zero grade)
	*sthHya'te	sthlyate

Note that *sthaH- *sthHta'- sthaHtum (sthA- sthita'- sthAtum, स्था- स्थित- स्थातुम्) is analogous to bhā-

bhRta'- bhartum (भृ- भृत- भर्तुम्).

The root, *h₂enh₁- "to breathe", *h₂enh₁ōs "act of breathing" forms gen sg. as *h₂nh₁oe's > *h₂ne's, from which the nominal form for "nose" obtains as *h₂ne's -> nas- f. (sanskrit) and derivatives. (Meier-Brugger p. 119) The variability of the conjugation in the present system of अन्- an- "to breathe", forming parasm.pres.ind.3rd.sg. a'nati and a'niti can perhaps be clarified using a pres.ind.3rd.sg. form like *h₂e'nh₁-ti > *h₂a'nh₁.ti > a'niti (second athematic conjugation) -> a'nati (first thematic conjugation).

Long vowel grades.

The long grades (lengthened grades) of vowel alternations have their origin from full grade roots and syllables and are referred to as **qualitative ablaut**. In addition to the zero grade and full grade (e-grade) discussed above, reconstructed also are o-grade (full grade) and lengthened e-grade and lengthened o-grade. This is predominantly done on the basis of greek phonology with considerable supporting evidence from germanic and balto-slavic forms. (Meier-Brugger pp.144-158) The most common example cited is from greek in the word for "father," *ph₂ters, *ph₂tēr. (Note that *-VRs, where R is a resonant could become *-VR (Fortson p. 64), like *k₁uons -> k₁uōn "dog" -> श्वन्- Zva'n-)

	full grade	lengthened grade	null grade
e	pate'ra (acc.sg)	patēr (nom.sg)	patros (gen.sg)
o	eu-pa'tora (acc.sg)	eu-pa'tōr (nom.sg)	

The o-grade as a full grade allophone of the e-grade may have chronologically preceded the development of the zero grade. The o-grade is a qualitative e/o vowel alternation. It is conceptualized as a weakening of the vowel in the sequences -eR and -oR, where R = r, l, m, n, allowing the coalescence into -oR in many forms. (Szemerényi p. 120). The long vowel grades largely represent compensatory lengthening from consonant loss (laryngeal or otherwise). Indeed the simple loss of laryngeals is used to account for numerous instances of long vowels. Even the word, *mūs "mouse" is hypothesized to have arisen from *mus-s, and nās (nom.sg) from *nas-s (nom.sg.), with root, *nas-. (Szemerényi p.117) In short, the long grade represents a transformation of the normal full grade in particular circumstances. (Szemerényi p. 119).

The changes, e/o, ē/ō, ∅ (null) are observed for many roots and syllables.

For sanskrit and the entire indo-iranian system, one must consider the unconditioned merger of *e, *o, *a into *a, both long and short vowels. This shared innovation is often cited as one of the most characteristic features of the indo-iranian phonological system. The quantitative ablaut (full grade-zero grade) is well preserved in sanskrit and remains readily recognized. However the qualitative vowel alternations (o-grade and lengthened grades) are obscured in indo-iranian as a result of the mergers,

PIE [*e, *o, *a] -> PIIr [*a] and PIE [*e:, *o:, *a:] -> PIIr [*a:]

In sanskrit, additionally, vowels in neighboring syllables do not affect each other, that is, qualitative ablaut is not operational. "This inertness or seeming equipollency of vowel features is a characteristic of Indo-Aryan." (Kobayashi p. 136)

Having reconstructed late PIE forms on the basis of greek and other ie systems, there are clues where to look. For instance, reduplicated sanskrit forms, such as कृ- kR-, चकार cakAra, suggest a prior 'e' in the reduplicating syllable and 'ō' in the root syllable. (see Brugmann's Law below, Meier-Brugger p. 147, Fortson p. 183)

B. Changes in late PIE leading to proto-indo-iranian (PIIr).

The concept of PIIr represents a collection of phonologic (and morphologic, syntactic) qualities -- that distinguish indo-iranian from other ie systems but at the same time (for the most part) -- that are shared by indo-iranian dialects before their differentiation into indic, iranian and kafiri. Here we will outline a relative chronology of phonological changes occurring in late PIE and early PIIr, These may need to be presented as groups of changes where the timing is unclear.

Deciding on a starting point is difficult, since PIE underwent an evolution in its own right from early PIE through middle to late PIE. Such events as the coloring of laryngeals and vowel alternations

represent innovations shared by all ie languages and so relate to the common PIE period. Since many of these early events account for the phonology and structure of ie languages later in their development, they should be included in the scheme of evolution.

The phonological changes from early to late PIE and in late PIE itself can be viewed as a setting in which dialectal variations were facilitated, and these dialectal variations are likely to have taken place well before the time we can identify language differentiation in PIE. Accordingly, the view of late PIE as linguistically inhomogeneous -- with numerous dialect continua, isoglosses and even discreet dialects -- is consistent with subsequent developments. Such is the case with PIIr as well, which is considered to have shown early differentiation, at least dialectal, of indic from iranian. (Sims-Williams, pp. 79-83).

B.1. Loss of syllabic nasals, *m̥ and *n̥.

The syllabic nasals, *m̥ and *n̥, are recovered in PIE as allophones of consonantal *m and *n, (Meier-Brugger p.99) with the help of large correspondence sets from many ie language systems. In analogy to well attested vedic भृ- bhR- भृ- bhar- भृत- bhRta'-, the root of मन्- man-, *m̥nta'- > मत- mata'- is obtained as *m̥n-. The initial use of prop vowels in PIE is followed by nasalization of the prop vowel and then denasalization. That is, [*m̥, *n̥] > [a] (short vowel). But this process may be interrupted if a another vowel follows, yielding a(m) and a(n). In sanskrit the negating prefix, *n̥-, has the form, a-, unless followed by a vowel; then the 'n' is preserved as an-. Attested ie languages exhibit various stages of this process, as menti (latin), ПАМАТЬ (ocs), mati'- f. (sanskrit). On the basis of sanskrit evidence, the loss of syllabic nasals precedes the loss of laryngeals with compensatory lengthening. (Meier-Brugger p. 124) as illustrated by the following, **ĝnh₁-to'- "born" -> *jah₁-to'- -> jAta'- (ppl. of jan-), zāta- (avestan). Greek and latin forms similarly reflect laryngeal compensatory lengthening that is expected to act only on the prop vowel not the original vocalic nasal. While the complete loss of the syllabic nasals is common to all ie languages, the selection of the prop vowel and the extent of progression of this process creates dialectal isoglosses in the late PIE community.

Only indo-iranian and greek show the full excursion of the vocalic nasals to [a:], Anatolian, armenian and tocharian make use of 'a' as the prop vowel, albeit preserving the consonantal nasal as -am-, -an-. The other groups of ie languages employ 'e', 'i' or 'u' as a prop vowel. One might also appreciate for indo-iranian that the loss of syllabic nasals occurs well before the unconditioned merger of 'e', 'o' and 'a' - and so the prop vowel might have been 'e' as in italo-celtic and slavic, but not 'i' as in baltic, nor 'u' as in gothic.

For indo-iranian,
PIE [*m̥, *n̥] > [a] or [an, am].

After this change, 'm' and 'n' can only be consonantal in avestan and sanskrit. (Beekes-1988 pp. 95-96)

By way of relative chronology, Kobayashi places this event to a time in late PIE (pre-PIIrr) when 'a' was the default epenthetic vowel (Kobayashi pp.137-138), but might have been 'e' as mentioned above.

period	event	epenthetic vowel
PIE	schwa secundum	null, schwa [ø, ə]
pre-PIIrr	[*m̥, *n̥] > [a]	a
PIIrr-vedic	H > i	i
OIA	rC > raC	a

Another of Saussure's accomplishments was the deduction that the inflection in the accusative singular is for PIE was *-m̥ (and its allophone -m), resulting in sanskrit in *-m -> -m for thematic nouns and *-m̥ -> -am for athematic nouns (masc and fem). (Luraghi p. 64)

B.2. Palatalization of palatal velars, *k̑, *ĝ, *ĝh.

While the velar phonological contrasts described in the phonological inventory above remain in force --

labiovelar:	k ^w	g ^w	g ^{wh}
plain velar:	k	g	g ^h

palatal velar: \hat{k} \hat{g} \hat{g}^h
 -- the palatal velars undergo palatalization and affrication in a large group of ie languages --
 $[\hat{k}, \hat{g}, \hat{g}^h] > [c, j, j^h]$

These palatal affricates [c, j, j^h] later during the PIIr period developed into [ॠ [ɕ] (Z), ॡ [dʒ] (j), ॢ [h] (h) < ॣ [dʒ^h] (jh)] in indic and [ś, ź, ź^h] in iranian, but remained as [c, j, j^h] in nuristani (kafiri). This forms an important isogloss in PIE yielding what becomes known as the satəm group, named after the avestan word for "one hundred" -- comprising indo-iranian, baltic, slavic, albanian and armenian -- also referred to as the "central" group of ie languages.

*k^hto'm (one hundred) -> शतम् Zata'- n. (sanskrit), satəm (avestan), сѣто' (ocs), szi'mtas (lith)
 -> ε-κατον (greek), centum (latin), hunda (goth), cant (welsh), kǎnt (tocharian A), kante (Tocharian B)

The remaining "outer" ie group, not participating in this innovation, are referred to as the centum group, named after the latin word for "one hundred" -- comprising greek, italo-celtic, tocharian, and germanic. Interestingly, as this isogloss divides greek (centum) and armenian (satəm), it also divides hittite (centum) from luwian and lycian (both satəm). (Szemerényi p. 148 footnote, Meier-Brugger p. 130) A number of words in baltic show unpalatalized velars corresponding to their palatalized cognates in other satəm languages. (Clackson p. 52) With the satəmization isogloss running through such closely related groups as greco-armenian and anatolian, it is prudent not to overemphasize this process as a defining change in ie languages, as was done in early ie research. By analogy then should one postpone the subsequent deaffrication -- seen in proto-indic and proto-iranian but with preservation of affrication in proto-nuristani -- to the PIIr period and later? Szemerényi points out difficulties in using nuristani data, thereby implying that the full progression of the palatalization of the palatal velars to deaffricated sibilants in PIIr, as also seen for slavic, need not be delayed on the basis of the nuristani data alone. (Szemerényi p. 148)

This process yields the palatal affricates of PIIr, with the phonological contrasts preserved:

labiovelar:	k^w	g^w	g^{wh}
plain velar:	k	g	g ^h
palatal affricates:	c	j	j ^h

The labiovelars and plain velars are believed not to have changed at this point. (approx 4100-3800 BCE, Harmatta)

Evidence based on borrowings contribute to this picture. The recognition of the finnish words for "eight", kah-deksan, and "nine", yh-deksän, as having a PIIr form of "ten", deksan, that is a reflex of *det's'an (or [detʃan] -- *deḱm̥ (PIE) -> *detʃam (PIIr) -> दश- daZa- (sanskrit) -- helps to time and localize the phonological change. And the hittite word for "five", panza, is a borrowing from proto-indic from about 1500 BC, suggesting that not only had the vowel merger of 'e', 'o' and 'a' already taken place, but that the palatalization of the palatal velars -- *penk^we > पञ्च- paJca -- would have been completed at least 500 years earlier, before 2000 BC. (Szemerényi p. 147, Fortson p. 184, Tremblay p. 172, see also Parpola-2012)

Considering the distribution of the palatalization of the palatal velars as affecting only the central group, it has been conceptualized as a phonological change emanating from a center and then spreading outwards, with the prime central candidates being indo-iranian or slavic. (Szemerényi p. 147)

For the root, *ue' \hat{k} - -> वॠ- vaZ- "wish, command", conjugated in parasm.pres.ind., with strong stem वॠ- va'Z- **and** weak stem उॠ- uZ-, one might suppose the following evolution:

1sg va'Zmi <- *ue'tʃ-mi <- *ue' \hat{k} -mi

- 2 va'kSi <- *ue'kSi <- *ue'k̂Si (dissimilation of [tʃ] to [kS])
 3 va'STi <- *ue'tʃ-ti <- *ue'k̂-ti
- 1pl uZma's <- *utʃ-ma's <- *uek̂ma's
 2 uSTha' <- *utʃ-tha' <- *uek̂-tha'
 3 uZa'nti <- *utʃ-a'nti <- *uek̂-a'nti

As described above the PIE palatal velars developed into palatal affricates, affecting a large group of ie languages, [k̂, ĝ, ĝʰ] > [c, j, jʰ]. The palatal affricates [c, j, jʰ] represent a transition state from which further palatalization and spirantization (deaffrication) occurred in the satəm languages. And there is some difference among investigators as to the timing of this event. The full excursion of this palatalization, with particular attention to indo-iranian (Fortson p. 206, Sims-Williams p. 104), can be represented thus:

PIE	sanskrit	avestan	nuristani(kafiri)	ocs	lith	armenian
*k̂	श् [ʃ] (Z)	s	c [ts]	c [s]	š	s
*ĝ	ज् [dʒ] (j)	z	z [dz]	z [z]	ž	c
*ĝʰ	ह h [h]	z	z [dz]	z [z]	ž	j z

The similarity of outcomes in slavic and iranian is noteworthy. Recognizing that this process involves a large group of ie languages the discussion of its initial stages should be included in the common ie period, even though the later and final stages would have been processed by the ie languages individually and perhaps at different rates.

An important consideration is that the original PIE sibilant, 's', is preserved mostly intact in all the ie languages. The palatalization of palatal velars is the source of additional sibilants in the satəm group.

B.3. Labiovelars merge with plain velars.

The satəm group of ie languages also share the loss of phonological contrast between labiovelars and plain velars. The timing of this process is definitely after palatalization of the palatal velars into palatal affricates. Although Harmatta provides the timeline, 3500-3200 BCE, for the merger of labio and plain velars, this process can only be said to have occurred sometime after the palatalization of palatal velars but before the palatalization of plain velars before [i, i, e]. As a result there is some variability in the relative chronology presented by various authors regarding this step. Indeed, a number of other phonological changes occur in the time frame after the development of the palatal affricates.

In the satəm group and in particular in PIIr the labiovelars merged with the remaining velar series, [kʷ, gʷ, gʷʰ] > [k, g, gʰ],

with the resulting consonant inventory being simplified to the following:

plain velar:	k	g	gʰ
palatal affricates:	c	j	jʰ

This development is an obligatory step in accounting for the later palatalization of the velars [k, g, gʰ] preceding [i, i, e].

B.4. Palatalization of plain velars before front vowels.

Some time after the merging of the labio and plain velars, the velars, [k, g, gʰ], preceding [i, i, e], having produced the palatalized allophones, [kʲ, gʲ, gʲʰ], developed into the post-(palatal)-alveolar affricates, [č, j, jʰ]. (Skjærvø pp.48-51, Kobayashi p. 13)

[k, g, gʰ][i, i, e] > [kʲ, gʲ, gʲʰ][i, i, e]

[kʲ, gʲ, gʲʰ] > [č, j, jʰ]

It is obligatory that the above change went to completion before the PIIr vowel merger,

PIE [*e, *o, *a] -> PIIr [*a] and PIE [*e:, *o:, *a:] -> PIIr [*a:],

after which [č, j, jʰ] become phonemic.

Both Skjærvø and Kobayashi present two palatal series for PIIr that maintain phonological contrast by place of articulation (Skjærvø p. 50, Kobayashi pp. 73-74):

plain velars:	k	g	g ^h
secondary palatal (palato-alveolars):	č [tʃ]	j [dʒ]	j ^h
primary palatal (palatal affricates):	c [tʃ]	j [dʒ]	j ^h

This arrangement allows for the leisurely deaffrication (spirantization) during the PIIr period of the primary palatal affricates [c, j, jʰ] -- which developed from the palatal velars [č, ġ, ġʰ] -- into [ʃ [ʃ] (Z), ʒ [dʒ] (j), ʒʰ [h] (h) < ʒʰ [dʒʰ] (jh)] in indic and [š, ž, žʰ] in iranian but to continue as [c, j, jʰ] in nuristani (kafiri).

While the primary palatal affricate series is understood as being pronounced as [c [tʃ] or [tʃ], j [dʒ] or [dʒ], jʰ], the anticipated pronunciation of the two palatal affricate series are conceptualized as palatalized velars or palatal stops approaching dorsal affricates, as [č [tʃ] or [k], j [dʒ] or [g], jʰ]. (Kobayashi p. 74)

The palatalization of plain (and labio) velars before front vowels is referred to as **the Law of Palatals**. (Clackson p.32)

The indoeuropeanists (much earlier work than Skjærvø and Kobayashi), however, avoid the positing of two phonologically contrasting palatal series by admitting the completion of the palatalization of the original palatal velars well before the palatalization of plain velars before front vowels. (Harmatta, Voyles, Meier-Brugger p. 130) Fortson, Clackson and Szemerényi do not directly address this relative chronology. For proto-nuristani this creates a probable merger of the palatals generated by both palatalization processes. In the nuristani (kafiri) group, then, words exhibiting the further palatalization of the original palatal velars -- i.e., containing indic forms with ʃ [ʃ] and ʒʰ [h] or iranian forms with [š] and [ž] -- are considered borrowings from indic and iranian proper. (Sims-Williams p.104)

The palatalization of velars before front vowels involves indo-iranian and slavic - e.g., (listed under merged labio and plain velars, [kʷ, k], [č] -> [k], [č])

*k

*kreu_h₂- / *kru_h₂- "raw, bloody" -> kraviS- n. "meat" (sanskrit), кръвь (ocs) - no change before 'r'

*kʷo- "who" -> कः kas (sanskrit), кто (ocs) -- no change before 'o'

*kʷet_uer- "four" -> catu'r-, catvA'r- (strong stem) (sanskrit), āxtūrim "4 times" (late avestan), четьре (ocs), keturi (lith) - palatalization of velar before front vowel 'e'

*pe'nkʷe "five" -> पञ्च paJca (sanskrit)

*kʷekʷr- "did" -> *cakr- (PIIr), caxr- (avestan), (Fortson p. 181)

*kʷekʷorh₂e "he did" -> *cekora (PIIr) -> चकार cakAra (parasm.perf.ind.3rd.sg. कृ-)

*g

*gʷou- "cow" -> gav- m."bull" f. "cow" - no change before 'o'

*gʷih₃uo- "living" -> जीव- jIva- "alive", живъ (ocs) - palatalizn before front vowel 'i'

*gʷen- "woman" -> ja'ni- f. (sanskrit); jaini- (avestan), жена (ocs)

*g^h

*h₁lŋgʷh-u'- / *h₁lŋgʷh-ro'- -> raghu'- "swift", laghu'- "light" (sanskrit) - no change before 'u'

*gʷh-en- "strike" -> han- ghnanti (parasm.pres.ind.3rd.pl.), ghnant- (pres.act.ppl.) (sanskrit)

-> jainti (avestan) < j^henti < g^henti < *gʷhenti (PIE)

-> гонити (ocs)

Accordingly, the full excursion of the palatalization of plain velars (merged PIE labio and plain velars) before [i, i, e] results in the following (ocs and lithuanian for comparison):

late PIE ->	PIIr ->	sanskrit	avestan	ocs	lith
[kʷ, k] -> [k]	č [tʃ]	च् [tʃ] (c)	c [tʃ]	ч	k
[gʷ, g] -> [g]	j [dʒ]	ज् [dʒ] (j)	j [dʒ]	ж, з	g
[gʷ ^h , g ^h] > [g ^h]	j ^h	ह [h] (h)	j [dʒ]	з	g

One should observe that in latin (a centum language), the palatalization of 'k' before front vowels does indeed occur, although a "tad" later, during its development into the modern romance languages, as centum (latin) > cent (french), cento (italian).

In indo-iranian and slavic, prior to the PIE vowel merger of [e, o, a] > [a], the merged labial and plain velars became palatalized before e, i and the semivowel y (i [j]) (see Szemerényi p. 63, Meier-Brugger p. 130).

B.5. Consonant Clusters.

In PIE consonant clusters are found not only in roots, but are the result of inflection (suffixation), word formation and word boundaries. Consonant clusters in PIE occur most commonly at the beginnings of words, with a word-initial maximum of three. But occasionally word-internal sequences of four are observed. (Fortson p. 58)

Two-consonant word-initial combinations are represented by almost all possible consonant combinations, and those where the second is a resonant being the most frequent. The second consonant is a stop or laryngeal only when the first is an 's'. Word-initial clusters beginning with the consonants, 'l', 'r', 'l', and 'n' are not observed (note sonority principle).

e.g.,

*k ^w rei- "buy"	> क्री- krl- "buy"
*ǵneh ₃ - "know"	> ज्ञा- jJA- "know"
*h ₂ ner- "man"	> नर- nara- "man"
*h ₃ reǵ- "stretch out hands"	> रा- रास् rA- rAs- "give, present"
*sh ₂ eh ₁ -i- "bind"	> सा- sA- (si-), bind

Word-initial clusters with three consonants are observed.

*h ₂ ster- "star"	> तार- tAra- mn. "star", तारा- f.
*h ₁ s ₁ eh ₁ - "be" optative	> syA- (parasm.pres.opt. stem of as- "be")

The following is an example of a word final consonant cluster formed through inflection -- a present active participle of the root *bher- "to carry, bear,"

*bheronts (pres.act.ppl.m.nom.sg.) > भरन् bharan(-ts) (parasm.pres.act.ppl.m.nom.sg. भृ- bhR-)

In sanskrit word-final consonant clusters are simplified to the consonant following the last vowel.

By convention, the PIE root is described in its full grade (गुण grade), the sanskrit root in the zero grade (स्वर grade).

PIE already had mechanisms and rules by which to process consonant clusters formed through inflection, suffixation and at word boundaries. These are reconstructed from ie correspondence sets of inflected forms.

Voicing assimilation and aspiration. Apposed consonants exhibit regressive (right to left) voicing assimilation, as

the conjugation of PIE *h₁ed- "to eat" forming the act.pres.ind.2nd.sg. h₁ed- + -si -> h₁etsi inherited by sanskrit as, अद्- ad- -> [अद्-सि ad-si] -> अत्सि atsi (parasm.pres.ind.2nd.sg.)

and by hittite as "ezzi" (pronounced e't-si).

*ni-sd-o -> *ni-zd-o "nest" -> нѣздо (ocs), नीड- niDa'- m. (sanskrit) (see above)

However, if a voiced aspirate is followed by an unvoiced consonant, the voiced aspirate loses its aspiration and the unvoiced consonant becomes voiced and aspirated. This is referred to as

Bartholomae's Law, so

*mugh-to'- "dazed" (PIE) -> मुग्ध- mugdha'-, मूढ- mUDha'- "confused" (ppl of मुह्- muh-)

*urd^h-to'- "grow, mature" -> [*vr̥dh-ta'-] -> [*vr̥d-dha'-] -> वृद्ध- vRddha'- (ppl. of वृध्- vRdh-)

-> -> [*vr̥dh-ta'-] -> [*vr̥d-dha'-] -> [*vrz-dha'-] -> vrzda- (avestan)

And this law is still active in sanskrit, as बुध्-त- -> बुद्ध-, लभ्-तुम् -> लब्धुम्.

But in the case of unvoiced aspirates that arise from PIE unvoiced stop + laryngeal h₂, anaptyxis of 'i' is produced by the laryngeal as well as aspiration of the unvoiced stop, so Bartholomae's Law does not

apply, as (Kobayashi p. 117)

*meth₂-to'- "ripped" -> [*mat^h-i-ta'-] (not [*mat^ha'-]) -> mathita'- (ppl. of manth- math- "stir")

Avestan preserves the progressive assimilation of Bartholomae's Law (Fortson p. 204), like in the cluster -zd-, although consonant aspiration has been lost. By way of relative chronology, Bartholomae's Law operates before the loss of aspirates in Iranian (Beekes-1988 p. 75).

Relating to aspiration but not voicing assimilation is **Grassmann's Law**, which describes the loss of aspiration in the first of two aspirated stops in sequence, as *bheudh-eti -> bodhati, *bhudh-to'- (PIE) -> buddha'- (sanskrit). (Fortson p. 188) That is, an aspirate at the beginning of a syllable loses its aspiration if another aspirate comes at the end of the same syllable or at the beginning of the next. (Edgerton p. 5, Burrow p. 70) The presence of two voiced aspirates, as well as one voiced and one aspirate, in roots of CeC structure is reconstructed for PIE. (The presence of a voiceless stop with another aspirate is not permitted in PIE, unless the voiceless aspirate is preceded by 's' (Kobayashi p. 105)) With the operation of Grassmann's Law, and the deaspiration of the first voiced aspirate consonant, one would anticipate the generation of homonyms. There are reconstructed minimal pairs in PIE contrasting in the aspiration of the initial voiced stop, But sanskrit has no homonyms generated by Grassmann's Law -- i.e., [*C^heC^h, *CeC^h] > [CeC^h]. This has led to the suggestion that PIE roots be represented with a single aspirate and that the diaspirate roots may be a result of "aspiration throwback," an autosegmental reinking of the [spread glottis] (aspiration) phonological feature from the single aspirate giving it mobility. (Kobayashi pp. 114, 122, Burrow p. 71, Wh155, 391f) E.g., druh- "enemy", dhruk (nom.sg.), dhruqbhis (instr.pl.), dhruqbhyas (dat-abl.pl.), dhruksu (loc.pl.), in which the plural forms violate Grassmann's Law. Aspiration throwback does not affect Bartholomae's Law.

Sieb's Law, elaborated by Illic-Svityc, states that in PIE in word-initial position a voiced stop became unvoiced and voiced aspirate became unvoiced (and could also become unaspirated) when preceded by 's', so that word initial 'sk' and 'sg' become 'sk', while 's' + 'gh' become 'sk^h' (sanskrit), 'σχ' (greek), 'sk' (other ie languages). (Szemerényi p. 104) This process represents one significant source of unvoiced aspirates inherited by sanskrit. (Kobayashi p. 104)

Dental-dental clusters. In PIE the occurrence of two dental consonants in apposition resulted in the epenthesis of 's' between them. This combination was extremely common, occurring, for instance, whenever a stem final dental was followed by an inflection beginning with a consonant. The sequences, *-tt- (also resulting from *-dt- (vs)) and *-dd-, resulted in *-tst- and *-dzd-. This cluster persists in anatolian as -tst-, but undergoes simplification elsewhere, as '-tt-' (sanskrit), '-st-' (iranian, greek, baltic, slavic), '-ss-' (italic, celtic, germanic). (Fortson pp. 63, 181, 204, 230, Beekes-1988 p. 74)

E.g., PIE *h₁ed- "eat" ->

*h₁ed-te (imperative.2nd.sg) -> *h₁et-te (voicing assimilation) -> *h₁etste ('s' epenthesis)
-> ēzten (pronounced e'tsten, hittite), अत्ता atta (sanskrit)

*h₁ēd-ti (act.pres.ind.3rd.sg) -> *h₁ēt-ti (voicing assimilation) -> *h₁ētste ('s' epenthesis)
-> अत्ति atti (sanskrit), ésti (lithuanian), ясть (inf. ясти) (ocs) <- jasti (psl.)

In the event of aspirated dentals Bartholomae's Law operates before the 's' epenthesis, so

In PIE: *-dh-t- -> *-d-dh- -> *-d-z-dh- (inherited by PIIr)

In Indic: *tst > tt, *dzd > dd, dzdh > ddh

In Iranian: *tst > st, *dzd > zd, *dzdh > *zdh > zd

e.g., *uid-to'- "known" -> vitta'- (vid- "find", originally identical with vid- "know"), vista- (avestan),

*sed- "sit" -> *sed-to'- (ppl.) -> सद्- sad- सत्- satta'- सन्न- sanna'- (sanskrit), hasta- (avestan), -sessus (latin), sess (Irish), сѣсти (ocs), sésti (lithuanian) (Szemerényi p. 103)

The epenthesis of 's' in PIE avoids gemination across morpheme boundary. (Kobayashi p. 38) This is inherited by PIIr. While avestan continues to block gemination across a morpheme boundary, indic proceeds to eliminate the epenthesezid sibilant and we observe abundant gemination in sanskrit.

Degemination of *ss. The cluster of *-ss- arising at morpheme boundaries was simplified in PIE to a single 's'. E.g., *h₁es- "to be", *h₁es-si (pres.ind.2nd.sg.) -> *h₁esi. So, अस्- as- "be", असि asi (parasm.pres.ind.2nd.sg.) (sanskrit), eī < *ehi < *esi (greek). (Fortson p. 63, Meier-Brugger pp. 104-106) This process may have begun even in the pre-PIE period and is referred to as the pre-PIE geminate

simplification rule.

In this case, again, gemination across a morpheme boundary is avoided.

Degemination of *ss is inherited by and continued in PIIr. Avestan may demonstrate fricative clusters, but geminate sibilants are simplified as they are in PIIr and PIE. (Kobayashi p. 44, Skjærvø p. 50) After the PIIr period, indic preserves some degeminate forms -- like 'asi' (parasm.pres.ind.2nd.sg. of as- "be"), apa'su < *apas-su (loc.pl. a'pas- n. "work"), अंहुसु aMhasu (loc.pl. aMhas- n. "sin") -- but these are considered relic forms.

In sanskrit, however, by the vedic period, geminate sibilants become common -- either 'ss' or with the first sibilant attenuated to visarga as 'Hs'. The sequence of स्-ष् 'sS' is changed to विसर्ग-ष् 'visarga-S', as in चतुःषत् catuHSata "400". And the sequence स्-श् 'sZ' always turns into विसर्ग-श् 'visarga-Z'. In brief, as illustrated by the prefix, dus-, the 's' becomes a visarga (and only infrequently 's, S or Z') before स्, ष, श्, 's, S, Z'.

-स्-/-ष्- -ss-/-SS-

वक्षस्सु va'kSassu (loc.pl. va'kSas- n. "chest")

श्रवस्सु Zra'vassu (loc.pl. Zra'vas- n. "sound")

हविष्षु haviSSu (loc.pl. havis- n. "burnt offering, oblation with fire")

निष्पिध- niSSidh- and निःपिध- niHSidh- f. "gift, donation" (< nis- + sidh- "succeed")
but only niHSidh- "to frighten away" (< nis- + sidh- "to repel")

विसर्ग-स् / विसर्ग-ष्- -Hs-/-HS-

चतुःसहस्र- catuHsahasra- "4000"

पुरःसदः puraHsadaH or pura-sadaH "presiding in front"

दःसगरः duHsagaraH "sea of troubles" (see MWD entry for दुस्- dus)

दुःषहस- duHSahas- "weakness, intolerance" <- dus- + sahas- n. "power"

Degemination and the block on gemination across morpheme boundaries present in PIE and PIIr ceases to be observed in sanskrit from before the vedic period.

Consonant clusters resulting in sanskrit क्ष- kS- There are a number of PIE consonant clusters each showing a distinct development in ie languages. Interestingly, a great many of them in sanskrit have merged to क्ष- kS-. As a result the original consonant cluster can only be recovered using all available ie languages. When comparing sanskrit forms containing क्ष- kS- with ie cognates, one should be prepared to encounter a very different consonant or consonant group.

A brief mention was made in the section on PIE phonological inventory about consonant clusters, specifically about dental-velar "t-k" clusters and several examples were presented. The t-k cluster, whose dental-velar sequence is preserved only in anatolian and tocharian, illustrates some of the considerations arising in reconstruction.

PIE *d^héǵhōm- str.stem, *d^hǵhm- wk.stem, "earth", (Meier-Brugger p.106, Beekes-95 p.134)

PIE *d^héǵhōm (nom.sg) -> tēkan (nom.sg) (hittite)

PIE *d^hǵhm- wk.stem -> takn- (proto-anatolian), suggesting that the development of a schwa secundum in *d^hǵhm- -> *d^həǵhm- -> takn- allowed anatolian to keep the initial dental (Maier-Brugger p.106), without which the weak stem is simplified, as *d^hǵhm- -> *ǵhm-, so

PIE *d^hǵhm- -> *ǵhm-:

zam- (avestan), χαμαι "on earth" (greek), humī "on earth" > humus (latin), žeme (lithuanian), земля (ocs), or undergoes metathesis, as *d^hǵhm- -> *ǵhd^hm- or *d^héǵhōm -> *d^hǵhōm- -> *ǵhd^hōm-, so that PIE *ǵhd^h- -> [*k^ht^h-] -> χθ (greek), क्ष- kS- (sanskrit).

So for sanskrit, PIE *d^héǵhōm-, *d^hǵhm- ->

1) *ǵhd^hōm (metathesis) -> kSam- f. "earth";

2) *ǵhm- (simplification of wk.stem) -> ga'm- f., ja'm- f. "earth".

Note that the sanskrit roots, gam- and jam- f. "earth", are attested only in the weak cases (instrumental,

ablative, genitive) (Mac338), not in the nominative or accusative, so that in declension some of the attested forms for क्षम्- kSam- f. in the singular would be: क्षाः kSAs (nom.sg.), क्षाम् kSAM (acc.sg.), क्षमा kSamA, ज्मा jmA (instr.sg.), क्षे kSe (dat.sg.), क्षमः kSmas, ग्मः gmas, ज्मः jmas (abl-gen.sg.).

Corresponding to sanskrit क्ष- kS-, proto-iranian yields [š, ž]. (Skjærvø)

(The dental consonant of the metathesized dental-velar cluster is represented in greek as θ, or as the old Anglo-Saxon runic "thorn" letter - þ; these clusters became known as "thorn" clusters.)

The main PIE consonant clusters giving rise to sanskrit क्ष- kS- are the following:

PIE	avestangreek	hittite	tocharian	sanskrit examples
*k ^w s-	xš	ps	k ^w s	a'kSi - "eye", op ^h t ^h almos (greek)
*ks-	xš	ks	ks	kSam- "endure"
*ks-	š	ks		myakS- mikS- "mix", мѣсити "knead" (ocs)
*g ^{wh} s-		ps		adhAkSIt (s-aorist of dah- "burn")
*g ^h s-	ž	ks		adhukSas (sa-aorist of duh- "milk")
*ġs-				amRkSat (sa- aor of marj- mRj- "wipe")
*tk-	š	kt	tk	kSi- "dwell", šaēiti (OAvest)
*d ^h g ^h -			tk	
*d ^h ġ ^h -	z	k ^h t ^h	tk	kSam- f. "earth"
*d ^h g ^{wh} -	ž	p ^h t ^h	kts	kSar- "flow", yžar (YAvest)

(Kobayashi pp. 60-64, Beekes-1988 p. 77)

By way of timing, there is evidence for changes in consonant clusters occurring before Grassmann's Law in late PIE (Meier-Brugger p. 104). Only conservative forms in the more archaic ie languages exhibit anything resembling the reconstructed consonant clusters. The consonant clusters inherited by PIIr continue to evolve as evidenced by the different outcomes in indic and in iranian. In addition, the development of क्ष- kS- is incomplete in a number of prakrits that exhibit (PIE and PIIr) forms that are precursors to क्ष kS- (Kobayashi p. 64-66), which further suggests that many indic prakrits begin their development from late PIIr, pre-vedic indic systems that may be separate from those that give rise to vedic and classical sanskrit.

One sanskrit root that has multiple forms, possibly arising from a single, earlier consonant cluster is छुर्- छुरति chur- churati "cut, incise", खुर्- खुरति khur- khurati "break into pieces", क्षुर्- क्षरति kSur- kSurati "cut, dig scratch". A number of explanations are possible for this variation, including dialect borrowing, onomatopoeia, preserved archaic form, etc.

It is likely that the processing of consonant clusters began inside the PIE system itself and that the process continued gradually, involving more clusters over time, changes becoming more specific to each language group over time, and for sanskrit reaching completion as क्ष kS- only in the prevedic period of indic.

B.6. Word-Final Consonants.

In PIE consonants in word-final position undergo a number of changes in addition to those characteristic of PIE consonants in general. These processes begin in the PIE period and continue on into the individual ie language systems.

Simplification of word final consonants with compensatory lengthening. Certain word-final consonant clusters containing resonants become simplified with compensatory lengthening of the preceding vowel. (Fortson p.63-64) **Stang's Law** observes that word-final sequences of a vowel followed by either a laryngeal or a glide ([i̯ j̯], [u̯ w̯]) and then a nasal undergoes loss of the laryngeal or glide with compensatory lengthening of the vowel, so [*VHm] > [*V:m] and [*VCm] > [*V:m], where C is a glide -- e.g., *d̥jeum > *d̥jēm -> द्याम् dyAm, *g^woum > *g^wōm -> गाम् gAm. **Szemerényi's Law** observes that the word-final vowel-resonant-sibilant (or laryngeal) undergoes loss of the final sibilant with compensatory vowel lengthening, *-VRs > *-VR so that earlier forms, *ph₂ters "father" and *k_uons "dog" become *ph₂tēr and *k_uōn -- with the resonants being the non-syllabic glides ([i̯ j̯], [u̯ w̯]), liquids (r , l), and nasals (n , m), and the final 's' representing the nominative singular case marker. Conversely, there is a tendency, a behavior observed inconsistently, called **Osthoff's Law**, for a vowel to shorten when

followed by a resonant plus consonant, $*-\bar{V} > *-\bar{V} / _RC$. (Kobayashi p. 26, Fortson p.64) E.g.,
 $*h_2ueh_1nto-$ "wind" -> वात- vAta- (ppl. of वा- vA- "[wind] to blow, exhale") (sanskrit)
-> huwant- (hittite), ventus (latin), winds (goth), feth (old irish), вѣтръ (psl.).
The above group of changes is attributed to a period of PIE before late PIE.

Loss of word-final 'n' after long \bar{o} . In PIE final 'n' is lost after a long [o:]. (Fortson p. 64) E.g.,
 $*k_uons > *k_u\bar{o}n > *k_u\bar{o}$ -> श्वन्- Zvan- श्वा ZvA (sanskrit), cú (old irish)
 $*(H)r\bar{e}g\bar{e}n-s$ (nom.sg.) "king" > $*r\bar{e}g\bar{e}n$ -> राजन्- rAjan- राजा rAjA
 $*g_s$
 $*d^h\bar{g}hem\bar{o}n > *d^h\bar{g}hem\bar{o}$ -> homō (latin)
 $*\eta m\bar{e}n-$ -> ИМА (ocs)
This is an early change, probably middle PIE, as it affects all branches of ie, and is established well before PIIr, as shown by वृत्र-हन् vRtra-han- वृत्र-हा vRtra-hA (nom.sg.) and vər^oθra-jā (avestan) "VRtra-slayer".
(Kobayashi p. 36)

Law of Finals, Law of Initials. A "Law of Initials" was formulated by Vennemann in 1972, stating that medial syllable-initial consonant clusters should be possible word-initial clusters. By analogy, a "Law of Finals" is formulated, providing "a rule of thumb" for predicting permissible word-final consonants, based on syllable-final consonant clusters. The word-final position is to a degree extra-metrical, so the prediction rules formulated on this basis are more feeble and prone to variation. (Kobayashi p. 35)

In sanskrit word-final consonant combinations have a number of restrictions. Not only do the rules of sandhi determine the surface representation of the word (Whitney 139-152), but consonant phonological behaviors from PIIr and earlier are inherited. In sanskrit, continuants are avoided in word-final position (Kobayashi p. 35), although a final 'l' is admitted (Whitney 144). Continuants produced by conjugation, for instance, are replaced by a non-continuant consonant which is often etymologically appropriate, suggesting that the inflected forms are of early (PIIr or earlier) origin and that phonological restrictions on word-final position blocked the evolution of these consonants. E.g., vac-, Rc-, etc. Also, (Kobayashi p. 35)

यज्- yaj- "to offer, sacrifice" -> $[*a'-yAk-s-t]$ -> अयाक्षीत् ayAkSIt, अयाट् ayAT

म्यक्ष्- myakS- "to be situated" -> $[*a'-myakS-t]$ -> अम्यक् amyak

Similarly, a final श् Z reverts to PIE क् 'k' (or ट् T) [-continuant].

Visarga. Sanskrit words etymologically ending in a vowel plus 'r' or 's' (both continuants) undergo sandhi change of the 'r' and 's' to visarga. By sandhi rules, the visarga may revert back to 'r' or 's' (or another sibilant) depending on the environment.

In some instances, if the final consonant is preceded by अ/आ 'a/A', the underlying form with 'r' or 's' resurfaces when the word is followed by a vowel. Examples from vedic: वर्- var- n. "water" वाः vAH (nom.sg.), द्वार- dvAr- f. "door" द्वाः dvAH (nom.sg.), but वारिव vAr iva and द्वार- dvAra- n. "door" (later form).

Let us consider the chronology of the change, [-as, -is, -us]# > [-aH, -iH, -uH]#.

When following अ/आ 'a/A', the visarga is lost before vowels and voiced consonants and the short अ 'a' changes to ओ 'o'. In the ऋग्वेद (RV), an alternative development of -as is seen as -e, as सूर्येदुहिता sUre duhitA "daughter of the sun". The -e is also characteristic of the eastern prakrits (Magadhi मागधी). In avestan, -ō is the usual outcome of final -as, but interestingly a dialectal iranian variation in the form of -ə, like the Magadhi prakrits, is observed. (Burrow p. 101)

When following इ 'i' or उ 'u', the visarga before vowels and voiced consonants becomes 'r'. The original sibilant 's', perhaps having become 'š' [ʃ] or indic ष [ʃ], was likely voiced in this environment, like [z] or [ʒ]; this voiced continuant then yielded 'r'. (Burrow p.101). The lenition of final 'r' following a vowel was likely analogous. Analogous too is the change of visarga to 's' before unvoiced dentals even when it is

originally 'r', as punar -> पुनस्तम् punas tam. Some oscillation of 's' and 'r' in word final position, like in ऊधस्- Udhas- and ऊधर्- Udhar-, further illustrates this tendency. (Burrow p.102) This amounts to a near-merger of 's' and 'r' in word final position. (Kobayashi p. 151)

Kobayashi postulates that syllable final 's', especially when preceding a voiceless stop, behaves as though it is part of the subsequent syllable. (Kobayashi p. 44) This is distinct from other ie languages, including avestan, which include the final sibilant as part of the coda of the preceding syllable. Only slavic, like sanskrit, lacks coda consonants in word-final position. Furthermore, in sanskrit, a word-final sibilant before a word-initial sibilant-voiceless stop cluster is lost, or fuses with the following 's', as in agnis stave -> agni STave.

To continue to address the chronology of visarga from sibilant development we may cite a number of finno-ugric borrowings from indo-iranian. (A description of proto-uralic and PIIr contacts can be found in Kuzmina pp. 199-207.) Relevant to this discussion, all the finno-ugric borrowings (see Harmatta p.363) occur without a trace of final sibilant.

छागः chAga- m. "goat" -> čaka "man" (finno-ugric)

मनुष्य- manuSya- m. "man" -> [*manuča] > mańca "man" (finno-ugric)

The above considerations localize the lenition of final post-vocalic sibilants to visarga in the late PIE or very early PIIr period.

B.7. Sibilants.

In PIE, only one sibilant is reconstructed, voiceless 's'.

In all the ie languages, in many roots and words it is preserved mostly intact. (See PIE inventory section.) That is, upon examining extensive ie correspondence sets, it is clear that in many instances the sibilant represents the original PIE sibilant. (Meier-Brugger pp.102-106) This simple, important, initial starting point is worth keeping in mind when considering the very complex subject of indo-european sibilants.

The PIE voiced sibilant, 'z', behaves an allophone of 's'. The 'z' arises in roots and morphemes containing 's' when they are in a voicing environment, such as before a voiced consonant (right-to-left, regressive assimilation). That is, in PIE there is no phonological contrast between the voiced and unvoiced sibilant.

In ie languages, the original PIE 's' is in many cases preserved intact. But over time (diachronically) in other cases, as we have discussed, the sibilant can be lost -- as in Szemerényi's Law (a middle PIE process), as in sibilant degemination, as in word-initial sibilant apheresis -- new sibilants can be acquired -- as by epenthesis in dental-dental clusters, simplification of consonant clusters, the serial palatalization of velars -- and thirdly the sibilants can undergo changes in phonological features -- such as palatalization, retroflexion, voicing and visarga formation.

It should be added that the diachronic changes involving sibilants begin no later than the middle PIE period and they continue in all ie languages to the present day, a period of time spanning some six millenia.

Accordingly, when we assert that late PIE had but one reconstructable sibilant, this refers to the state of ie sibilants at a time before the divergence of PIE dialects into language groups with their own distinct phonological processes. This serves as a good starting point for discussing ie sibilants.

Voicing of sibilants. The allophonic status of voiced sibilants continues into PIIr, there being no evidence of phonologic contrast - i.e., phonemicization of voiced sibilants -- up to that period. The phonemicization of voiced sibilants in iranian and their loss in indic occurs well after the PIIr period. (Skjærvø p.48, Beekes-1988 p. 14, Kobayashi p. 105) The observation in vedic prosody of a lost timing slot with the preceding syllable becoming metrically heavy in words that would etymologically have had a voiced sibilant suggests the verses were composed with the voiced sibilant present; i.e., that the voiced sibilants were present for a long time after the PIIr period, presumably until the immediate pre-vedic period. It is surmised that the final loss of voiced sibilants in indic occurred after the loss of laryngeals. By the time of vedic sanskrit, then, a voiced [+voiced] oral obstruent [-sonorant] must be a non-continuant [-continuant]. (Kobayashi p. 50)

An interesting exception (to the chronology of the loss of voiced sibilants described above) is

observed with the word, सद्- sad- सीदति sdati (sanskrit), hiḏa- (avestan), сѣдѣти (ocs) -- as the only known instance of such loss of *z in the PIE period. (Kobayashi p.50)

The voiced sibilant is otherwise not lost in iranian, slavic and baltic. (Kobayashi p. 107)

As mentioned earlier, all voiced sibilants are lost in sanskrit, generally without a trace, but in some contexts their loss results in compensatory change, particularly when retroflexion is involved, as in our example, *ni-sd-o- (PIE) -> *nizdo- (late PIE) -> [RUKI sound change] -> *niždo- (PIIr) -> *nižda- (PIIr) -> [retroflexion of alveopalatal sibilants] -> *nižDa- -> नीड-/नीळ- nIDa- (sanskrit).

In addition (in sanskrit), the PIIr voiced aspirate *j^h is lost before a dental stop, presumably by way of a deaffricated, voiced fricative (Kobayashi p. 49), as

*saj^h- "prevail" -> सह- sah- (root) -> साढ- sADha'- (or) (ppl.सोढ-) < [*saz^h-d^ha'-] < *saj^h-d^ha'-

*vaj^h- "carry" -> वह- vah- (root) -> ऊढ- UDha'- (ppl.) < [*vaz^h-d^ha'-] < *vaj^h-d^ha'-

Rise of the sibilants. In the sanskrit phonological inventory we have three phonemic sibilants, स् s (dental), ष S (retroflex), श् ś(Z) (palatal), a voiceless aspirate, ह् h, and विसर्गः visarga. Avestan has corresponding unvoiced and voiced sibilants, [s] [z] (dental), [sʲ] [zʲ] [сь, зь] ((alveolo-)palatal), ([ʃ](retroflex?)), [ɕ] [ɟ] (? [ʒ OR ʒ] [ʁ]) (palatal), a glottal stop (') and a voiceless aspirate [h]. The other ie language systems each demonstrate their own acquisition and reduction of sibilants.

We have already introduced a number of processes by which sibilants are produced -- epenthesis in dental-dental clusters, simplification of consonant clusters (yielding क्ष् in sanskrit), the serial palatalization of velars -- and lost -- Szemerényi's Law, sibilant degemination, word-initial sibilant loss.

In the case of the palatalization of velars, it is worth reiterating that recent authors (Skjærvø, Kobayashi) maintain that by the common PIIr period the palatalization process had probably not gone its full excursion to sibilants, but had yielded the primary palatals (palatal affricates) -- [c [tʃ], j [dʒ], j^h] -- and the secondary palatals (palato-alveolars) -- [č [tʃ], j [dʒ], j^h]. This is supported by the observation that in nuristani (kafiri) the primary palatals [c, j, j^h] do not progress to sibilants. The final development of the palatal velars in indo-iranian are generally as follows: (Fortson p. 206, Sims-Williams p. 104)

PIE palatal velars	sanskrit	avestan	nuristani (kafiri)
ǰ	श् [ɕ] (Z)	s [s]	c [ts]
ǵ	ज् [ɟ] (j)	z [z]	z [dz]
ǵ ^h	ह् [h] (h)	z [z]	z [dz]

With regards to the nuristani evidence, it must be appreciated that the nuristani group of languages are attested only recently and direct evidence of early nuristani development is exiguous. In addition, a number of nuristani words suggest the absence of the RUKI rule (Pedersen's Law) (Sims-Williams p. 104-5). As a result, the development of the PIE palatal velars into sibilants by the PIIr period can not entirely be excused. We will discuss the evolution of the primary and secondary palatals in indo-iranian -- i.e., the final development of the PIE palatal velar and PIE merged plain velars -- in the PIIr section.

In very simple terms (oversimplified), the three sibilants in sanskrit have their origin thus:

स् 's' [+anterior][distributed] is from PIE;

श् 'ś' (Z) [-anterior][distributed] is from the palatal velars;

ष् 'S' [-anterior][distributed] is from the ruki rule, the palatal velars before dentals, and consonant ("thorn") clusters. (Fortson 182, Kobayashi 54, 160). Whitney declares, "the occurrence of ष 'S' in sanskrit words is nearly limited to cases falling under this [RUKI] rule; others are rather sporadic anomalies -- except where ष 'S' is the product of श् 'Z' and क्ष् 'kS' before a dental, as in द्रष्टुम् draSTum..." (Whitney 182)

A degree of repetition is needed for clarity. The following sections elaborate upon these and introduce additional processes.

The RUKI rule (Pedersen's Law). By way of introduction, let us recall the sanskrit retroflexion rules surrounding the retroflexion of स् 's'. The letter, [स् 's'], becomes [ष् 'S'] when preceded by 'k', 'r' (any

rhotic) or a non-'a' vowel, unless followed by a rhotic. So,

क्/स्/V(non-अ) [+/- anusvara, visarga] स् [not ऋ र] --> ष्

A rhotic following the sibilant blocks the change, as उस् usra, तिसस् tistras (nom-acc.f. तिसृ- tisar- f. of त्रि- tri- "3"), तिसृषु tisRSu (loc.f. तिसृ- tisar- f.), सिसर्ति sisarti, सिसृतम् sisRtam, सरीसृप sarIsRpa, परिसृत् parisrut, परिसृ- parisR-, and even परिससुः parisasruH. Sporadic exceptions occur, as विष्टिर् viSTir, विष्टार viSTARA, निष्टृत niSTRta, गविष्टिर gaviSThira. (Wh 181) Although the retroflexion rule is also extended to non-syllabic ल् 'l' by indian grammarians, there are no instances of it in vedic and "the प्रतिशाख्याः prAtiZAkhyas give no such rule." (Wh 180b)

The 's' of पुस् puMs and हिस् hiMs (and its forms, like हिनस्ति hinasti) remains unchanged. (Wh 183a)

This sanskrit retroflexion rule has its origin in late PIE, where the process will be seen to be very analogous.

Evidence from indo-iranian, slavic, baltic, albanian and armenian (all satəm languages) supports a process of palatalization of sibilants [s, z] following [k, r, i, u] taking place no later than late PIE. The consistency of this process with so many phonemes render improbable the likelihood of parallel development in these various language groups. (Burrow p. 80-81, Beekes-1988 p. 80) This process is not seen in the centum ie languages -- italo-celtic, greek, tocharian or anatolian.

The RUKI rule (or Pedersen's Law) refers to the change of articulation of the sibilant from dental [+anterior] to alveopalatal [-anterior] when immediately following the letters, [k, r, i, u]. This change is not hindered by nasalization of the preceding vowel, but is blocked by a subsequent rhotic. It is generally agreed that at first the articulation of the sibilant so produced was probably postalveolar, like 'š' [ʃ] and 'ž' [ʒ], or alveopalatal, like 'ś' [ɕ] and 'ź' [ʑ]. (Kobayashi pp. 149, 184, Fortson p. 182, Longerich) In later development, this sibilant remained alveopalatal in iranian, became retroflex in indic and resulted in [ʃ] or [ʒ] in slavic.

The consistency or penetration of the RUKI rule varies in the language groups involved. It is most consistently demonstrated for indo-iranian and slavic, but only partially observed in baltic, albanian and armenian. In armenian only two stems are cited as reflecting this process, t'aršamim "I wither" and veštasan "16", while in albanian PIE 's' changed to 'š' in most environments, making its recognition difficult. (Lubotsky-1999 p. 300) In the baltic languages, frequently discussed together with slavic as balto-slavic, the RUKI rule is not seen in latvian and old prussian, while it is observed only in some words in lithuanian, especially following a rhotic, as viršus "high" (वर्यхъ, ocs) and aušra "dawn" (aurora, latin). (Fortson p. 380) In slavic, the effects of the RUKI rule are widespread, with the initial change of 's' [s] > 'š' [ʃ], being preserved before front vowels [i, e], but progressing to [x] before non-front vowels, [a, o, u]. The RUKI rule operates most consistently in indo-iranian, with rare exceptions in sanskrit and occasional adjustments in avestan. The PIIr phonological system acquired the alveopalatal sibilants [ʃ] and [ʒ] (or[ɕ] and [ʑ]) initially generated by this process.

Much has been written about the phonological environment of the phonemes [k, r, i, u] with regards to their effect on the original 's'. An interesting approach was taken by Longerich, who studied the acoustic effects of the environment thus created, suggesting that a lower frequency sibilant may be generated in this setting and misperceived by the listener as non-anterior. She was able to show a hierarchy of acoustic effect, rhotics [r] > [k], [i] > [u], which corresponds to the consistency of change and the frequency of exceptions. One should note that in avestan the 'st' following a 'u' preserves a dental 's', for instance. (Lubotsky-1999 p. 302)

In iranian, furthermore, the RUKI rule was also seen to operate after labial consonants, as in afš (avestan), ap- (sanskrit) "water" (Fortson p. 180), and after [g^h] (Skjærvø pp. 48-49), so that PIIr [ś, ź] developed from [s, z] when following r, R, i, u, k, gh, p and bh. (ru(p)ki? rule). A nasal before the sibilant had no effect on this process. The resulting [ś] became voiced [ź] before voiced stops and vowels, esp in prefixes and before enclitics.

[s, z]: (C[+/-nas]) [s, z] > [ś, ź], [ʃ, ʒ]
C = [r, R, i, u, k, gh, p, bh]

[ś]: C[+voi] or [ś] V > [ź]

One should add that in indo-iranian the RUKI rule also operates after a vocalic laryngeal that yields 'i' (Beekes-1988 p. 81) and after [r] < [l] (Lubotsky-1999 p. 300).

For indic, the anticipated retroflexion of the (postalveolar or alveopalatal) sibilant produced by the RUKI sound change would have occurred after the PIIr period, This returns us to our earlier problem of the palatalization of the palatal velars. To recapitulate, one can safely state that by the PIIr period, the palatal velars had undergone palatalization and affrication to form the primary palatals, [k̠, ɡ̠, ɟ̠] > [c, j, jʰ]. The question of whether or not these primary palatals had undergone further deaffrication (spirantization, deocclusion) by the PIIr period is not settled. If so, there would be a chance of merger with the sibilants produced by the RUKI sound change (Kobayashi p. 150); and, if not, a risk of merger with the secondary palatals produced from the palatalization of the merged labial and plain velars before fronted vowels would exist. (Skjærvø pp. 48-50)

Nuristani (kafiri) data shows that PIE *s yielded the retroflex 's' [ʂ] after 'r' (rhotics), but yielded the alveopalatal 'ś' [ʃ] or unchanged 's' following [k, i, u]. (Longerich p. 37) This raises the possibility that each of the conditioning phonemes [k, r, i, u] may have had their effect on 's' at different times and with different intensity.

A wave model (diffusion) best accounts for this change in PIIr, proto-slavic and the other satəm languages, with the origin of the change most likely in the language group most consistently showing this sound change, i.e., indo-iranian or slavic.

By way of sibilant relative chronology, at this point, we can formulate the following sequence:

PIE:

- 1) s-epenthesis in dental-dental clusters, *tt > *tst
- 2) RUKI sound change, yielding alveopalatal sibilants, [s, z] > [ʂ, ʐ].

PIIr:

- 3) deaffrication of primary palatals (PIE palatal velars)
 - [k̠, ɡ̠, ɟ̠] > [c, j, jʰ] > [ʃ, ʒ, ʒʰ] (indic), [s, z, z] (avestan)
 - in PIIr period (Kobayashi p. 150)
- 4) simplification of *tst to *tt (sanskrit) and *st (avestan)
 - after RUKI, (Beekes-1988 p. 74)
 - not affected by preceding [k, r, i, u] (Lubotsky-1999 p. 300) (relevant for iranian)
- 5) retroflexion of sibilants (indic), [+distributed] feature
 - arising from RUKI and from PIE palatal velars (PIIr primary palatals) before dentals
 - phonemically distinct from [-distributed, -anterior] sibilant, ʃ ʒ (Z).

The RUKI sound change represents the most significant and productive source of alveopalatal sibilants in PIIr and in turn of the retroflex sibilant, ʃ [ʂ], in sanskrit.

Palatal velars before dentals. A second significant source of retroflex sibilant, ʃ S, in sanskrit is the alternation of palatal obstruents - च् c, छ् ch, ज् j, झ् jh, ष् S, ʒ Z - with ष् S or क् k in inflection when followed by a suffix beginning with a dental stop. (Wh 182, Kobayashi p. 53) And the PIIr palatal affricates, [c, j, jʰ], developed into [ʂ, ʐ, ʐʰ] before dentals (and variably after labials). (Skjærvø pp. 48-50) From the synchronic perspective of sanskrit itself, the consonants -च् c, छ् ch, ज् j, झ् jh - usually alternate with क् k and instances of alternation with ष् S are considered exceptions. The consonants, ष् S and ʒ Z, predictably form ष् S before a dental stop.

Kobayashi (pp. 53-54) enumerates the ppl of some aniT roots - -ष्ट -STa vs. -क्त -kta. (Kobayashi p. 53-54). One will recall that क्त kS is often treated as ष् S. (Wh 146)

*k̠ > Z	vaZ- "wish" naZ- naGZ-? "die" pracch- (k̠-sk̠) "ask" takS- (-tk̠-)"timber" cakS- (ks) "look"	vaSTa-? (but 3U pres ind vavakti, vivaSTi) naSTa- (inf. naZitum, naGSTum) pRSTa- taSTa- "fashion, trim, prune" caSTa-
*ɡ̠ > j	yaj- "worship, offer"	iSTa- (note iS- iSTa' "wish")

	marj- mRj- "wipe" sarj- sRj- "release"	mRSTa- sRSTa-	"send forth, emit, throw"
*ġ ^h			
other	uS- "burn" RS- "flow" kRS- "drag" kruZ- "cry out" tuS- "be content" daGZ- daMZ- daZ-, bite bhraJZ- bhraZ-, fall, drop viZ- "enter" ZAs- ZiS-, order, punish, teach spRZ-, touch	uSTa'- RSTa'- kRSTa'- kruSTa'- tuSTa- daSTa'- bhraSTa- (-bhRSTa-) viSTa'- ZiSTa- ZAsta- ZAsita- spRSTa'-	
	secondary palatal (palato-alveolars):	ć [tś]	ǰ [dź]
*g > ǰ [dź] (2-ary pal)	bhaj- "share, enjoy" tej- tij- "sharpen" yoj- yuj- "yoke"	bhakta- tikta- yukta-	"join"
*g ^w - > ǰ [dź] (2-ary pal)	nej- nij- "wash"	nikta-	
other	aJj-, annoint, decorate, honour tyaj-, abandon pac- "cook" bhuj- "enjoy" muc- "release" ra(J)j- raJj- raj-, color (окрашивать) ric- "leave" vac- "speak" vic-, sift, separate out vij-, tremble, move suddenly, dart (as from fear) vRj-, twist Zak-, be able Zuc-, burn, shine sa(J)j- saJj- saj-, hang, adhere, attach sic-, pour out, splash	akta- (aGktvA, -ajya) tyakta- pakta- bhukta'- mukta'- rakta- rikta- ukta'- vikta- vikta- vigna- vRkta- (ger. -vRjya) Zakta- Zukta- sakta- (ger. -sajya) sikta-	

From the above it appears that the two alternation patterns (with क् k and instances of alternation with ष् S) are explained by their origin from PIE velars, with the forms containing क् k arising from PIE labial and plain velars (PIIr secondary palatal affricates) and those containing ष् S arising from PIE palatal velars (PIIr primary palatal affricates).

Occlusion of sibilants in fricative clusters. The deocclusion of PIE *k̥ > PIIr ć > skt ś (श्) appears to be blocked when followed by 's' or pada boundary. Firstly, this pertains to श् ś (Z) derived from PIE palatal velars, as दिश्- diZ- "point" -> अदिक्षि adikSi, अदिक्षत् adikSat (s-aorist) but अदिदिशत् adidiZat (redup aorist). Secondly, sibilants which come from PIE 's' also change to 't' or 'k' before another sibilant, as द्विष्- dviS- "hate" -> [dveS- + -si] -> द्वेक्षि dvekSi (param.s-pres.ind.2nd.sg.). (Kobayashi p. 58) In Sanskrit, this process becomes productive from the Vedic period onwards and is readily seen in the forms of the locative plural, the desiderative, the s-future and sigmatic aorists.

Sanskrit roots ending in ह् 'h'. Building on the discussions above about voiced sibilants and palatal velars before dentals we can address the phonology of sanskrit roots ending in ह् 'h'. We have put this unit in this section (on sibilants) since it involves the loss of voiced sibilants arising from PIE palatal velars.

Sanskrit roots ending in ह् 'h' are described as forming two groups, in the first of which the ह् 'h' reverts to its etymological PIE velar, and in the second the root is inflected by retroflexion and loss with compensatory lengthening of the preceding vowel.

In the first group, one observes a reversion to the etymological PIE consonant cluster in conjugation, as

PIE	avestan	sanskrit root	ppl.
*d ^h eg ^{wh} -	daž-	dah- "burn"	dagdha-
*d ^h ug ^h -		duh- "milk"	dugdha-
*d ^h rug ^h -	druž-	druh- "be hostile"	drugdha-
*sneig ^{wh} - "snow"	snaēž- "snow"	snih- "to stick"	snigdha- (snIDha-)

From the PIE roots it is clear that the ह् 'h' in these verbal roots originates from PIE labial and plain velars, i.e., PIIr secondary palatal affricates.

In the second group, the 'h' becomes a retroflex in denclensions before 'bh' and 'su', and in word-final external combination. In verbal conjugation, before a dental [t, th, d, dh] the dental is retroflexed with loss of the 'h' and compensatory lengthening of the preceding vowel, but a preceding vocalic ऋ ऌ is not lengthened. (Wh222-224)

PIE	avestan	sanskrit	ppl.	भूतेकृदन्त
*ueǵh-	vaz-	vah- "carry"	UDha-	ऊढ-
*seǵh- (*sǵh-)		sah- "endure, prevail"	sADha- soDha-	साढ- सोढ-
*h ₃ meiǵh-	maēz-	mih- "urinate"	mIDha-	मीढ-
*leǵh-	riz-	rih- lih- "lick"	IIDha- rIDha-	लीढ- रीढ-
*guj ^h - (PIIr)	guz-	guh- "hide"	gUDha-	गूढ-
		ruh- "climb"	rUDha-	रूढ-
*d ^h erǵh-	dərəz-	dRh- "make firm"	dRDha-	दृढ-
*b ^h enǵh-	bəzuuant-	baGh- "thicken"	bADha-	बाढ-
*sperǵh-	(ā)spərəz	spRh- "be eager"		

(For the above examples, PIE forms mostly from Cheung)

From the PIE roots it is clear that the ह् 'h' in these verbal roots originates from PIE palatal velars, i.e., PIIr primary palatal affricates. From B.7.Sibilants - Voicing of sibilants, the following sequence was suggested,

*ueǵh-to'- (PIE) > *vaj^h-ta'- (PIIr) > [*važ-d^ha'-] > [*uz-D^ha'-] > ऊढ- UDha'-

That is, from the PIIr form, the primary palatal affricate [j^h] (arising from the PIE palatal velar) causes voicing and aspiration of the following dental, and undergoes deaffrication to [ž] and becomes a voiced alveolopalatal. The resultant voiced alveolopalatal [ž] becomes retroflexed to [ʒ], causes the retroflexion of the following dental, and the unaccented root undergoes saMprasAraNa (संप्रसारण). The voiced sibilant is lost with compensatory lengthening of the vowel.

In this second group, the 'h' reverts to velar only before endings with 's' in verb formation and derivatives -- as in the sigmatic aorist, vah- avAkSIt, ruh- arukSat -- because the deocclusion of PIE *k̑ > PIIr ć > skt ś (श) is blocked when followed by 's' or pada boundary. (see B.7.Sibilants and B.5.Consonant clusters-Consonant clusters resulting in sanskrit क्ष- kS-).

In the section, B.7.Sibilants - Palatal velars before dentals, we appreciated that the inflection of roots ending in ज् 'j' -- in particular the formation of the passive past participle -- could be understood from

their etymological origin. That is, in roots whose ज् 'j' originates from the PIE labial and plain velars and therefore PIIr secondary palatal affricates, the ज् 'j' reverts to a velar, as *g (PIE) > *j [dʒ] (PIIr 2-ary pal affr), yuj- yukta- "joined". But in roots whose ज् 'j' originates from the PIE palatal velars and therefore the PIIr primary palatal affricates, the ज् 'j' forms a sibilant, as *ǵ (PIE) > *j (PIIr 1-ary pal affr), yaj- iSTa- "offered, worshipped."

In Sanskrit grammars the sandhi of roots ending in ह् 'h' is discussed alongside the behavior of roots ending in ज् 'j'. In both instances their inflection cannot be accounted for from within the system of Sanskrit itself.

Consonant clusters as a source of sibilants. As described above, a number of PIE consonant clusters, many of them not even containing a sibilant, yield Sanskrit क्ष्- kṣ- and Proto-Iranian [š, ž].

Word initial 's'. The dynamics of loss of sibilants (and laryngeals) can be said to have started in middle PIE, as we have already described above, in the form of Szemerényi's Law, Sieb's Law, word-final 's', visarga formation, dental-dental clusters.

In early IE languages the sibilant also alternates with the null phoneme (∅) ("s-mobile") even within the same language, synchronically. (Szemerényi p. 94, Meier-Brugger p. 105) E.g., *speḱ- (PIE) > पश्- paZ- "see", स्पश्- spaZ- "behold", श्पष्ट- spaSTa- (ppl.) "perceived". But numerous supporting examples obtain when comparing cognates, as super "above" (Latin) and उप upa- "above", उपरि upari "over" (Sanskrit). (Gamkrelidze p. 121) On the other hand many words show a very stable initial PIE *s, as *suesor- "sister" -> स्वसृ- svasar- f. (Sanskrit) (Gamkrelidze p. 123).

The word-initial labialized PIE sibilant *sṷ shows a number of outcomes: it may be preserved either as su- or sv-, as in supta- and svapati; the labial element *ṷ may simply be lost, as in soror (Latin), क्षीर- kṣīra- n. "milk" (Sanskrit) (while xšvīd- (Avestan)); and the initial *s may be lost, as in उप upa "above" (Sanskrit). (Gamkrelidze pp. 119-125)

The development of PIE *-sk̥- The development of the PIE cluster, *-sk̥-, is of special interest to Sanskrit. In word initial position *-sk̥- loses the sibilant and yields छ् [č] -- but in mid position it develops as *-sk̥- > -sč- > cc^h. However, the analogous combinations of [-*sp^[h]-, -*st^[h]-, -*st^[h]-] yield [-sp-, -st-, -sk-]. Apparently, the full development of the palatal velar in *-sk̥- is arrested at the stage of the affricated छ् [č], as a result of the preceding sibilant; then, the sibilant is either lost word initially or undergoes affrication to yield च्छ् 'ch'. (One alternative explanation involves the metathesis of *-sk̥- at an early stage.) (Gamkrelidze p. 121, Kobayashi pp. 67-80, Szemerényi p. 273) Thus,

*-sk̥- PIE > *-sc- [stʃ] PIIr -> -च्छ्- -cch- [tʃ tʃ^h] (affrication of 's' +/- aspiration from 's').

E.g., in the formation of the present indicative stem, the suffix, *-sk̥é/ó-, is added to the root, yielding the following:

*h₂pr̥(k)-sk̥é/ó- "ask" -> प्रच्छ्- pracch- "ask", पृच्छति pṛcchati (parasm.pres.ind.3rd.sg.)

-> просити "ask", проша (1st.sg.) (ocs), prsa- (Avestan)

*h₂is-sk̥é/ó- "seek" -> इष्- iS- "wish", इच्छति icchati (parasm.pres.ind.3rd.sg.)

-> искати (inf.), искж or ищж (pres.ind.1st.sg), ищещи (2nd.sg.) "seek" (ocs)

*gṃ-sk̥é/ó- "go" -> गम्- gam- "go", गच्छति gacchati (parasm.pres.ind.3rd.sg.)

Word initial *sk̥- yields छ् [č], as noted above, as

*sk̥^[h]id- "cut" -> छिद्- chid- (Sanskrit), sid- (Avestan), sk^hizo- (Greek)

Of considerable curiosity and interest is that Sanskrit texts written in Malayalam script have 'cś' in

place of 'cch', so (पृच्छति pRcśati instead of पृच्छति pRcchati. (Kobayashi, p.80) With the malayalam orthography as -cś-, one might even anticipate the sequence,

*-sĳ- PIE > *-cĳ- [tʃ k] PIIr -> -च्छ- -cZ- [tʃ ʃ] (if the palatal velar *ĳ goes all the way to [ʃ])

The cluster, *-sĳ-, is generally inherited as -sk- in centum languages, as poscere "ask" (latin), arco "I ask" (old irish), paskau "I keep" (tocharian B), baske "go" (homeric greek).

Six, the number. Partial correspondence set for "six:"

*s_ueĳs- (*s(w)eĳs-) -> षष् SaS or षट् SaT (sanskrit), xšvaš (avest)

-> vech (armenian), šeši (lithuanian), шесть (ocs)

-> εξ (greek), sex (latin), (Fortson p. 210, Szemerényi p. 222)

Considering the armenian form, Szemerényi raises the possibility that the form without 's' may have been original, with the 's' added prothetically in analogy to septm "seven". One should consider our earlier discussion on the word-initial labialized PIE sibilant *s_u. By this we suggest the armenian form probably represents s-apheresis.

In the case of sanskrit, the change of the initial sibilant स् 's' to retroflex ष 'S' represents a unique development. It is explained variously by different authors. Gamkrelidze (p.124) proposes the rise of word initial cluster, क्ष 'kS' (a RUKI context), with subsequent loss of 'k', so *kSaT > SaT. Kobayashi (pp. 156-157) describes a process of backward spreading of retroflexion to account for this. No RUKI context is identified for SaS- In support, there are these considerations:

1) All of the declined forms for SaS- have retroflexed root final consonants, as

N.A.	षट्	Sa'T
I.	षड्भिः	SaDbhi's
D.Ab.	षड्भ्यः	SaDbhya's
G.	षण्णाम्	SaNNA'm
L.	षट्सु	SaTsu'

2) The verbal root सह- sah- "prevail, overcome" in conjugation preserves the 's', but in word formations in which the root ends in a ट 'T', the 's' shows some retroflexed forms, as तुरा-षाह्- turA-SAh- (nom.sg. तुरा-षाट् turA-SAT) "overpowering the mighty", विरा-षह्- virA-Sah- (nom.sg. विरा-षाट् virA-SAT) "overpowering, subduing men", वृथा-षह्- vRthA-Sah (nom.sg. वृथा-षाट् vRthA-SAT) "one who easily conquers" (वृथा vRthA "at will, at random, easily") (orthography from MWD). The spread of retroflexion was first advanced by Wackernagel and later supported by Schindler and Renou.

Whitney suggests that षष् SaS behaves like षक्ष् SakS, with the attendant sandhi yielding षट् SaT (Wh 146b, 182c, MWD).

The backward spread of retroflexion seems the most plausible formulation. Other examples exist, as तुराषाट् turA-SAT, विराषाट् virA-SAT (sah- "subdue") अषाढ- a'SADha-, षोढा- SoDhA'-, but सराट् samrAT, सराट् sarAT. Kobayashi (pp. 156-158) forms the rule that in any word the retroflexes -- ट् इ ढ् [t d q^h] -- spread retroflexion left all the way to an 's', unless an 'r' intervenes. The retroflexes create a phonological right end boundary. If there is a preceding 's' in the word to establish a left end (anterior) boundary, retroflexion proceeds all the way to the 's'. An intervening 'r' blocks the **retroflexion throwback**, since it creates a [-ant] boundary.

B.8. Laryngeals.

Laryngeals have been introduced in our earlier units. Too, some evidence for their existence has been presented. They are described in the PIE inventory as is the lengthy process of their loss, starting in middle PIE with **laryngeal coloring** (effects on neighboring 'e' to yield [e, a, o]), their later effects on

neighboring vowels upon their loss (such as compensatory lengthening), and their occurrence as allophonic, syllabic, vocalic laryngeals. In the section on phonological changes affecting the morpheme, their importance in PIE root and morpheme structure is outlined, as is their role in clarifying inflectional paradigms. Some similarities of laryngeals with sibilants have also been noted, especially in PIE root structure (sonority principle), their role in the formation of PIE long vowel grades, and the time line of their evolution starting in middle PIE is analogous.

What to do with laryngeals. The starting point of these discussions is usually the phonological system setup for PIE by Brugmann. (Lehmann 3.5) On one extreme, some reject the laryngeals outright and on the other extreme laryngeals are invoked, and indeed multiplied in number, to explain all the mysteries of PIE phonology. (Lehmann 3.5, Szemerényi p. 128) The laryngeal theory has some significant accomplishments to its credit, e.g., for our purposes it provides an attractive clarification of the development of Sanskrit *seT*-roots and their inflections.

With regards to Hittite evidence, the number of words with laryngeal reflexes is not great and the orthography presents certain challenges. (Lehmann 3.4) Hittite evidence is strongest, but also inconsistent. (Szemerényi pp.137-138) Up to six different laryngeals have been postulated by some. Szemerényi suggests that we can only speak of one laryngeal for certain and we have to consider that PIE roots may have been of structure *eC* and *VC*. (p. 139) But for our purposes, we will more or less continue with the prevailing idea of there being three laryngeals.

The general approach by most investigators has been to incorporate the PIE phonological systems developed by Brugmann and Hirt and build on them, incorporating laryngeals to the extent they help clarify attested data. Laryngeals do not modify the theory of ablaut. (Lehmann 12.2) Exploring their possible role in unclarified PIE problems is useful, too. A negative outcome in these areas or even false extensions of the laryngeal theory does not invalidate the theory itself. Having said this, the laryngeals deserve a proper consideration in their own right.

Laryngeal environments in PIE.

In describing PIE root structure one adheres to the CVC formula presented above in the section on roots in "Phonological changes affecting the morpheme." As a result, for roots reconstructed with the structure *eC* or *VC* an initial laryngeal is postulated. Similarly, a final laryngeal is postulated for roots reconstructed with an open syllable, especially if containing a long vowel. Surprisingly, when Hittite was discovered and initially investigated a significant number of words showed laryngeal reflexes in those very positions, as hypothesized.

(see Meier-Brugger pp. 111-124, Lehmann 3.4, Fortson, Beekes-1988 pp.83-93, Gamkrelidze pp. 165-213, Skjærvø pp. 48-51, Leiden etymol.dict.latin)

Roots with initial laryngeal.

	PIE	Hittite	Sanskrit	Other
h_1e-	* h_1es- "be"	-	as-	est (Latin), есть (OCS), etc.
	h_1s- (zero grade)			
h_2e-	* h_2ant- "face"	$ḥant-s$ "forehead" $a'n̄ti$ "before"		ante (Latin), end (English)
	* $h_2aǵ-$ "drive"	-	aj- "drive"	αγεῖν (Greek), agere (Latin)
	* h_2enH-o "old lady"	$ḥa-an-na-as$ "g-mother"		anus "old lady" (Latin)
	* $h_2r̥ǵ-ro-$ "swift, shining"	$ḥar-ki-is$ "white"	ऋज- Rjra'- "fast; reddish"	αργος (Greek), ярость, рыждь (OCS) arjuna- "white" αργης (Greek)
	* h_2eu-eh_1- "enjoy, consume"	$ḥu-u-us-ki-si$ "awaits"		
			avasa- "food"	aveō "be eager" (Latin)
h_3e-	* $h_3o/e-k^w-m̄n-$ "see"	-	akSi-	oculus (Latin), очи (OCS)
	* $h_3o/e-st$ "bone"	$ḥa-as-tai$ "bone" $asthi-$ "bone"		οστέον (Greek), ossis (Latin)
		$ḥe-kur$ "peak"	agra- "first; peak"	

Roots with final laryngeal.

*-eh₁- before a consonant results in compensatory lengthening of the vowel, as
 *d^heh₁- "put" -> धा- dhA- "put", dėti "to lay" (lithuanian), на-дѣти "put on" (ocs)
 *h₂ueh₁- "blow" -> वा- vA-, वाति vAti (parasm.pres.ind.3rd.sg.), व्वाति (ocs)
 *reh₁- "grant, give" > रा- rA- "grant, bestow", रते rAte (Atm.pres.ind.3rd.sg.)

*-eh₁- before a vowel leaves the vowel unchanged and the loss of *h₁ results in hiatus, as
 *h₂ueh₁-nt-o- "wind" > [*H₂uaHata-] > [*ua.ata- (hiatus)] > vAta- m. "wind" (avestan and vedic), ventus (latin)
 *reh₁-i "property" > [*raHi-] > [*ra.i (hiatus)] > rayi'- m. "possession"

-eh₂- before a consonant results in [-ah₂-] > [*ā], as
 *-eh₂-m (acc.sg. inflection) > *-ah₂-m > *-amm > *-ām,
 but is preserved in hittite as [*-ah₂- > ah₂], as
 *peh₂- > *pah₂- "look after, graze" > paḥs "protect", pa-ah₂-ša-an-zi "he protects" (hittite), प- pA- "protect",
 पाति pAti (parasm.pres.ind.3rd.sg.), pāscō (latin), пасти (ocs)

-eh₃- before a consonant results in [-oh₂-] > [*ō], as
 *deh₃- > *doh₃- > *dō- "give" (PIE) > दा- dA- "give", дати (ocs), dō, dare (latin)

Interconsonantal laryngeals. The zero grade of *h_xe and *eh_x is *h_x. Between consonants (usually in an unstressed zero-grade syllable) the laryngeal becomes vocalic or null (∅), CHC > CḤC (CəC) or CC.

Interconsonantal *h₁ results in 'e' in greek, 'i' in PIIr, 'a' in all other ie languages, as
 d^heh₁- "put", d^hh₁-to'- (ppl.) -> θετο'ς "placed" (greek), dhA-, [*d^hita'-] > hita'- (ppl.) (sanskrit)

Interconsonantal *h₂ results in 'a' in greek, 'i' in PIIr, 'a' in all other ie languages, as
 *ph₂ter- "father" -> πατηρ (greek), पितृ- pita'r- (sanskrit), pitā (avestan), father (english)

Interconsonantal *h₃ results in 'o' in greek, 'i' in PIIr, 'a' in all other ie languages, as
 *deh₃- > *doh₃- "give", *edh₃-to (perf.ind.3rd.sg.) -> εδοτο (greek), adita (aor.3rd.sg.) (sanskrit)

*peh₃- > *poh₃- "drink", *ph₃-to'- (ppl.) -> पा- pA- "drink", पित- pita'- (ppl.)

While the PIE interconsonantal laryngeal is reflected as 'i' in PIIr, avestan and vedic differ in how they manifest this process. Beekes compares the outcome of PIE *CHC in initial, medial and final syllables. (Beekes-1988 pp.85-87) In word final syllables, CHC, like word final CH, results in CiC, as in PIE *sak^wtH- "thigh" -> सक्थि- sa'kthi- n. (sanskrit), haxti, haxtiṛāh (avestan),

the 1st and 2nd pl. middle endings,

PIE *-med^hh₂, *-ved^hh₂ -> -mahī, -vahi (sanskrit), -madi, -vadi (avestan)

nom.pl.n. ending, (PIE nom.pl.n. ending is -h₂, Fortson p. 106; nAman- n. "name")

PIE *h₂nom^hh₂ -> -ani, नामानि nAmAni (sanskrit), -ani, nāmani (avestan)

But in word initial and word medial CHC syllables the laryngeal is lost in avestan, but preserved as 'i' in sanskrit, as

sanskrit	avestan
dra'viNas- n. "property"	draunah "sacrifice"
bra'vltu (imper.3rd.sg.)	mrautu
pathibhis (instr.pl.)	padbiś
pItar- m. "father"	pta (but pita- in YA _v)

The laryngeal in CHC may yield 'i' in avestan if the laryngeal is followed by two consonants, as in piθrai, and duhitr-. This leads to Beekes formulating the following relative chronology for interconsonantal laryngeals in indo-iranian:

	init CHC	medial CHC	final CHC (or CH)
PIE	H	H	H
PIIr	i, H	i, H	i
avestan	(i), ∅	(i), ∅	i
sanskrit	i	i	i

Given this, Beekes submits that the change of H > i in PIIr is followed in sanskrit by a secondary vocalization of H.

Word-initial laryngeal before a consonant. A word-initial laryngeal before a consonant usually becomes null (\emptyset). This is the case for sanskrit and most IE languages. But in greek, [h_1C, h_2C, h_3C] > [eC, aC, oC]. In armenian and old phrygian preconsonantal H is vocalized. For hittite [h_1C] > [aC] and sometimes [h_2C] > [hC].

* h_1C : * h_1s -enti "they are" (pres.3rd.pl.) -> santi (parasm.pres.ind.3rd.pl. of as-) (sanskrit), sant- "being" (pres.act.ppl.) sat (pres.act.ppl.n.nom.sg.), but "not being" is Asat < * η - h_1 sat, with apparent preservation of the preconsonantal laryngeal as 'a'. (Meier-Brugger p. 116)

* h_2C : * h_2ste 'r- "star" -> ḫaster (hittite), ἀστῆρ (greek), स्तृ- star- m. (sanskrit), star (english)

* h_3C : ** h_3neid - "malign" -> ονείδος (greek), नि-दा- ni-dA- "bind, fasten", nidAna- n."cause, cause of illness", निदान-स्थान- nidAna-sthAna "pathology" (MWD).

Laryngeal in post-plosive prevocalic position. A laryngeal occurring before a vowel and immediately after a consonant stop (occlusive, plosive) may affect the phonologic qualities of the stop. (Meier-Brugger pp. 117-118, Szemerényi p. 125, Kobayashi pp.103-104) The particular effects on the consonant stop give us some idea of the phonologic qualities of the laryngeal involved.

Take for example the root, *steh₂- (> *stah₂-). The pres.ind.3rd.sg. form is reconstructed as *(s)ti-sth₂-e-ti (perhaps *(s)th₂-sth₂-e-ti?) and has the form तिस्थति tisthati in sanskrit. The stop remains unvoiced but becomes aspirated; this aspirated unvoiced stop छ् 'th' in sanskrit is generalized for the root itself, yielding स्था- sthA-.

For *pe'nt-oh₂-s (nom.sg.) "path" and *pnt-h₂-e's (gen.sg.) -> pañtā (nom.sg.) and paθō (avestan), पन्थाः pa'nthAs (nom.sg.) and पथः patha's (gen.sg.) (sanskrit), we see the aspiration of the stop and that it becomes generalized for all forms in sanskrit, but in avestan the aspiration is seen as in PIE only in the forms where the stop is immediately followed by the laryngeal. The laryngeal, * h_2 , was probably an unvoiced aspirate, as reflected by hittite ḫ.

The pres.ind.3rd.sg. of *peh₃- (> *poh₃-) "drink" is reconstructed as *pi-ph₃-eti (> *pi-b-eti). In sanskrit, the root पा- pA- "drink" has the parasm.pres.ind.3rd.sg. form, पिबति pibati. The laryngeal, * h_3 , causes the voicing of the immediately preceding consonant stop, *p > *b. Note that the laryngeal, * h_3 , is postulated to be voiced. (Meier-Brugger p. 117, Szemerényi p. 125)

Consonants that are not stops are not affected and the laryngeal is simply lost without effect, as illustrated by the word for "blood" (a neuter noun in PIE, hittite and sanskrit) for which hittite has preserved the laryngeal as 'h', and whose sanskrit stems are असृज्- a'sRj- (strong stem) and अस्न- asa'n- (weak stem):

	PIE	hittite	sanskrit
nom-acc.sg.	* h_1e 'sh ₂ -r	(e)-eš-ḫar	असृज् a'sRj
gen.sg.	* h_1sh_2 -eno's	(e)-iš-ḫan	अस्नः asna's (later, असृजः a'sRjas)

Note that there is a nasal in the strong stem in the nom-acc.pl. as असृजि a'sRJi.

Laryngeals and lengthened grade vowels. The laryngeals exerted their coloring effect on neighboring 'e' at a very early stage, likely middle PIE, yielding [h_1e, h_2e, h_3e] > [h_1e, h_2a, h_3o] and [eh_1, eh_2, eh_3] > [$\bar{e}h_1, \bar{a}h_2, \bar{o}h_3$]. But even before this took place, the e-vowel in certain roots is believed to have undergone qualitative ablaut to o-grade (full grade) and lengthened e-grade, rendering the vowel in those roots impervious to laryngeal coloring.

Recalling that qualitative ablaut is allophonic and that the long grade represents a transformation of the normal full grade in particular circumstances, one should expect the synchronic coexistence of regular full grade roots with their ablauted counterparts.

Thus, chronologically:

(The vowel 'e' changes around h_1 are analogous. Only h_2 and h_3 are shown, for clarity.)

1) full grade 'e' coexists with allophonic qualitative ablauted 'o' and 'ē'.

$h_2e, h_2o, h_2ē$ and $eh_2, oh_2, ēh_2$

$h_3e, h_3o, h_3ē$ and $eh_3, oh_2, ēh_3$

2) laryngeal coloring

$[h_1e, h_2e, h_3e] > [h_1e, h_2a, h_3o]$ and $[eh_1, eh_2, eh_3] > [ēh_1, āh_2, ōh_3]$

3) resultant spectrum (with convergence of some roots after h_3)

$h_2a, h_2o, h_2ē$ and $ah_2, oh_2, ēh_2$

$h_3o, h_3o, h_3ē$ and $ōh_3, oh_2, ēh_3$

Vocalic resonants and laryngeals. The vocalic liquids (r, l), and nasals (η, m) followed by a laryngeal (esp preconsonantly) show the following outcomes in ie languages. (Meier-Brugger p. 121-124, Gamkrelidze pp. 204-205, Clackson p. 59)

$[iH, uH] \rightarrow [\bar{i}, \bar{u}]$ in PIIr (avestan and sanskrit) and most ie languages, including greek and latin. In PIIr, $[\bar{i}, \bar{u}]$ represent a phonemic contrast from $[i, u]$.

$[\text{*}\eta h_1, \text{*}\eta h_2, \text{*}\eta h_3] \rightarrow [n\bar{e}, n\bar{a}, n\bar{o}]$ (greek)

-> $[\bar{a}]$ before consonant, $[an]$ before a vowel (sanskrit)

-> $[\bar{a}]$ before consonant, $[an]$ before a vowel (avestan)

-> $[n\bar{a}]$ (latin)

-> $[un]$ (germanic)

$[\text{*}\text{m}h_1, \text{*}\text{m}h_2, \text{*}\text{m}h_3] \rightarrow$ like $\text{*}\eta h_x$ above

$[\text{*}r h_1, \text{*}l h_1, \text{*}r h_2, \text{*}l h_2, \text{*}r h_3, \text{*}l h_3] \rightarrow [r\bar{e}/l\bar{e}, r\bar{a}/l\bar{a}, r\bar{o}/l\bar{o}]$ (greek)

-> $[\bar{i}r]$ (or $[\bar{u}r]$ before consonants, $[ir, ur]$ before vowels (sanskrit)

-> $[ar]$ (occasionally $[ər]$) (avestan) (Skjærvø, p. 50)

-> $[r\bar{a}, l\bar{a}]$ (latin)

-> $[ur, ul]$ (germanic)

e.g., $\text{*}k\bar{r}h_2\text{-to}' \rightarrow$ शृ- ZR- "break, crush", शीर्त- ZIrta'- शूर्त- ZUrta'-

(MWD शृ- ZRR- "crush, break", शीर्ण- ZIrNa'-, शीर्त- ZIrta'- "fragile"; शूर्त- ZUrta'- "broken, slain")

$\text{*}p\bar{l}h_1\text{-no}' \rightarrow$ पूर्ण- pUrNa'- "full, filled" (Fortson p. 189)

The laryngeal is retained in sanskrit until after the change $\text{*}\eta > \text{*}a$, after which the loss of the laryngeal produces compensatory lengthening, as $\text{*}\eta h_1\text{-to}' \rightarrow \text{*}jah_1\text{-to}' \rightarrow j\bar{a}ta'$ (ppl. of jan-), (Meier-Brugger p. 124, Kobayashi p. 138), zāta- (avestan) (Beekes-1988 p. 93).

Accent and laryngeal forms. The role of accent in determining the full grade or zero grade of a syllable is described in the section above, "Accent and zero grade." The presence of a laryngeal in the syllable has no direct bearing on the accentological properties of the morpheme. When a syllable containing a laryngeal is reduced to zero grade the accompanying vowel becomes null, or if the vowel was long grade it may be reduced to schwa (ə). This leaves either an interconsonantal laryngeal in the reduced syllable or a preconsonantal word-initial laryngeal.

Laryngeals and PIIr.

Laryngeals are believed to still be present in PIIr. Their evolution was continuous from middle PIE through PIIr to the immediate pre-vedic and pre-avestan period. They $[h_1, h_2, h_3]$ continued to behave as the resonants $[i, u, r, l, m, n]$, being consonantal or syllabic allophones, depending on the context.

Laryngeal merger. The idea of laryngeal merger originates from the apparent phonological convergence of vocalic laryngeals. Indeed Lindemann posits the merger of all laryngeals to have occurred in late PIE, before the differentiation of ie language groups. (Kobayashi, p. 129) Beekes also

suggests the merger of laryngeals by the time of PIIr on the basis that interconsonantal laryngeals have converged to 'i' and that intervocalic laryngeals -- presumably pronounced as glottal stop [ʔ], why not [h] or [ʎ] -- are not distinguishable in PIIr. (Beekes-1988 p. 83)

Gamkrelidze (p.170) considers that laryngeal convergence is a concomitant of the phonemicization of [a, e, o], a result of laryngeal coloring. But since the independent PIE phonemes, 'o' and 'a', can be reconstructed without laryngeals, they are already phonemes and the extrapolation to laryngeals is perhaps inferential.

However, the three laryngeals show a unique development in each of the branches of ie. It is therefore much more likely that the three laryngeals are inherited as three distinct phonemes (at least consonantly) by each developing ie language group and processed within the phonological rules of the respective language systems. Furthermore, "the three laryngeals show different developments even among the so-called 'core' ie languages, namely Greek, Germanic, Balto-Slavic and Indo-Aryan." (Kobayashi p. 130) That is, PIIr should be considered to have acquired the laryngeals as three distinct phonemes.

Laryngeal h₂ effects in PIIr. The a-coloring laryngeal, h₂, has a number of unique effects in PIIr, and behaves differently from h₁ and h₃. (Kobayashi pp.130-131) The other two laryngeals, h₁ and h₃, are not distinguishable in PIIr; so their earlier merger cannot be excluded.

Firstly, let us briefly address h₂ in PIE. In Anatolian (especially Hittite), word initial PIE *h₂ sometimes results in 'h' (as in the examples above), but occasionally does not. In the instances that it does not, a second a-coloring laryngeal, h₄, is hypothesized by some, since it remains otherwise unexplained why the initial 'h' might be absent. Let us consider the PIE word for "white" and its ie cognates, reconstructed with either h₂ or h₄, as an example:

*h₂elb^ho's- > *h₂olb^ho's (lengthened vowel grade) (de Vann p. 32, Tremblay p. 128)

*h₄elb^ho's- (Mallory and Adams p. 55)

--> alpa- "cloud" (Hittite)

--> albus "white" (Latin), Alpīs "Alps" (Latin)

--> albīz (Old High German), Elbe (New High German)

--> лебедь (OCS) < *olbōdъ, *olbъdъ, *elbedъ, *elbъdъ (PSL)

In short, h₂ or h₄ can be distinguished only word initially and only when there is a Hittite cognate.

An additional argument in favor of the existence of both h₂ or h₄ is that in PIIr one of these causes aspiration of unvoiced consonants, while the other does not. Proposing a second a-coloring laryngeal in PIE in the form of *h₄ is hypothetical.

The realization by Kurylowicz (1935) that many voiceless aspirates in OIA owe their appearance to the combination of a voiceless stop + h₂ effected a reordering of Brugmann's widely accepted late PIE inventory to exclude unvoiced aspirates. (Kobayashi p. 103) The laryngeal in Indic disappears after aspirating the consonant, but may also produce an interconsonantal 'i' if the following morpheme starts with a stop, so [C][h₂] > [C^h], [C][h₂][C] > [C^h][i][C]. (Kobayashi p. 117) E.g., *meth₂- "rip" > मन्थ्- मथ्- math- "shake", मथित- math-ita'- (ppl.) rather than mattha-.

Skjærvø (pp.48-51) summarizes the effects of h₂ in PIIr:

- 1) aspirated the voiceless stops before vowels, which became voiceless aspirates in Indic but spirants in Iranian (Beekes-1988 p. 87, Kobayashi p. 103)
- 2) left a hiatus or glide between vowels,
- 3) h₂ between consonants left [ə],
- 4) h₂ after a vowel and before a consonant resulted in compensatory vowel lengthening.

Unvoiced aspirates. In the sections above, "Laryngeal in post-plosive prevocalic position" and "Laryngeal h₂ effects in PIIr" the effect of h₂ aspirating the preceding unvoiced consonant was introduced. Aspiration of the preceding unvoiced stop is seen most consistently in word non-initial position, as in the examples above. But a word initial unvoiced consonant stop followed by h₂ remains unaspirated, as in pita'r-, and in that context behaves like h₁ and h₃, disappearing without a trace or leaving 'i' interconsonantly. (Note that h₁ and h₃ in PIIr do not cause aspiration of a preceding consonant.) However, if the word initial unvoiced consonant stop (that is followed by h₂) has or acquires a preceding 's', then aspiration becomes possible, with the sibilant progressively assimilating the following unvoiced consonant with the feature [+spread glottis]. (Kobayashi pp. 108-111) In such a manner a neighboring

sibilant may promote aspiration.. (Kobayashi p. 104-107) A sibilant + stop combination may even be allophonic with the aspirated stop, [s][C] <-> [C^h]. And by the time of vedic sanskrit the aspirated unvoiced consonants arising from their combination with h₂ [Ch₂] > [C^h] have become phonemic. (Kobayashi p. 109, 132)

The aspiration of unvoiced consonants is estimated to be late PIE or early PIIr. In sanskrit, थ् 'th' is not found word initially. In greek 'th' is represented by τ and θ, 'kh' by χ; in armenian - 'th, 'x' and occasionally 'ph'. In germanic, slavic and baltic the aspirates are represented by their unaspirated equivalents, while in slavic the 'kh' becomes 'x'. (Szemerényi p. 68-69) Consider these cognates:

पथ- path- m. "way", पन्थाः panthAs (nom.sg.) "way, road" (sanskrit), पाτος "path" (greek), pōns "bridge" (latin), ПАТЬ "road" (ocs)

रथ- ratha- m. "chariot" (sanskrit), rota "wheel" (latin), ratas (lithuanian)

मन्थ- manth- "shake", मन्थति manthati (sanskrit), μoθος "battle" (greek), МАСТИ, МАТЖ "shake", МАТЕЖЬ "confusion" (ocs)

अस्थि- asthi- n. "bone" (sanskrit), οστεον (greek), os (latin), кость (ocs)

शङ्ख- ZaGkha- m. "shell", κογχοs "mussel shell" (greek)

As anticipated from the above discussion, in sanskrit, voiceless aspirates after a sibilant are quite common, as स्खल्- skhal- "stumble", स्फूर्ज्- sphUrj- "rumble", स्फ्य- sphya- n. "oar", स्फा- spha- "to fatten", स्फट्- sphaT- "split", स्था- sthA- "stand", स्थग्- sthag- "conceal", -इष्ठ- -iSTha- (superlative suffix), The origin of many of these unvoiced aspirates after a sibilant is a result of **Sieb's Law**, which is stated as, "If an s-mobile is added to a root that begins with a voiced consonant, that consonant is devoiced. If it is aspirated, it retains its aspiration." Sieb's Law is particularly important in germanic phonology.

Szemerényi suggests that in PIE voicing in the aspirate series may have been irrelevant, and submits the presence of unvoiced aspirates in PIE cannot be entirely excluded. (Szemerényi p.143-144) The rules governing aspiration -- i.e., precisely under what conditions the laryngeals cause aspiration -- require further study. (Fortson p. 188)

Recall from our section on the root that a sanskrit root can not have more than one aspirated consonant. (Whitney 155a, Kobayashi p. 114).

In summary, major sources of unvoiced aspirates in PIIr are non word-initial unvoiced consonants + h₂, word-initial stop + h₂ preceded by a sibilant, and voiced aspirates preceded by a sibilant (Sieb's Law).

-[C][h₂] > -[C^h] and -[C][h₂][C] > -[C^h][i][C] (non word-initial)
s[C][h₂] > s[C^h], s[C][h₂][C] > s[C^h][i][C] (word-initial)
s[C^h[+voi]] > s[C^h[-voi]] / #[s]_. (Sieb's Law)

Spirantization of unvoiced aspirates in iranian. The section above, "laryngeal in post-plosive prevocalic position," describes the development of voiceless aspirates in a stop + laryngeal + vowel environment. In iranian the voiceless aspirate stops inherited by this late PIE-early PIIr process undergoes spirantization, as [p^h, t^h, k^h]V > [f, θ, x]V. E.g., (Beekes-1988 p. 88)

PIE *plth₂u'- "broad" -> prθu- (avestan), पृथु- pRthu'- (sanskrit)

PIE *-th₁e- (2nd pl primary ending) -> -θa (avestan), -थ -tha (sanskrit)

PIE *p₁th₂os "road" -> paθa- (avestan), pathas (sanskrit)

PIE *roth₂o- "chariot" -> raθa- (avestan), ra'tha- (sanskrit)

PIE *k^hnetH- "strike" -> snaθis "weapon" (avestan), श्नेथ- Znath- "strike, kill" (sanskrit)

Furthermore, in iranian, voiceless stops in general undergo spirantization before a non-syllabic consonant (even a laryngeal), yielding [p, t, k]C > [f, θ, x]C. For instance, (Fortson p. 204, Beekes-1988 pp.73-74)

PIIr *pra- "forth, forward" -> fra- (avestan and OPers)

PIIr *catuāras "four" -> caθuuārō (avestan)

PIE *kreu- "bloody, raw flesh" -> PIIr *krūra -> xrūra (avestan)

In pre-iranian PIIr both the new aspirated unvoiced stops [p^h, t^h, k^h] and unaspirated stops before

consonants [p, t, k] undergo spirantization (fricativization) to [f, θ, x]. (Skjærvø p. 50)

The traditional approach for Iranian is to describe that the unvoiced aspirate is first created from the laryngeal, and after that the unvoiced aspirate is spirantized (fricativized). So, for instance, tH > t^h > θ.

The voiced aspirates inherited from PIE by way of PIIr are processed differently in Iranian and simply lose the aspiration, as PIIr *bharanti "they take" > bharanti (Sanskrit), barainti (Avestan), bara(n)tiy (OPers). That is, in Iranian, but not in Indic, the aspirated voiced consonant stops lose their aspiration and merge with regular voiced consonants. The **deaspiration of voiced aspirates** is an early PIIr process that is also shared by Balto-Slavic and Germanic. (Beekes-1988 p. 71, Fortson p. 203, Szemerényi p. 68)

However Beekes points out that voiced aspirates - both from PIE voiced aspirates and voiced aspirates generated from laryngeals - do not undergo spirantization. (Beekes-1988 p. 88, Fortson p. 203-204)

Beekes suggests it is conceivable that the fricatives are the product of a direct development of voiceless stops to fricatives before a consonant in Iranian, that is post-PIIr. So, for Iranian, tH > θH > θ, just like spirantization before other consonants, as tr > θr, etc. If this is the case, it would draw Slavic and Armenian into an isogloss with Iranian.

Interconsonantal laryngeal and i-epenthesis in PIIr. PIIr demonstrates a consistent representation of vocalic H as 'i' ('a' in other IE languages). Melchert suggests that in Hittite the interconsonantal laryngeal is firstly deleted (syncope) and that anaptyxis of a "filler" vowel occurs after this, thereat postulating a schwa. (Kobayashi pp. 132-133) But in PIIr, the interconsonantal laryngeal behaves as a consonant even after the insertion of 'i' has taken place, so that the chronological order of laryngeal loss and i-epenthesis may be the opposite of Anatolian. (Kobayashi p. 133) Even so, the direct change of vocalic H > i remains quite possible.

The phenomenon of i-epenthesis (svarabhakti) may be an analogic extension of H > 'i' in Sanskrit. This secondary phenomenon is seen in Sanskrit and not at all in Avestan. Unrelated to laryngeals, it is seen in the following contexts: (Kobayashi pp. 136-137)

1) connective 'i' in perfects - when a perfect stem ending in a consonant takes an ending beginning with a consonant, an unoriginal, non-laryngeal, epenthetic 'i' is inserted, even in aniT verbs.

2) seT behavior - when the future suffix, -sya' is added to a full grade root a connecting 'i' is observed even in aniT verbs. (But in his review of Kobayashi's work, Byrd (p.3) suggests that the apparent epenthetic 'i' in future forms may be derived from an original *-h₁- inherent to the future suffix, as *-h₁s-e/o- > -इष्य- -iSya-, citing the Greek form, *ten-h₁s-e/o > teneō "I shall hold", containing 'e' as evidence of h₁.)

Examples of the s-future studied by Saussure (see Accent and Zero Grade) suggest the nature of the laryngeal is intrinsic to the verbal root, i.e., a seT verb.)

3) s-aorist forms - an 'i' is inserted in the 2nd and 3rd sg. to avoid sandhi loss of final consonants.

4) word final 'i' - hRd- n. "heart" also has the form, hArdi- m. in the RV and AV. (see MWD) (The root had no root-final laryngeal. The final 'i' represents paragoge.)

Accordingly, not all instances of interconsonantal 'i' in Sanskrit are of laryngeal origin, in particular, when the corresponding Avestan form has no 'i'. As such, non-laryngeal i-epenthesis is a post-PIIr Indic phenomenon.

Metrical effects and intervocalic laryngeals. Like the resonants, laryngeals between vowels behave as consonants. The loss of intervocalic consonantal laryngeals in Sanskrit and Old Avestan are evidenced by hiatuses or glottal stops. Observations of metric phenomena in the ऋग्वेद Rigveda reveal heavy syllables and extra syllables in verses that are attributed to words that had undergone laryngeal loss. In Old Avestan long vowels and diphthongs resulting from laryngeal loss remain disyllabic (2μ). (Skjærvø p. 49)

The following examples are illustrative.

वात- vAta- m. "wind" is consistently trisyllabic, as va-ata, < PIE *h₂weh₁-nt-. (Clackson p. 58, Fortson p. 189)

जा'ना- ja'na- "people" has a heavy first syllable, < PIE *ǵo'nh₁o- (Kobayashi p. 24)

-आम् -Am - gen.pl. ending always has two syllables, < PIIr *-a-am < PIIr *-a?am (this form remains in Avestan) < PIE *-h₂-om (Kobayashi p. 24, Beekes-1988 pp. 90-91)

पृथिवी- pRthivl- f. "earth" has a heavy first syllable, < PIE *p̥l̥th₂-u-ih₂ (Kobayashi p. 128)

This suggests that at the time of composition of the vedic verses the intervocalic consonantal laryngeals were either still present or had become glottal stops, like [ʔ], or obligatory hiatuses. As discussed in the section on sibilants, the voiced sibilants were also likely present at the time the vedic verses were composed. The laryngeals were likely lost before the voiced sibilants.

In many instances, avestan shows a hiatus or glottal stop where sanskrit has an 'i' or consonantal 'y' (sandhi) between vowels (Beekes-1988 p. 89-91), as

PIE	sanskrit	avestan
*priHo'-	priya'-	friʔa "friendly"
*ǵ ^h uH-eio-	hva'ya-	zuʔaya- "call"
-iHa (gerunds)	-iya-	variʔa- "desirable", zaviʔa- "to be called", zahiʔa- "risible"

In instances of -VHV- crossing a morpheme boundary as -VH-V-, such as between root -VH- and suffix -V-, the laryngeal is preserved as a glottal stop in avestan and as 'i' (or its consonantal equivalent) in sanskrit. (Lubotsky-1995 p. 214)

In the setting of *RHV (vocalic resonant - laryngeal - vowel), where the first vowel is a resonant avestan and sanskrit develop differently (Beekes-1988 p. 93), as

PIE	sanskrit	avestan
*prH-	purā	parā "before"
*trHo'os-	tira's-	tarah "through"
*urHu-	uru'-	varu- "broad"
*snH-a-	sana'-	hana- (thematic aorist) < han- "win"

This suggests the presence of the laryngeal well after the common PIIr period.

A special case of interconsonantal laryngeal change is presented by the loss of a laryngeal after a consonant and before a consonantal 'y' [j]. This is referred to as **Pinault's Law**. E.g., *krewH₂s- > क़वः kravi's, but *krewyo- > क़व्याः kravyAs.

Various outcomes of intervocalic laryngeals in sanskrit. As mentioned above, in cases of -VHV- crossing a morpheme boundary as -VH-V- the laryngeal and its subsequent reflexes as a glottal stop in avestan or as 'i' in sanskrit tend to be preserved.

But in instances where the PIE *-VHV is within a morpheme, in the second component of compounds, and even in some morpheme boundaries, a contraction of -VHV may occur. In these cases, the laryngeal is lost without a trace. Lubotsky (1995) enumerates some of these outcomes.

*-aHi > monosyllabic 'e'

PIE *deh₂i-uer- -> देवृ- deva'r- m. "husband's brother", дѣверь (psl)

PIE *d^heh₁i-neh₂- -> dhenA- f. "stream of milk", daēnā (avestan)

*-aHi > disyllabic 'e'

superlatives with the suffix -iSTha-, as ज्येष्ठ- jyeSTha- "most powerful" < *jyaH-iSTha-,

*daH-iSTha- > देष्ठ- deSTha- "the most bountiful", *dhaH-iSTha- > धेष्ठ- dheSTha- "providing the most",

*yaH-iSTha- > येष्ठ- yeSTha- "going most quickly"

The contraction *-aHi- > [e, e:] is seen as analogous to *-ayi- > [e, e:].

*-aHi- > -ayi

*Hreh₁i- -> रयि- rayi'- f. "wealth, goods", an i-stem derived from रA- rA- "to bestow, give"

*-aHi > -ai- (both mono and disyllabic), e.g., [augment (आ-)] + [i, u] -> [ai, au], suggesting that at some earlier stage in PIIr the augmented form and the initial vowel were pronounced separately or with hiatus and coalesced only later to the diphthongs, as for इ- i- "go",

*aH-yam > आयम् A'yam (parasm.imperf.ind.1st.sg.)

*aH-it > [*ā-it] or [*āʔit] > औत् ait (parasm.imperf.ind.3rd.sg.)

*-aHu- > [o, au] (both mono- and di-syllabic), but not [-avu-]

*gaHu- "cow" > ga'v- nom.sg. *gaHu-s > gau's
acc.sg. *gaH-am > gA'm

instr.sg. *gaHu-A > ga'vA
 abl.gen.sg *gaHu-s > go's (not ga'vas)
 acc.pl *gaH-as > gA's
 gen.pl *gaHu-*h₂-om > go'vAm, go'nAm
 *neh₂-u- > nau- f. "ship" nom.sg. *neh₂-u-s > naus
 acc.sg. *neh₂-u-am > nA'vam
 gen.sg *neh₂-u-os > nAvas

B.9. PIE phonological laws with limited effects on PIIr.

A number of phonologic laws and phonological processes are regularly included in descriptions of the PIE phonologic system. They are included here because they describe changes occurring in late PIE. A number of authors have investigated their importance or relevance to the development of PIIr and Sanskrit.

We are including these processes here for completeness, recognizing that their contribution to the development of PIIr may be underinvestigated, disputed or at least exiguous.

Teeter's Law. "The language of the family you know best always turns out to be the most archaic." This "rule" is first cited in 1976 by Indo-Europeanist, Calvert Watkins. The inclusion of this "law" is intended as humor.

Boukolos Rule describes the loss of the labial element of labiovelars when followed by *u. (Fortson p. 64) The rule operates in centum languages and in Greek in particular.

कूर्म- kUrma'- m. "turtle"; (Gk. κλεμμς, χελς, χελωνη (mwd))

Siever's Law, as later modified by Edgerton and Lindeman, refers to the alternation (epenthesis of a vowel corresponding to the resonant) of the resonant semivowels as a function of the weight of the preceding syllable. In PIE, y -> iy, w -> uw, following a heavy syllable, as Sanskrit द्यु- dyu- becomes pronounced as diyu- following a heavy syllable (one containing a long vowel, a diphthong or ending in two consonants). It is noteworthy that the noun, द्यु- dyu- दिव्- div-, a commonly cited example from Sanskrit, not only changes form but also gender to give two semantic values, the feminine noun meaning "heaven" and the masculine noun meaning "day." In many examples from Sanskrit, given the multiplicity of forms, there is much more operating than just Siever's Law, that is, there are multiple other morphologic and phonologic processes. In other words, for PIE Siever's Law describes only one of many potential changes that resonants can undergo; it therefore has limited predictive value for PIE and for PIIr. (Beekes-1988 pp. 99-100)

Siever's Law was developed on the basis of Germanic languages where the phonologic change is discreet and works in both directions (anaptyxis and syncope). Ringe convincingly describes the relevance and predictive value of Siever's Law for Germanic. (Ringe-2006 pp.116-122) Edgerton attempted to extend the law to all six resonants and to apply the law to Vedic -- but most of his cited examples have turned out to have alternative explanations. Lindeman, meanwhile, believed that the law operates only in word-initial syllables. This law may have operated in PIE -- but its relevance seems mainly for Germanic, where it is very productive.

Brugmann's Law states that a short 'o' in open syllables in PIE becomes lengthened to long 'ō', and then -- by the merger of vowels [e, o, a] > [a] -- a long 'ā' in PIIr, so *o (PIE) > *ā (PIIr) in open syllables (Fortson p. 183, Kobayashi p. 26-27). This rule serves the purpose of accounting for a long 'ā' where one would expect a short 'a' after the PIIr merger, [e, o, a] > [a]. This rule is separate from and anterior to the PIIr merger and is believed to have taken place in PIE. This rule seems to apply to 'o' that is the ablauted form from 'e'. Any 'o' that is not a result of ablaut yields a short 'a'. And since the qualitative ablaut e > o was lost by the PIIr merger, [e, o, a] > [a], it thus appears that this 'o' is only sporadically replaced by [a] > [a:]. The numerous exceptions to Brugmann's Law are often explained using laryngeals.

Returning to our example of कृ- kR- in the perfect indicative, the 1st and 3rd sg. forms are explained as arising from a difference in syllabification with the 'o' in the open syllable being lengthened, as

(Fortson p. 183),

1st.sg. *k^we-k^wor-h₂e > चकर cakara (but the parallel form चकार cakAra is admitted)

3rd.sg. *k^we-k^wo-re > चकार cakAra

However, there remain frequent unexplained inconsistencies in this rule, as with the adverb-preverb, प्रति- prati- (sanskrit), προς < *προτι (greek), both with a short vowel in the open syllable. For avestan, numerous deviations from the historical vowel length inherited from PIIr are attested, and the idea that 'a' in closed syllables remains short but in open syllables becomes long is not supported and represents an oversimplification. (Beekes-1988 pp. 48-49) This limits the predictive value of Brugmann's Law.

B.10. Phonemes relatively preserved in the PIE-PIIr interval.

vowels [+syll]

e e: a a: o o: (not yet merged to a a:)
ei ei: ai ai: oi oi: (not yet merged to ai ai:)
eu eu: au au: ou ou: (not yet merged to au au:)

i u (ə) r l (not yet [r, l] > [r])

consonants [-syll]

laryngeals (H) h₁ h₂ h₃ (process of laryngeal loss and merger begun in PIE)
velar: k g g^h (before non-front vowels)
dental: t d d^h l r (pre-merger) n
s (z) (preserved but with **major** additions and losses)
labial: p b b^h w m

By PIIr relatively preserved or unchanged are the following PIE phonemes:

labials
dentals

The voiced aspirates, particularly of the dental and labial series, are inherited relatively intact by PIIr and in turn by sanskrit.

(some unvoiced labials, dentals and velars aspirated in late PIE or in PIIr)

plain velars before non-front vowels (but with addition of merged labio velars)

(plain velars (and other consonants) in consonant clusters changed in late PIE or PIIr)

sibilant 's' - with major additions, changes and deletions

vowels undergo dynamic change because of PIE ablaut and consonant changes

laryngeals (loss and mergers starting in middle PIE)

C. Phonological processes in proto-indo-iranian (PIIr).

The phonological processes of PIIr have their origins in PIE. The attested indic, iranian and nuristani languages demonstrate numerous shared innovations that distinguish them from other ie languages and allows us to group them into one indo-iranian family. Given the abundance and quality of data, particularly from sanskrit and avestan, it is possible to reconstruct an intermediate proto-indo-iranian (PIIr) stage of development. PIIr in turn affords a valuable synchronic reference point that enables a more detailed understanding than PIE of language processes leading up to and immediately preceding the attested period of vedic sanskrit and gathic avestan.

Phonological change from PIE is continuous, and for many of these changes -- such as the evolution of sibilants, laryngeals, consonant clusters, word-final consonants, voiceless aspirates, etc. -- it is difficult to draw a line between those changes that are shared with some of the other ie language groups (i.e., late PIE) and those that have become specific to PIIr. For that reason and for the sake of continuity,

the descriptions of late PIE changes described above have been followed through into the PIIr period and for continuity to the period of attested avestan and sanskrit.

The serial palatalization of velars lends itself to periodization and description in stages. So the subsequent fate of these phonemes in PIIr will be described in this section.

A number of processes, some of whose origin might have been in late PIE, have a distinct indo-iranian character and will be presented in this section. These include the vowel merger [e, o, a] > [a], the merger of [l, r] > [r], the deocclusion of palatal affricates, development of aspirate consonants, and more.

C.1. Vowel merger, [e, o, a] > [a]

The most salient phonological development in the history of the indo-iranian language system is the vowel merger, [e, o, a] > [a], in which all grades and diphthongs are affected. This merger is regarded as an **unconditioned change**, a change occurring in all settings without regard to phonetic environment. In contrast, **conditioned changes**, of which many instances have been described above, occur in specific phonetic circumstances. Hardly a textbook of historical linguistics exists that fails to mention this change as a classical example of unconditioned change.

The forms affected in this merger are these:

PIE to PIIr:

[e, o, a] > [a] [e:, o:, a:] > [a:]
 [ei, oi, ai] > [ai] [ei:, oi:, ai:] > [ai:]
 [eu, ou, au] > [au] [eu:, ou:, au:] > [au:]

Noteworthy is that the three vowels affected (along with their diphthongs) represent syllabic phonemes without non-syllabic consonantal allophones, in contrast to the resonants and laryngeals.

Vowel grade is preserved in this merger, but exceptions are generated by the effects of laryngeals and by Brugmann's Law, whose effects would have taken place before this merger. The phonological contrast between the three vowels is lost, reducing the eighteen PIE phonemes to six in PIIr.

Following the common PIIr period, avestan and OPers preserve the diphthongs, PIIr *[ai, au], as [aē, ao] and [ai, au], respectively. In avestan, the form PIIr *[ai] > [aē] takes the form [ōi] before consonant clusters, sibilant + consonant, and replacing final *[ai] in monosyllabic words. (Skjærvø p. 55, Fortson p. 204) The avestan form, PIIr *[au] > [ao], is usually represented as [ēu] in old avestan and as [ao] in young avestan. Many of the avestan forms as [au, ou, aou] represent labialization of [a] and not always derived from PIIr *au. Finally, in avestan the forms [āi] and [āu] not not distinguishable from 'ā' + epenthetic 'i' or 'u'.

Following the common PIIr period, in sanskrit, the diphthongs, PIIr *[ai, au], become monophthongized as [ए, औ][e, o], and keep their two-mora length, while the long diphthongs [ऐ, औ][āi, āu] remain as they are in PIIr. (Fortson p. 189-190) Earlier works on sanskrit represent these long diphthongs as [āi, āu], but in more recent times they have been represented simply as [ai, au].

PIIr	Sanskrit	Avestan	Old Persian
*[a]	अ a	a	a
*[a:]	आ ā	ā	ā
*[ai]	ए e (or ē)	ēi, ōi	ai
*[ai:]	ऐ ai (or āi)	āi	āi
*[au]	औ o (or ō)	ēu, ao	au
*[au:]	औ au (or āu)	āu	āu

It has not been determined whether the merger [e, o, a] > [a] occurred as a single concerted process or in stages as [o] > [a] followed by [e] > [a]. Anatolian languages inherited all the PIE vowels and

in all languages (except Lycian) one observes the mergers, [o, a] > [a] and [o:, a:] > [a:]. (Fortson p. 156) In Russian and Belarusian an 'o' in unstressed syllables becomes 'a'. But without more studies, it would be difficult to infer that either of these two processes are part of the same one that initiated the vowel merger in PIE. Even so, the possibility that [o, a] merged to [a] separately from [e, a] > [a] is feasible. (as described in Harmatta's work)

Kobayashi outlines these considerations that may have grouped the non-high vowels together and created a phonetic environment facilitating their merger:

PIE ablaut has a length gradation involving *e, *o and *a, serving grammatical function;

PIE shows alternation between *e and *o, serving grammatical function;

PIE *e, *o and *a form PIE syllable nuclei, while the high vowels, *i and *u behave like the resonants;

PIE high vowels and resonants behave differently from the non-high vowels, and no PIE process admits the change of a non-high vowel to or from a high vowel. That is, in PIE no process changes the value of [+high] in a vowel and there are no vocalic phoneme pairs in which this value is phonologically contrastive. (Kobayashi p. 134)

The PIE merger [e, o, a] > [a] represents loss of phonological contrast (or merger) of all non-high vowels, leaving the feature [+high] to serve as the only feature that distinguishes [a] from the high vowels, [i, u] and the vocalic resonants. (Kobayashi p. 135) In other words, the feature [+low] as contrastive is lost, forcing [a] to merge with [e] and [o].

By way of relative chronology, as described in the earlier sections, it is obligatory that the vowel merger [e, o, a] > [a] occurred after the palatalization of palatal velars, after the palatalization of the merged labial and plain velars before front vowels, and after the loss of syllabic nasals. In the section on the palatalization of palatal velars some evidence was presented in the form of Finnish borrowings that would localize that change in Eastern Europe and before the vowel merger. In addition, the Hittite borrowings from Indic dialects of PIE (in Mitanni) of words like "panza" for "five" draws a hard line at about 1500 BCE, suggesting the completion of the vowel merger before that time. (Szemerényi p. 147, Fortson p. 184)

One of the principal phonological consequences of this merger for PIE is the loss of qualitative ablaut, i.e., the vowel alternations involving PIE full o-grade and the lengthened grades are obscured. (See the section above on long vowel grades.) Meanwhile, as also noted above, we observe the excellent preservation in PIE (and later Avestan and Sanskrit) of quantitative ablaut involving the effect of accent and the full grade-zero grade alternation.

C.2. Merger of liquid resonants, [r, l] > [r].

The PIE dialects developing into PIE inherit the vocalic and consonantal liquid resonants as described in the PIE inventory above, that is ([r [+syll], r [-syll] ; [l [+syll], l [-syll]]). Recall that in PIE consonantal and vocalic resonants are allophonic.

In PIE a process of merging r and l takes place -- that is, the two consonants [r, l] merge to one and the two vowels [r, l] merge to one.

For the entire Iranian system the process goes to completion as [r, l] > [r] and [r, l] > [r], such that there are no traces of the laterals [l, ɭ] in Avestan and Old Persian. The inherited PIE laterals are preserved as rhotics. In a few Iranian languages, however, the 'l' is preserved in some words, like læsæg "salmon" (Ossetic), listin "lick" (Kurdish).

In Indic -- as represented by Vedic and Classical Sanskrit -- the merging of 'l' and 'r' to 'r' goes to near completion with a predominance of 'r' reflecting inherited 'l' in most instances. But a notable, small number of words preserve the 'l'. This merger is generally referred to as the merger of 'l' and 'r' to 'r', [l, r] > [r], because of the overwhelming attested evidence from Sanskrit and Avestan. However, in a number of Eastern Indic dialects, like Magadhi, the outcome of the merger is 'l' and not 'r', so [l, r] > [l]. Only in "the middle" is the distinction between 'r' and 'l' partially preserved and in Sanskrit both vocalic and consonantal 'l' remain phonemic. (Fortson p. 182, 189, Kobayashi p. 145) Furthermore a significant number of words in Sanskrit have parallel rhotic and lateral forms.

Examples (some are taken from sections above):

From PIE *r: [*r] > [r] (sanskrit and avestan); [*r] > [ṛ][r] (sanskrit); [ərə] (avestan)
(there are no known instances of change to 'l')

- [*r] *mr-to- "dead" -> मृत- mRta'- (sanskrit), mərəta- (avestan)
*dṛk- "see" -> दृश्- dRZ- दृष्टि- dRSTi- f. "seeing" (sanskrit), daršti- (avestan)
(in YAv [*r] > [ar] before [š, ž] (Beekes-1988 p. 94)
θβōrəštār- (phon-θvrštar-) "creator" (OAv), त्वष्टृ- tva'STar- m. "maker, creator"
(but OAv [*r] > [ərə]; in this example the first 'ə' is colored by the preceding
labial. Note the zero-grade root in OAv. (Beekes-1988 p. 94)
[*r] *rot^ho- "chariot" -> रथ- ratha- m. (sanskrit), raθa (avestan) (Gamkrelidze p. 718)

From PIE *l: [*l] > [r, ल][r, l] (sanskrit), [r] (avestan); [*l] > [ṛ, लृ][r, l] (sanskrit); [r, ərə] (avestan)

- [*l] *ul^wos "wolf" --> वृकः vRkas (vedic skt), vəhrka- (avestan)
*m^ldu- "soft" -> मृदु- mRdu- "delicate, soft"
*plu- "much, many" -> पुरु- puru'- (sanskrit), paru- (O.Pers)
*l^k- "high" -> ऋष्व- RSva'- (sanskrit), ršva (avestan)
(Gamkrelidze p. 517, Beekes-1988 p. 94)
कल्प- kLp- "adapt", कल्पन्त- kLpta'- (ppl.) - ie origin? help (Engl), gelb "rescue" (lithuanian)
कृप्- kRp- "lament, pity", कृपते kRpate (Atm.pres.ind.3rd.sg.) (contrasted with kLp-)
[*l] *leuk- "shine" -> रोचते rocate (sanskrit), raocaiieiti, raucāh- (avestan)
*klewos *n-d^hg^{wh}itom "imperishable fame"
-> श्रवोऽक्षितम् Zravas akSitam (sanskrit)
*kleu- *kleu-to'- (ppl.) -> श्रु- Zru- "hear", श्रुत- Zruta'- (ppl.) (but श्लोक- Zloka- "verse")
-> *šrauta- (pre-avestan) > sraota- (avestan)
*pleu- "swim, float" -> प्लु- प्लवते plu- plavate "float, swim" (sanskrit)
-> fra-frāuuaiia- "to make s-thing float away" (YAv)
-> dunmō.fru- "flying with the clouds" (YAv)
(The 'l' in sanskrit plu- is clearly inherited from PIE via PlIr.)

Sanskrit roots with parallel rhotic and lateral forms:

- | | |
|---|--|
| चर्- चरति car- carati "move" | चल्- चलति cal- calati "move" |
| रिह्- रिहते rih- rihate "lick" | लिह्- लिहति lih- lihati "lick" |
| रङ्घ्- रङ्घते raGh- raGhate "hasten" | लङ्घति laGgh- laGghati "cross over" |
| रभ्- रभते rabh- rabhate "take possession" | लभ्- लभते labh- labhate "seize" |
| रिप्- रिप- "smear" (RV) | लिप्- लिम्पति lip- limpati "smear, rub over" |

Sanskrit roots with parallel 'r' and 'l' forms, but semantically divergent:

- | | |
|--|--|
| रि- री- रिनति ri- ri- rinAti "release, melt" | ली- लिनाति li- linAti "cling" |
| रक्ष्- रक्षति rakS- rakSati "protect" | लक्ष्- लक्षते akS- lakSate "mark" |
| ह्राद्- ह्रादते hrAd- hrAdate "make noise" | ह्लाद्- ह्लादते hlAd- hlAdate "refresh, rejoice" |

There has been much discussion surrounding the near- but non-completeness of the [l, r] merger to [r] in indic. Vedic sanskrit shows very infrequent instances of 'l'. In later sanskrit the 'l' becomes a little

more common. Some sanskritists have proposed that the merger to 'r' in prevedic sanskrit was complete and that the modest number of forms containing 'l' are borrowings from eastern indic dialects, as they are explained for later sanskrit. Alternatively, the exiguity of 'l' in the ऋग्वेद Rigveda may be a characteristic of that northwestern indic dialect that underwent a development similar to iranian. (Kobayashi pp.144-145)

Evidence from nuristani is relevant here. Some of the nuristani languages, like Kamviri and Kati have a number of words with 'l' that correspond to post-vedic sanskrit words with 'l', as kol "time" (Kamviri), कल- kala- (sanskrit); nila- "dark" (Kamviri), नील- nīla- (sanskrit); liza- "lick" (Kamviri), लिह्- lih- रिह्- rih- (sanskrit); mol, mul "dirt, firith" (Kati), मल- ma'la- n. (sanskrit). And many words containing 'r' in nuristani correspond to those in sanskrit, as mara "death" (Kamviri), मर- mara- m. (sanskrit); drgr "long" (Kati), दीर्घ- dlrgha- (sanskrit). (Kobayashi pp.145-146)

In vedic sanskrit, retroflex voiced dentals [ḍ, ḍ̥][d, d̥] have lateral allophones [ḷ, ḷ̥][l, l̥]. (Kobayashi p. 13) E.g., अग्निमीळे agnim l'e or अग्निमीडे agnim l'De "I am praising Agni." (ईड्- ID- "to praise")

In sanskrit a number of dentals [s, t, th, d, dh, n] become retroflex when preceded by etymological 'l', thereby accounting for a number of retroflexes that are otherwise contextually hard to account for. This represents **Fortunatov's Law**, which is believed to operate in PIE, and states that a PIE sequence if *l and a dental consonant leads to retroflexion of the dental with loss of the 'l', so

[*l][*s, *t, *th, *d, *dh, *n] or [ल][स्, त्, थ्, द्, ध्, न्] > [ष्, ट्, ठ्, ड्, ढ्, ण्]

This effect requires a distinction between 'r' and 'l', as such an effect is not seen with 'r'. Unfortunately, there is an absence of credible cognates in iranian or nuristani; so the validity of Fortunatov's Law for indo-iranian remains unconfirmed. (Kobayashi pp.145-146)

Despite both being grouped as liquid resonants, 'r' and 'l' show additional differences that are relevant to indo-iranian phonology. Rhotics [r] have the phonological feature of [+continuant]. The presence of central occlusion makes a phoneme non-continuant, like the nasals [n, m] and the stops. The laterals [l] can be considered either non-continuant [-cont] because of their central occlusion or as continuant [+cont] because of their lateral aperture, depending on the language system.

Firstly, in sanskrit, 'l' can be geminated across morpheme and word boundaries, like the non-continuant nasals, e.g., vallabha- "beloved", valli- f. "earth; creeping plant", malla- m. "wrestler, boxer", mallaka- m. "tooth", त्रिल्लं लोकान् triL lokAn (Wh206a), मेहनाद्वनंकरणाऽल्लोमभ्यस्ते नखेभ्यः mehanAdvanaMkaraNAI lomabhyaste nakhebhyaH (RV 10.163.5) -- mehanAt vanaMkaraNAI lomabhyaH te nakebhyaH (minus sandhi) (all ablative case) "from unine-making organs, from hair, from nails." In this manner, the behavior of 'l' resembles that of the non-continuant nasals. In contrast, the resonant 'r' is never doubled in sanskrit and at word boundaries, by sandhi rules, the final 'r' either becomes visarga or is lost with compensatory lengthening. Rarely, consonantal र् 'r' may precede the vocalic ऋ 'r̥' as in निरृ- nir-R- "be deprived of", निरृत्य nirRtya (gerund) and निरृज्- nir-Rj- "let out". There is a strong restriction in sanskrit against geminate rhotics. (Kobayashi p. 99)

Secondly, 'l' plays no role in the palatalization of sibilants in the ie ruki rule. And in sanskrit, 'l' neither causes the retroflexion of a sibilant that follows nor does 'l' block the retroflexion when it follows the sibilant.

Thirdly, "of the semivowels, the ल् 'l' alone is an admitted [word] final." (Wh144)

The ल् 'l' in sanskrit behaves as a non-continuant (Kobayashi p. 99), whereas र् 'r' is a continuant. As a result 'l' and 'r' are not only phonemic but functionally, phonologically different.

C.3. Proto-indo-iranian (PIIr) phonological inventory.

Proto-indo-iranian (PIIr) phonological inventory.

vowels [+syll]

a a: i u (ə) r |

ai ai:
au au:

consonanta [-syll]

laryngeals (H)	h ₁	h ₂	h ₃	(merged to H?)		
velar:	k	g	g ^h			
secondary palatal affricates, palato-alveolar:	ć [tś]	ǰ [dź]	ǰ ^h [dź ^h]	ǰ̥ [j̥]	ś (ź)	
primary palatal affricates, palatal (affricates):	c [tʃ]	j [dʒ]	j ^h [dʒ ^h]			
dental:	t	d	d ^h	n	l r	s (z)
labial:	p	b	b ^h	m	ɸ [w]	

PIIr vowel gradation:

long (vRddhi)	a:	ai:	au:	Ar	An	Am
full: (guNa)	a	ai	au	ar	an	am
zero: (svara)		ǰ / i	ɸ / u	r/r	n / a	m / a (vocalic r, n, m)

Notes:

1) **laterals and rhotics.** None of the sources consulted include the laterals, [l [-syll], l̥ [+syll]], in the inventory. It is clear that Sanskrit inherited the 'l' from PIE via PIIr.

2) **Laryngeals.** In our inventory, we left the three laryngeals unmerged, since consonantal h₂ has effects in PIIr that are different from the other laryngeals. If the laryngeals are shown as merged, then the unvoiced aspirates, and possibly the long resonant vowel grades, would need to be included in the inventory.

Since the laryngeals persist well into the PIIr period, we have not included the long resonant vowels, [r̥:, l̥:, i:, u:].

3) **Palatal affricates.** Recent authors, like Kobayashi and Skjærvø, present two phonemically distinct series of palatal affricates, as we have done here. This avoids a serious merger problem in Nuristani.

The phonological value of the secondary palatal affricates may be even more dorsal (palatal) than indicated in the inventory above -- that is, as [k̠, g̠, g̠^h], rather than as shown [tś, dź, dź^h].

Earlier authors would have replaced the secondary palatal alveolars with [c, j, j^h] and the primary palatal affricates with one of [ś, ź, ź^h] (from Avestan), [ʃ̣, ǰ̣, ǰ̣^h] (from Sanskrit) or again [c, j, j^h] (from Nuristani).

4) **Sibilants.** The only sibilant included in most PIIr inventories is 's' and its voiced allophone, 'z'. But sibilants began their differentiation in the PIE period (from Ruki rule and palatal affricates before dental stops) and by the PIIr period would have produced the palatoalveolar unvoiced and voiced sibilants, [ś (ź)]. The phonetic value of [ś (ź)] may also be represented as palatoalveolar [ś̠ (ź̠)], [ʃ̠ (ǰ̠)], [ʃ̠, (ǰ̠)] or as alveolopalatal [ʃ̠, (ǰ̠)], [ɸ̠, (ǰ̠)], since the precise place of articulation is unclear.

If the palatalization of PIE palatal velars is believed to have gone its full excursion by PIIr then a third palatal series of sibilants would be included. We have included only the dental and palatoalveolar sibilants in our inventory, leaving the deaffrication (to palatal sibilants in Indic) of the primary palatal affricates [c, j, j^h] to the PIIr period.

(See: Kobayashi p. 13, Skjærvø p.50 (Avestan), Beekes-1988 p. 70 (Avestan))

C.4. Palatal affricates.

Let us briefly review the development of the two series of palatal affricates in our PIIr inventory from the perspective specifically of Indo-Iranian languages, rather than all of Indo-European.

From the initial late PIE inventory,

labiovelars:	k ^w	g ^w	g ^{wh}
plain velars:	k	g	g ^h

palatal velars: \hat{k} \hat{g} \hat{g}^h
the PIE palatal velars undergo palatalization (Law of Palatals) yielding palatal affricates that we refer to as the primary palatal affricates, resulting in

labiovelars: k^w g^w g^{wh}
plain velars: k g g^h
primary palatal affricates: c [tʃ] j [dʒ] j^h

Then, after the merger of labial and plain velars, resulting in

plain velars: k g g^h
primary palatal affricates: c [tʃ] j [dʒ] j^h

the plain velars before front vowels [i, i, e] become palatalized to a more dorsal, phonologically distinct series referred to as secondary palato-alveolar affricates, resulting in

plain velars: k g g^h
secondary palatal affricates: \acute{c} [tʃ] \acute{j} [dʒ] \acute{j}^h
primary palatal affricates: c [tʃ] j [dʒ] j^h

which represents the development at the PIIr stage, before its further differentiation in indo-iranian languages.

From the common PIIr period to the formation of separate indo-iranian language systems, the following obtains:

	PIIr			Sanskrit		
plain velars:	k	g	g^h	[k]	[g]	[g^h]
secondary palatal affricates:	\acute{c} [tʃ]	\acute{j} [dʒ]	\acute{j}^h	च् [tʃ]	ज् [dʒ]	ह [h]
primary palatal affricates:	c [tʃ]	j [dʒ]	j^h	श् [ɕ]	ज् [dʒ]	ह [h]

	PIIr			Avestan		
plain velars:	k	g	g^h	k	g	g
secondary palatal affricates:	\acute{c} [tʃ]	\acute{j} [dʒ]	\acute{j}^h	c [tʃ]	j [dʒ]	j [dʒ]
primary palatal affricates:	c [tʃ]	j [dʒ]	j^h	s	z	z

	PIIr			Nuristani		
plain velars:	k	g	g^h	k	g	g
secondary palatal affricates:	\acute{c} [tʃ]	\acute{j} [dʒ]	\acute{j}^h	\acute{c} [tʃ]	j [dʒ]	j [dʒ]
primary palatal affricates:	c [tʃ]	j [dʒ]	j^h	c [ts]	z [dz]	z [dz]

Nuristani data. As a third distinct branch of indo-iranian the nuristani group of languages deserves serious consideration as a potentially major contributor to our understanding of proto-indo-iranian (PIIr). The Nuristani languages are also referred to as Kafiri, and are distinct from Dardic. The speakers today inhabit the Nuristan province of Afghanistan and the area around Chitral in northern Pakistan. The people are divided into tribes and speak a number of languages of which the major five languages are Kamkata-vari (including the dialects, Kata-vari, Kamviri, Mumviri), Vasi-vari, Askunu, Kalasa-ala and Tregami. In the Rigveda 7.18.7 (first line), they are referred to as Alinas (अलिनासः alinAsas, vedic nom.pl. of अलिन्- alina-, MWD). Their languages have been studied by G. Morgenstierne (1940's) and more recently by R. Strand, A. Degener, I. Hegedus and others.

The present state of scholarship, an enormous effort by some notwithstanding, is represented by general characterization, vocabularies are still being compiled, systematic grammars are in progress, and the phonology of the dialects are being described. The position of nuristani as being separate from indic and iranian has only lately been agreed upon and discussions are ongoing over whether or not nuristani evolved directly from PIIr, branched off from early iranian or from early pre-vedic indic. Although most investigators like Strand and Degener lean towards an early branching from indic, work by Hegedus showing the minimal impact of the ruki rule in nuristani implies early dialectal differentiation at the time of the formation of PIIr. Specifically, Hegedus suggests that in the proto-nuristani PIIr dialects the palatal

velar had changed to a palatal affricate, *k̑ > *č [tʃ], before the operation of the ruki rule. As a result the anticipated change in sibilants from [k, u, i, r] does not take place. Even so, given the hierarchy of acoustic effect, rhotics [r] > [k], [i] > [u], one should expect the effect at least after [r]. In addition, it is known that nuristani does not have iranian fricatives. And in nuristani the aspirated consonants are deaspirated, e.g., [g, gʰ] > [g].

Perhaps the most significant contribution of nuristani to our understanding of PIIr phonology is the fate of palatal velars. These are represented in nuristani as palatal affricates in some dialects and as dental affricates in others. The word for "ten" in Kamviri as duć (sanskrit दश- daśa-), for instance. The work of Strand demonstrates a clear tendency of dental fronting of affricates, as č [tʃ] > [ts] and j [dʒ] > [dz] -- i.e., [ʧ] > [ʦ], [дж] > [дз].

In some nuristani dialects even the secondary palatal affricates (originally merged plain velars) are fronted to coincide with those of the primary palatal affricates (originally palatal velars), suggesting that the unfronted forms represent the proto-nuristani state. (phonemes also represented in cyrillic for clarity)

	proto-Nuristani and Nuristani			Nuristani (some dialects)		
PIIr [c, j, jʰ] ->						
secondary palatal affricates:	č [tʃ]	j [dʒ]	j [dʒ]	c [ts]	z [dz]	z [dz]
	ч	дж	дж	ц	дз	дз
primary palatal affricates:	c [ts]	z [dz]	z [dz]	c [ts]	z [dz]	z [dz]
	ц	дз	дз	ц	дз	дз

This tendency to fronting (or "prognathizing" - term used by Strand) may also explain the "absence" of the operation of the ruki rule on sibilants, as they may have conceivably been fronted back to [s].

All of this uncertainty aside, it remains hard to account for the affricate palatals in nuristani without realizing their direct inheritance from PIIr, since in iranian and indic they have been deaffricated. As Strand points out, re-affrication (from spirants or fricatives) would be less likely. Degener, too, points out that a salient feature of nuristani is the absence of loss of affrication of palatal affricates. In other words, **in nuristani the PIIr palatal affricates retain their affrication even though in many dialects they have changed to dental affricates.** This single point is significant in our understanding of the affricate nature of the palatal affricate series in PIIr. (Strand, Kobayashi p. 74)

There are some important general considerations in using nuristani data. Many of these are pointed out by Szemerényi (p. 148-149):

- 1) Nuristani is attested only since the 19th century. (Compare this with avestan and vedic sanskrit which date back to the second millenium BCE.)
- 2) Nuristani is characterized by numerous iranian and indic borrowings over the centuries.
- 3) The volume of material is relatively small and not studied as well as avestan and sanskrit.
- 4) Building on the first point, using language data from the 19th and 20th centuries CE to understand phonological processes taking place in the period of PIIr (a millenium or more before avestan and vedic) or even late PIE (at least one more millenium) is a very long stretch.

These discouraging points are not enough reason to dismiss nuristani data. Instead the quality of the observation needs to be taken into account. For our purposes of the nature of PIIr palatal affricate series the nuristani data does provide a valuable insight.

(see: (full references can be found below in the historical phonology references section)

Degener, A. The nuristani languages. pp. 103-117 in Sims Williams.

Hegedus, I. The ruki rule in nuristani.

Strand, R. Basic processes in the evolution of the nuristani languages.)

No deaffrication of secondary palatal affricates. The PIIr secondary palatal affricates, a product of palatalization of PIE plain velars before front vowels (as described in that section), were phonemically contrastive with regards to the PIIr primary palatal affricates, that were produced by the palatalization of the PIE palatal velars. Our understanding of the pronunciation of these two palatal affricate series in PIIr is analagous to that of the PIE velars from which they arose. That is, recalling from the PIE section, the primary palatal affricate series is understood as being pronounced as [c [tʃ] or [tʃ], j [dʒ] or [dʒ], jʰ] and the two palatal affricate series are conceptualized as palatalized velars (palatal stops)

approaching dorsal affricates, as [č [tš] or [kʲ], ǰ [dʒ] or [gʲ], ǰʰ]. (Kobayashi p. 74)

In both indic and iranian the primary palatal affricates undergo deaffrication (fricativization, spirantization). Only after this are the more dorsally articulated secondary palatal affricates then able to be articulated more anteriorly without loss of phonological contrast.

The secondary palatal affricates do not undergo deaffrication. Their outcome in both sanskrit and avestan (and nuristani) is the same, except that the voiced aspirate is deaspirated in iranian (and nuristani) and undergoes deocclusion (with loss of all but laryngeal features) in indic.

Deaffrication of primary palatal affricates - indic. The palatalization of PIE palatal velars has its origins in late PIE and affects all the satem languages, indo-iranian, balto-slavic, armenian and albanian. The process took place over enough time that it likely did not reach completion in the various ie languages systems until after their differentiation. The PIE palatal velars are inherited by PIIr as the primary palatal affricates. Let us consider their development in indic and iranian separately.

In the indic group of PIIr, all three primary palatal affricates are considered to have been sibilants at one time, that is, all three PIIr primary palatal affricates undergo assibilation. (Kobayashi pp. 74, 149) In indic they do not at any time develop into fronted dental affricates or sibilants. The evolution to deaffricated sibilants is accounted for by Kobayashi by postulating the operation of an "affricate filter" by which a consonant is permitted only one acoustic phase or root node - that is, the affricate, which has a stop and fricative phase, can become either a stop or a fricative, choosing between the phonological features of occlusion or frication. (Kobayashi pp. 74-75) He further suggests the presence of a "delinking process" of root nodes - in this case occlusion + frication - by which the leftmost is delinked. He uses this mechanism not only to explain the deaffrication process, but extends it to the deocclusion of aspirates. In the case of the voiced aspirate, [ǰʰ], there are three root nodes (or acoustic phases), occlusion + frication + aspiration, of which the first two are phased out resulting in [h]. (Kobaayashi p. 80)

This is a plausible development for [k̂] > c [tš] > ॡ [ɕ], but at the same time generates [ǰ] > j [dʒ] (दृज) > [ž] (ж). We know that by the time of vedic the outcome is the voiced affricate, ॡ [ɕ], and not the voiced spirant, [ž] (ж). A blocking mechanism, such as a prohibition against voiced sibilants would seem attractive, but we are aware that voiced sibilants in indic are present from PIIr nearly to the prevedic period. Kobayashi proposes a "repair process," by which the voiced spirant is repaired, referring to it as a reaffricating "repair process." (Kobayashi pp. 74, 80) However, it seems plausible to us that this "repair process" might simply be a merger with the voiced affricate from the secondary palatal series, which over time would have acquired a more anterior articulation, i.e. [ǰ [ɕ], [ž] (ж) > [ǰ [ɕ]].

The outcome of deocclusion of the voiced affricate aspirates (from both primary and secondary palatal affricate series) is [h] for both series of affricates. The deocclusion of ǰʰ [dʒʰ] > ॡ [h], in which all features are lost save the laryngeal feature of aspiration, is part of a process in sanskrit that affects far more than the voiced palatal affricates. In indic there is a "laryngeal first principle" with aspiration or laryngeal features being a higher priority than oral features. (Kobayashi p. 84) This affects other voiced aspirates like, bʰ and dʰ, and influences the phonological development of prakrits as well.

In the deocclusion of ǰʰ there may have been intermediate stages of deaffrication resembling that of [k̂] > c [tš] > ॡ [ɕ],

PIE voiced velars ->	PIIr palatal affricates ->	PIIr deaffricated ->	OIA (sanskrit)
merged plain g	secondary ǰ [dʒ], [gʲ]	[dʒ]	ॡ [ɕ]
gʰ	ǰʰ [dʒʰ], [gʲʰ]	[dʒʰ]	ॡ [h]
palatal ǰ	primary j [dʒ]	[ž]	ॡ [ɕ]
ǰʰ	ǰʰ [dʒʰ]	[žʰ]	ॡ [h]

but eventually by the pre-vedic period only the aspiration remains of the voiced aspirates either because of the delinking of leftmost root nodes described above or the "voiced sibilant filter" eliminating voiced sibilants. The deocclusion to [h] of the PIIr secondary palatal voiced aspirate [ǰʰ] takes place only after affrication of the velar has completed, gʰ > [gʲʰ] > [dʒʰ]. (Kobayashi p. 83) With regards to the presence of ॡ jh in sanskrit, Edgerton (p. 11) states that "jh exists only in loanwords (from either Middle Indic or

non-Aryan dialects), and in a few sound-imitative words. It is, in other words, hardly a normal Skt. phoneme."

The deocclusion of voiced aspirates will be further discussed below.

In the unit, B.7.Sibilants - palatal velars before dentals, we described a difference in inflection of sanskrit roots ending in 'j'. The roots originating from PIE palatal velars result in retroflex 'ṣ' before a dental; those originating from PIE merged plain velars result in velar 'k' before a dental, as yaj- iStā'- "offer" and bhaj- bhakta'- "enjoy". There appears to be no literature on whether or not these passed through a palatal affricate stage. It seems straightforward to see that the merged velars simply kept their occlusion in that position, whether or not it be by way of a secondary palatal affricate that would not be expected to deaffricate, *kt > [tʃt] or [kit] ? > 'kt'. But in the case of the palatal velars which formed the primary palatal affricates, the progression would probably have involved deaffrication to either the palatoalveolar sibilant or to the dorsal sibilant with later retroflexion, as *k̑t > [tʃt] > *tʃt [tʃt] > *št [ʃt] or [ɕt] > [ɕt] > [ʃt]. (see C.8. Sibilant consonants in PIIr)

Deaffrication of primary palatal affricates - iranian. In iranian the three primary palatal affricates of PIIr develop into fronted dental avestan sibilants (fricatives, spirants) but have a different outcome in OPers.

Recall from the laryngeal section (see Spirantization of unvoiced aspirates in iranian) that all the voiced aspirates in iranian simply lose their aspiration and merge with regular voiced consonants. This changes the voiced palatal affricate aspirates of both series in PIIr into deaspirated voiced palatal affricates.

	PIIr	->	pre-Iranian PIIr
secondary voiced palatal affricates:	j [dʒ] and j ^h	->	j [dʒ]
primary voiced palatal affricates:	j [dʒ] and j ^h	->	j [dʒ]

The outcome of the PIE palatal velars, by way of the primary palatal affricates differs greatly between avestan and old persian. (Fortson pp. 206, 213)

PIE	PIIr (1° pal.affr.)	avestan	OPers
*k̑	c [tʃ]	s	θ
*g̑	j [dʒ]	z	d

*ṽiṽ- "all" -> viθ- (OPers), vis- (avestan), вѣсь (ocs)

*eǵh₂om "I" -> adam (OPers), azam (avestan), aham (sanskrit), азъ (ocs)

Without the data from OPers, one might surmise that the process of deaffrication in iranian took place like it did in indic, [k̑] > c [tʃ] > [ʃ] (= ॠ [ɕ]), and only later was the sibilant fronted to the dental sibilant, [s], in avestan. Instead it is more plausible that an initial fronting of the palatal affricate to a dental affricate was followed by deaffrication in avestan and loss of the fricative phase in OPers.

PIE [*k̑, *g̑] > PIIr 1° pal.affr. *c[tʃ], *j [dʒ] -> dent.affr. *[ts], *[dz] -> [s, z] (avestan)
-> [θ, d] (OPers)

The tendency to affricate fronting is also seen in the nuristani data.

An analogous iranian phonological change is that of dental consonant + *s > *ss > s, as in drugvant- drugvasu < *-vat-su. (Beekes-1988 p. 75) cf. druhyavant- < druh- (sanskrit)

Recall from the section on sibilants (palatal velars before dentals) that the PIIr palatal affricates, [c, j, j^h], developed into [ʃ, ʒ, ʒ^h] before dentals in both indic and iranian. In that context the palatal affricates were not later fronted to dental affricates.

The outcome of avestan and slavic (ocs) are remarkably similar such that the possibility of an iranian-slavic isogloss is conceivable.

The relative chronology of PIIr palatal affricates.

Phonological Change	avestan		sanskrit
1) no deaffrication of 2° pal.affr.		+	+
2) deasp of voiced consonants	+		-

- | | | |
|---|---|---|
| 3) fronting of 1° palatal affricates to dental affr | + | - |
| 4) deaffrication of 1° pal affr | + | + |
| 5) deocclusion of asp.voiced C (jh > h) | - | + |
| 6) 2° pal.affr fronted to reg.pal.affr | + | + |
| 7) merger of voiced sibilant with j | - | + |

PIIr [c, j, j ^h] ->	Avestan			Sanskrit		
secondary palatal affricates:	c [tʃ]	j [dʒ]	j [dʒ]	c	j	h
primary palatal affricates:	s	z	z	Z	j	h

C.5. Deocclusion of voiced aspirates - indic.

The PIE voiced aspirates are inherited by all the ie languages, but sanskrit stands alone among the ie languages in representing voiced aspirates in its phonological inventory. (Burrow pp.69-71) In iranian the voiced aspirates undergo deaspiration, as is the case for slavic, baltic, albanian, armenian, and celtic -- that is, the voiced and aspirated voiced consonant stops merge. (Skjaervo p. 50) Even so, the voiced aspirates underwent some developments in sanskrit.

The deocclusion of the voiced aspirated palatal affricates to [h] was discussed above in the unit on the deaffrication of the primary palatal affricates in indic. The idea of a "laryngeal first principle" in indic was introduced in the context of palatal affricates that also widely applies to voiced aspirates in indic from the pre-vedic period of PIIr through to the development of prakrits.

Deocclusion of b^h and d^h. The deocclusion of bh and dh is widely attested in vedic and classical sanskrit. But the process is incomplete and seemingly sporadic with numerous attempts having been made towards its full characterization.

Both Burrow (pp. 69-71) and Kobayashi (pp.84-86) furnish examples that illustrate the process at the stage of late PIIr and vedic sanskrit.

*[d^h] > [h]

Atm. endings in 1st. du. and pl. primary -vahe, -mahe; cf. -maide (avestan) < *-medha+i (PIE)
secondary -vahai, vahi, -mahai, -mah; cf. -maidī (avestan) < *-uēdh₂, *-medhh₂ (PIE) (see also Szemerényi p. 238-239, Beekes-1988 p. 154)

(no forms containing 'dh' are attested in sanskrit)

Athematic present system, parasm.imper.2nd.sg. -dhi vs. -hi. (see below)

suffixation:

iha' (sanskrit), idha (Pali), iōa (avestan)

saha (sanskrit), sadha- (in vedic cmpds), cf. haōa (avestan)

kuha "where" (vedic),

कदा kadA "when", but कथ-प्रिय- kadha-priya- "ever pleased", adha "there"

-hi (suffix), उत्तराहि uttarAhi "going north", दक्षिणाहि dakSiNAhi "going south"

PIE *g^hrd^ho'- -> गृह- gRha'- m. "house" > geha- n. "house" (a later sanskrit form), geha- (Pali)

धा- dhA- "put", hita'- (ppl.), but in RV: -dhita'-, deva'-hiti, mitra'-dhiti-, vasu-dhiti-, dhitaAvan-

dhehi (parasm.pres.imptv.2nd.sg.)

dhitvA, hitvA, but only -dhAya (gerund)

dhitsa- didhisa- (desiderative stems)

nah- "bind", naddha'- (ppl.), na'hyati (parasm.pres.ind.3rd.sg.)

ah- "say", Aha (perf.ind.3rd sg.), ahu's (perf.ind.3rd.pl.)

ruh- "climb", rohati (parasm.pres.ind.3rd.sg.), rodhati (RV)

lo'hita- ro'hita- "red", but rudhira'- "red" (MWD), ruhira- "blood" (Pali)

*[b^h] > [h]

*kaku'bh- > kakuha'- "eminent, peak" (RV), kakubha'- (KATh.)

dabhra- "scant" (RV), dahra- (sanskrit), dahara- (little, thin)

abhra'- m. "sky, cloud, thundercloud", abhra'yant- "cloud-forming" (denominative pres.act.ppl.)

abbhra- (variant spelling, MWD, a form to avoid deocclusion?)

ग्रभ- grabh- ग्रह्- grah- गृह्- gRh- "seize", hasta-gRhya- (RV)

गृभीत- gRbhIta-, गृहीत- gRhIta- (pass.past.ppl.)

गृभ्णाति gRbhNAti, गृह्णाति gRhNAti (parasm.pres.ind.3rd.sg., both 9U forms, MWD)

गृहान gRhAna' (parasm.imptv.2nd.sg. 9U) <- गृह्णी- gRhNI- (weak stem)

(Vedic imptv. forms in -hi, as गृभ्णीहि gRbhNIhi', even गृह्णाहि gRhNAhi' (strong stem) (Wh723))

जग्राभ- jagrAbha जग्राह jagrAha (perf.ind.3rd.sg.)

अजिग्रहत् ajigrahat (redupl. aorist), अग्रभीत् agrabhIt (sigmatic aorist)

गृभ्य- gRbhaya-, ग्राह्य- grahaya- (causative stems)

जिघृक्ष- jighRkSa- (desiderative stem) (Wh 155a) ji-ghR-bh-sa-

The above forms attest to the synchronic coexistence of voiced aspirates and their deoccluded forms. Furthermore, occasional later forms in Pali and other prakrits show a preserved voiced aspirate.

Phonetic contexts of deocclusion. The explanation that the coexisting forms represent dialect variation or prrakritisms seems unconvincing considering the synchronous forms in conjugation, like in धा- dhA and ग्रभ- grabh-. The phonetic contexts promoting deocclusion to 'h' have been considered: 1) a preceding vowel, an unaccented preceding vowel (absence of udAtta) encourages deocclusion; 2) a preceding long vowel may encourage deocclusion; 3) the present system athematic parasm.pres.imptv.2nd.sg. full grade verbal stems encourage the occluded forms in -dhi, as edhi < *az-dhi (as- "be"), bodhi (budh- "wake"), siZAdhi (ZA- "sharpen"); 4) avoiding two h's in adjacent syllables may preserve 'dh', as in juhudhi (hu- "sacrifice"). These generalizations are encountered by numerous counterexamples. In short, forms with 'dh' and 'h' develop in many similar environments, making any generalization difficult. (Kobayashi p. 89)

In terms of frequency, however, it can be observed that deocclusion of 'dh' and 'bh' occurs more often after an unstressed high vowel, [i]. Even so, we can cite, द्विधा dvidhA "twofold", त्रिधा tridhA "threefold", अदीधृष addIdhRSa (redup.aor.3rd.sg. धृष्- dhRS- "dare"), etc.

Accordingly, to decide on the termination of -dhi or -hi in the 2nd.sg. active (parasm.) athematic presents one needs to resort not to phonology but to grammatical rules. The etymological ending -dhi is changed to -hi in verbal stems ending in a vowel or semivowels, except hu- juhudhi. The ending -dhi -hi is simply dropped in the 5th and 8th conjugations. In the ninth conjugation, the ending -hi is used after a vowel, but after a consonant the parasm.imptv.2nd.sg. adds -Ana' to the root, without 'NI', (Wh723).

The place of sanskrit in the process of deocclusion. In PIIr the voiced aspirates were inherited intact from PIE, as attested by numerous avestan and sanskrit forms. On the other hand, the prakrits in MIA demonstrate a clear progression of deocclusion, involving also unvoiced aspirates, as rudhira- "red" (sanskrit) > ruhira- "blood" (Pali), bhavati (bhU-) "he is" > hoti, hoi, sAdhu "be well" > sAhu (Pali), mukha- "face" > muha-, megha- "cloud" > meha, dadhAti "puts" > dahati (Pali). In the northwestern prakrits of Gandhara the consonant aspirates are generally preserved as they are in sanskrit, save for intervocalic aspirate stops which undergo lenition to the voiced sibilant (orthographic 's', phonetic [z]). In the eastern prakrits both aspirate deocclusion and consonant lenition are attested in the most advanced forms. Since sanskrit occupies a time period in between PIIr and the prakrits, one would infer that a set of phonological rules to describe the status of voiced aspirates in OIA should be able to be formulated.

The diachronic process of deocclusion of aspirates in indic spanning the period from PIIr to the

prakrits allows Kobayashi to refer to this as a "laryngeal first principle," in which the laryngeal phonological feature (aspiration, [+spread glottis]) has a higher priority than occlusive or buccal features. (Kobayashi p. 84) Despite the recognition of this long historical development, we are still left with numerous attestations in Sanskrit of synchronously coexisting forms -- both voiced aspirates and deoccluded forms occurring even in the same words.

One suggestion would be that the voiced aspirates and their deoccluded forms are allophonic. Perhaps at some stage, considering the history of each word separately, this might even be the case. But an examination of the Sanskrit forms in individual words reveals that for the most part the forms -- voiced aspirates vs. laryngeal 'h' -- appear fairly consistently, that is, there is no free alternation of these two forms. A complete phonological account of the status of voiced aspirates in OIA has yet to be formulated.

C.6. Laryngeals in PIIr.

The laryngeals inherited by PIIr from PIE undergo significant developments in the PIIr period and show a distinct development in Iranian and Indic before their final disappearance. Laryngeals are introduced in the phonological inventory and in the discussion of root structure in the PIE section. A more complete discussion follows in the laryngeal unit (section B.8) of "Changes in late PIE leading to PIIr," in which the divergent effects of laryngeals in early Iranian and Indic are presented.

C.7. Aspirate consonants in PIIr.

The aspirate consonants represent a special group of phonemes in Indo-Iranian. They are introduced in the section on consonant stops in the PIE inventory. A description of their development pertinent to the PIIr period and their divergent development in Iranian and Indic can be found in the following sections.

B.5. Consonant clusters - voicing assimilation and aspiration

B.8. Laryngeals - laryngeal in post-plosive prevocalic position

-laryngeal h₂ effects in PIIr

-unvoiced aspirates

-spirantization of unvoiced aspirates in Iranian

C.4. Palatal affricates - deaffrication of primary palatal affricates - Indic -Iranian

C.5. deocclusion of voiced aspirates

C.8. Sibilant consonants in PIIr.

The sibilants were introduced in the phonological inventory of the PIE section and elaborated upon in the sibilant section (B.7) of "Changes in late PIE leading to PIIr." The rise of three sibilant series was described -- 1) the original PIE dental sibilant 's' (and voiced allophone 'z'); palatoalveolar ('š' [ʃ], 'ž' [ʒ]) or alveopalatal ('ś' [ɕ], 'ź' [ʑ]); and 3) palatal sibilants ('š' [ɕ], 'ž' [ʑ]).

Since the PIE palatal velars were probably still primary palatal affricates at the stage of early PIIr, the palatal sibilants are not included in the PIIr phonological inventory. A relative chronology from the perspective of the palatal affricates, rather than the sibilants, is discussed in "C.4. Palatal affricates." From the PIIr stage as outlined in the PIIr inventory above, not only the palatal affricates, but the sibilants, too, undergo divergent developments in Indic and Iranian. There remain a number of changes in late PIIr (pre-Vedic and pre-Iranian) involving sibilants that should be discussed separately.

Retroflexion of sibilants in Indic. By the pre-Vedic period all palatoalveolar sibilants have undergone a change in articulation to retroflexion (cerebralization, मूर्धन्य- mUrdhanya- "formed on the roof [of the palate]"). The articulation of retroflexes (retroflexion) may be referred to as **coronalization** and is distinct from palatalization. The sibilants involved are those arising from the RUKI rule, from palatal velars before dental stops and from consonant clusters.

postalveolar ś [ʃ], ź [ʑ] [+anterior][-distributed] -> [ʂ], [ʑ][-ant][+distr]

The phonological feature responsible for this change may initially have been [+/-ant], and the addition of [+distr] occurred to maintain contrast from the dorsal sibilants produced from the PIE palatal velars (PIIr primary palatal affricates). (Kobayashi p. 150)

The loss of [+ant] by the sibilant would have caused a more dorsal articulation of a dental following it, which in turn may have spread its retroflexion back on the sibilant. (Kobayashi p. 151)

(postalveolar+dental) št [tʃ][+ant][-distr] -> [ɕt] [-ant] -> [ʃt] [-ant][+distr] (both retroflex)

The phonemicization of retroflex obstruents would have resulted in a reinterpretation of the originally allophonic PIE alternation [st][+ant][-distr] <-> [ʃt][+ant][-distr] to a phonologically contrastive one, [st][+ant][-distr] vs [ʃt][-ant][+distr].

The PIIr palatoalveolar voiced sibilant undergoes an analogous process, but in prevedic (after retroflexion) the voiced sibilant is lost with compensatory lengthening of the preceding vowel. (Burrow pp.96-99)

*mižd^ha- > mižd^ha- > mizd^ha- > मीढ- or मीळ- mīḍ^ha- mīDhA- "reward"

Further evidence of coronalization is the blocking of retroflexion in sanskrit before a rhotic (coronal), while in avestan there is no such restriction and the palatoalveolar š is still present, as visra- "bad meat", vaēša- "corruption" (avestan); तिस्रः tisra's (nom.pl.fem.) "3", तिसृणाम् tisRRNA'm (gen.pl.fem.), tišrō "3" (avestan). (Burrow pp.80-81, Wh482e, Mac406)

The original RUKI rule which in PIE and PIIr affected only the place of articulation of 's', becomes a rule in sanskrit which causes coronalization-retroflexion. (see B.7. Sibilants-RUKI rule)

The dorsal sibilant in indic. The development of the dorsal sibilant in sanskrit from the PIE palatal velar and the PIIr primary palatal aspirate has been described in earlier sections, PIE *k̑ > PIIr *c [tʃ] > श् [ɕ]. The relative chronology of this event remains as the only controversial point.

Among the arguments favoring the relatively late deaffrication from PIIr primary palatal affricate is to avoid a merger with the palatoalveolar sibilant [ʃ] before the latter undergoes coronalization to a retroflex [ʃ̣]. Our impression is that this worry is unjustified since the palatoalveolar sibilant is articulated anteriorly enough to remain distinct. (One may cite any of the modern slavic languages to demonstrate a distinct articulation and phonemic contrast of three sibilant series (voiced and unvoiced)) s, z (dental), s', z' [si, zi] (palatalized) -> š, ž [ɕ, ʒ] (dorsal)). Localizing the full excursion of the process, k̑ > ɕ, to the late PIE period would create difficulties in understanding the deaffrication of palatal affricates in PIIr, and this would also incur difficulties in explaining the iranian and slavic changes. In short, while it has yet to be determined when the dorsal sibilant was formed, its later development from a palatal affricate should not unduly influence the other relative chronologies.

The arrival of the dorsal (alveolopalatal) sibilant [ɕ] in pre-vedic established a three-way phonemic contrast of sibilants.

In summary, the development of the dorsal sibilant(s) is such:

PIE palatal velars ->	PIIr 1 ^o pal. affricates ->	PIIr deaffricated ->	OIA (sanskrit)
k̑	c [tʃ]	[tʃ]	श् [ɕ]
ǵ	j [dʒ]	[dʒ]	ज् [dʒ]
ǵ ^h	j ^h [dʒ ^h]	[dʒ ^h]	ह् [h]

The loss of voiced sibilants in indic. In indic the voiced sibilants are entirely eliminated -- putatively by a voiced sibilant filter -- in the late PIIr period, soon after the final loss of laryngeals, in the immediate prevedic period. The voiced sibilants at this stage would have been [z, ʒ, ʒ̣] (< [z, ž, ʒ̣]). In iranian both dental [z] and palatoalveolar [ž] are preserved, which facilitates the recovery of lost voiced sibilants using correspondence sets. The loss of voiced sibilants in indic was introduced in the PIE phonological inventory and in the section, B.7.Sibilants - voicing of sibilants.

The voiced sibilants that are lost or transformed are all those present in late PIIr -- that is, sibilants that in PIE or PIIr in a voicing environment (e.g., assimilation before a voiced dental). The loss of voiced sibilants may on one hand occur without a trace or merely leaving a prosodic timing slot in verse composition (as in intervocalic position) and on the other result in a number of compensatory changes. Some of the changes involving the loss of a voiced sibilant are as follows. (Burrow pp. 94-96)

1) Before a dissimilar consonant [z, z] > [d, d], as मास्- mAs- m. "month", माद्भिस् madbhis (instr.pl.); मज्ज- majj- "dive, sink" (< *madj- < *mazj-) cf. mazgoti (lithuanian).

2) between 'a' and dentals 'd', 'dh', it is lost with change of 'a' to 'e', [azd, azd^h] > [ed, ed^h], as अस्- as- एधि edhi (parasm.pres.imptv.2nd.sg.) < az-dhi'; नेदिष्ठ- nediSTha- "nearest", nazdišta- (avestan).

3) before 'd' and 'dh', [z, z] are lost with retroflexion of the dental and compensatory lengthening of the preceding vowel, [Vzd] > [V:d], as *nizdo- (late PIE) ->-> *nizDa- -> नीड-/नीळ- nIDa- (sanskrit); वह्- vah- "carry", ऊढ- UDha'- (ppl.) < *uzdha'-. In addition, a preceding short 'a' may be turned into 'e' or 'o', as वह्- vah- "carry", वोधुम् vodhum (inf.) < *vazdhum, षष् SaS, षोढा SoDhA "sixfold" < *sazdha-; क्रीड्- krID- "play" < *krizd-.

In this position the 'z' may occasionally be replaced by retroflex d, as दिश्- diZ- "point", दिदिड्दि didiDDhi, and even (in addition to षोढा SoDhA) षड्ढा SaDDhA < *saz-dhA.

Relative chronology of sibilants in indic.

PIE

- 1) s-epenthesis in dental-dental clusters, *tt > *tst
- 2) RUKI sound change, yielding alveopalatal sibilants, [s, z] > [š, ž] and palatal velars before dentals -> [š, ž]

PIIr

- 3) deaffrication of 1^o palatal affricates, c [tš], j [dž], j^h [dž^h] > 'š' [ɕ], 'ž' [ʒ], 'ž^h' [ʒ^h]
- 4) deocclusion of voiced aspirates (jh > h)
- 5) simplification of *tst to *tt (sanskrit) and *st (avestan)
- 6) "repair" or merger of unaspirated voiced sibilant with 'j', 'ž' [ʒ] > j [dž]
- 7) retroflexion of 'ś' [ʃ], 'ź' [ʒ] > ष [s], [z]
- 8) loss of voiced sibilants

Sibilants in OIA exhibit three unique behaviors among the ie languages:

- 1) The placement of sibilants in sanskrit syllables observes the PIE sonority scale; (described in A.2. Phonological changes affecting the morpheme - the root)
- 2) Retroflexion of sibilants;
- 3) Voiced sibilants are prohibited.

Pan-iranian [s] > [h]. Among the earliest iranian sound changes distinguishing it from indic is the change [s] > [h]. This sound change is considered to be relatively old in view of the observation that it affects all the iranian languages. (Sims-Williams p. 83) The sibilant *s becomes weakened to [h] before vowels and resonants, but not before stops and [n]. (Beekes-1988 p. 80, Skjaervo p.50) This change is similar to the one in greek in which [s] > [h], except word-initially (usually) and before stops, as *septm > hapta (greek), hapta (avestan), sapta- (sanskrit). (Fortson pp. 204, 227) Specifically, (see Beekes-1988 pp.79-83)

avestan	sanskrit
preserved [s] before stops and 'n':	
staumi "I praise"	staumi (stu- "praise")
vastai "he is dressed"	vaste (vas- "clothe")
zasta "hand"	hasta- m.
spasya- "to look"	पश्यति paZyati (दृश्- dRZ-)
nazdišta- "nearest"	नेदिष्ठ- nediSTha-
snaēža- "to snow"	हिम- hima- m. तुषार- tuSArA- "cold, snow", cf. снѣгъ (ocs)
sāsti "teach", sāsna- "teaching"	शास्त- ZAsta'- (ppl.) शास्- ZAs- शिष्- ZiS- "teach" (from PIE *k̑)

darsam "I saw"	adarZam (aor. दृश्- dRZ-) (from PIE *k̑)
[s] > [h] word initially, except before a stop or 'n':	
haθya- "true"	satya- "true"
hu- prefix "good"	su-
hva- prefix "one's own"	sva-
hūnu- "son"	सुनु- sUnu- m. "son, child"
[s] > [h] after 'a', except before a stop or 'n':	
ahmi "I am"	asmi (as-)
dahra- "wise"	dasra'- "doing great things"
ahu- "life"	asu- m. "life" (< as- "breathe")
prsa- "ask"	pracch- (< PIE *h2pṛ(k̑)-sḱé/ó- "ask", 's' before stop)
[s] > [h] after an, am (-ms- > -ns- > -nh-)	
sanha- "doctrine"	शङ्स्- शंस- ZaMs- "praise"
manhi (inj.1st.sg.)	man- "think"
word final -as > -ah > ō, -ās > -āh > ā (Beekes-1988 pp. 20, 32), analagous to visarga	

Considering the preserved 's' originating from PIE palatal velars (i.e., PIIr primary palatal affricates) one would anticipate that the change [s] > [h] predated the full excursion of the deaffrication of palatal affricates.

Phonemicization of voiced sibilants in iranian. Recall the absence of any phonemic contrast between voiced and unvoiced sibilants in PIE and PIIr, that is, [s] and [z] are allophonic, as are the pairs, [š] and [ž], [ʃ] and [ž]. As discussed in the section, B.7.Sibilants - voicing of sibilants, the unvoiced sibilant becomes voiced before voiced stops and often between and before vowels. For instance, in prefixes and before enclitic particles we can cite duž- niž- yūž -am. (Skjærvø p. 49)

The allophonic relation between voiced and unvoiced sibilants continues for a long time in late PIIr-early iranian, but by the time of avestan they become phonemic, as shown by relatively common minimal pairs: (see Beekes-1988 p. 14)

[s] vs [z]: sərəm, zərəm; savah- zavah-; saošyant-, zaoša-, asənō, azēm; sū-, zū-

[s] vs [š]: isāi, išāt; xraosəntam, zaoša

[z] vs [ž]: azdā, aždyāi; vōizdūm, vōiždat (PIE *ǵd- > žd, PIE *dd > zd)

In addition, the [-anterior] sibilants, [š, ʃs, ʃ], merge by the time of avestan. This results in the phonemic avestan sibilant inventory, [s, z, š, ž]. (Beekes-1988 p. 14)

Relative chronology of sibilants in iranian.

PIE

- 1) s-epenthesis in dental-dental clusters, *tt > *tst
- 2) RUKI sound change, yielding alveopalatal sibilants, [s, z] > [š, ž] and palatal velars before dentals -> [š, ž]

PIIr

- 3) [s] > [h] before vowels and resonants
- 4) deaffrication of 1^o palatal affricates, c [tš] > [s], j [dž], j^h [dž^h] > [z]
- 5) simplification of *tst to *tt (sanskrit) and *st (avestan), and *ts > *ss > s (iranian), -not affected by preceding [k, r, i, u] (Lubotsky-1999 p. 300) (relevant for iranian) -close parallel with slavica and armenian (Beekes-1988 p. 80 #44)

?) ('š' [ʃ], 'ž' [ž]) > [x]

- 6) merger of [-anterior] sibilants
- 7) phonemicization of voiced sibilants

C.9. Later iranian developments in PIIr.

A number of important phonological changes in PIIr that are precursors to the iranian phonological

system have already been addressed. They consist of the formation of PIIr from PIE and processes shared with indic in PIIr, many of which show a divergence from indic. Here we would like to present an overview and briefly address some additional processes peculiar to iranian.

In this section on phonological processes in PIIr, the phonological changes described for iranian have been for the most part pan-iranian, with only occasional exceptions, such as in the differing outcome of the deaffrication of PIIr palatal affricates in avestan and old persian. It is not true that everything in PIIr that cannot be identified as indic is dismissed as iranian. This point is brought into relief by the nuristani data. The iranian languages as a group have definite unifying features. An early iranian phonological inventory in PIIr based on the changes described to this point can be formulated. (see Skjærvø p. 51) At this point we assume a vowel inventory similar to that of PIIr above (in C.3. Proto-indo-iranian phonological inventory).

Early pan-iranian phonological consonant inventory in PIIr.

pharyngeal	h						
velar:	k	g	x				
palatalo-alveolar:	č [tš]	j [dž]					š ž
palatal:						i [j]	(š ž, NE iranian only)
dental:	t	d	θ	n	r (l)	s z	
labial:	p	b	f	m	ɸ [w]		

Notes:

- 1) the palatal sibilants in NE iranian arise from [č^u, j^u] > [š, ž].
- 2) the iranian merger [r, l] > [r] is complete, but in ossetian (alanic) [l] is present.

Early iranian dialects. In PIIr, early iranian differentiates into at least four groups of iranian languages characterized by their development of the palatal affricates. (taken from Skjærvø pp.50-51, Windfuhr p. 18-20)

Old northwest iranian, e.g., alanic (ossetian), initial p > f and word-internal r_i > l.

Old northeast iranian, e.g., middle iranian khotanese and modern wakhi, which form palatal sibilants [č^u, j^u] > [š, ž], in addition to the more dorsal alveolopalatal [š, ž].

Old central iranian, e.g., **avestan** and median, in which the primary palatal affricates [tš, dž] merge with [s, z], and in which [č^u, j^u] > [sp, zb], as spaiia "throw" and zbaia "invoke" (avestan).

Old southwest (perside) iranian, e.g., **OPers**, pārsa/fārs, in which the primary palatal affricates [tš, dž] merge with [θ, d], and in which [č^u, j^u] > [s, z]. Too, [θ] > [š] before i and n, as haθiia (avestan), hašiya (OPers), satya- (sanskrit) "truth"; araθni (avestan), arašni (OPers) "ell, cubit". Also PIIr [tr, čr] > [θr, čr] > [r] (merger), as puθra- (as in avestan) > puša (OPers) > pus (MPers), cf. putra- "son" (sanskrit); xšaθra- (as in avestan) > xšaša- (OPers), cf. क्षत्र- kSatra'- "power, might" (sanskrit) (Fortson p. 213)

Numerous median (a central iranian language) forms penetrate into OPers, as asan- "stone" vs. aθaga (OPers), aspa- "horse" vs. asa- (OPers), and coexist as parallel forms.

The iranian system consists of numerous languages developing from this approximate stage in PIIr. These dialects interact with one another resulting in multidirectional borrowings. Their earliest attested forms are avestan and old persian, even in their time only two of many varieties of iranian.

Scope of iranian in PIIr. A description of the phonological changes taking place in pre-iranian PIIr from this point would require a large change in our scope of study. Methodologically, this would require a backward reconstruction of early iranian dialects using a large volume and variety of iranian sources. Many iranian language systems are not fully described or adequately studied, moreover, so even a complete incorporation of available existing iranian language resources would leave much work to be done. The task is analogous to reconstructing indic dialects contemporary with the vedas on the basis of indian prakrits and modern indo-aryan languages. The reference by Windfuhr is an exemplary attempt at filling this need. Since our main focus is sanskrit phonology, we shall end the discussion of iranian with

a brief description of the phonological inventories of avestan and old persian.

Avestan. Avestan is attested by two main varieties -- Old Avestan, which was first transcribed around 600 BCE (using a middle persian (Pahlavi) script) after having been orally transmitted from the second millenium BCE and is represented by the texts, the yasna and videvdad sade -- and Young Avestan, composed in the first half of the first millenium BCE, having numerous similarites with OPers. What is described in any phonology of avestan, then, is the product of many layers (a thousand years' worth) of historical and redactory processes to the end of the Sasanian period and therefore reflect only very approximately the actual phonological systems of avestan when the languages was spoken. In principle, however, phonological contrasts should be recoverable.

OAv is very similar to the oldest parts of the Rigveda, both grammatically and lexically and its oldest variety is that of Gatha-Avestan, represented by the verses, Y28-34, 43-51 and perhaps 53. Avestan is based on languages spoken in NE Iran and central asia. There are phonological isoglosses separating OAv and YAv suggesting that they are not stages in the development of one language.

The vowels of avestan have undergone significant changes from the phonemic vowel inventory of PIIr (and that assumed for early proto-iranian), including raising, lowering, rounding, nasalization and anaptyxis.

Avestan vowels:

proto-iranian vowels		avestan vowels			
		front	central	back, rounded	nasal
high	i u	i i:		u u:	ii̯a̯ , uu̯a̯
mid	(ə)	e e:	ə ə:	o o:	ē̯a̯
low	a a:		a a:	a: (rounded)	a̯
	ɾ		ərə		ərə̯
dpth	ai ai:	ae:	ai: oi:		
	au au:	ao ao:	au: əu:		

Notes:

1) all vowels can be nasalized

e.g., [a, a:] n [spirant OR sibilant] > [a, a: +nasal][spirant OR sibilant]

Orthography: [i][+nasal] = ii̯a̯ , [u][+nasal] = uu̯a̯

[ə:][+nasal] = ē̯a̯

[a, a:][+nasal] = a̯

[ərə̯][+nasal] = ərə̯a̯

So, frii̯amahi < fri-n-mahi "we make friends"; huu̯amahi < hu-n-mahi "we press [out soma]" (sskt. sunuma'he, Atm.pres.ind.1st.pl.)

2) in OAv 'ə' is an allophone of 'a' before nasals and before 'uu'. in YAv 'ə:' is phonemic with its own ending and allomorph 'a̯'.

3) in OAv the long PIIr diphthongs, 'ai: au:', are orthographically identical with a: + 'i or 'u'.

4) the short diphthongs, au, ou and aou, are the result of labialization of 'a'.

5) alternation of vowel length is common and may be accent related

6) vocalic 'ɾ' is generally represented in avestan as 'ərə', but may be 'ir', 'ur' as in other iranian languages (and slavic). I.e., PIIr [ɾ] > [ər] + anaptyctic [ə].

The consonant inventory below represents phonemes attested in both OAv and YAv.

Avestan consonants:

place	stop/affr		fric	contin.	nasal	sib
glottal:	' [ʔ]		h			
labiovelar:		x ^w		ŋ ^w ŋ ^{wh}		

palatovelar:		ǰ		ǰ ǰ ^h
velar:	k g	x ɣ		ŋ ŋ ^h
palatal:				ɲ
retroflex(?):				ʂ
(alveo-)palatal:	tʃ dʒ			ʃ ʒ
alveolar:				r r ^h
dental:	t d	θ ð		n s z
labial: bilabial	p b	β	w	m
labiodental		f v		

Notes: For a description of the avestan phonological system, see Beekes-1988 pp.10-54 and Skjærvø pp. 43-70.

Old Persian. Old Persian texts written in cuneiform script are from the Achaemenid period (538-230BCE). The speakers are believed to have brought OPers to southern and SW Iran from central asia. OPers is more or less contemporary with YAv and is the predecessor of middle persian. By way of staging, it is intermediate between old and middle iranian. Because of its relative lateness, OPers needs to be used with caution, as one uses any data from middle iranian, in reconstructing old iranian.

The orthography of OPers does not fully reflect all of the phonemes of the languages, as confirmed by borrowings of other languages from OPers and by comparison with avestan.

Old Persian phonological inventory:

vowels: a a: e o i u (ə) ɾ

consonants:

pharyngeal	h					
velar:	k	g	x			
palatal:	č [tš]	j [dž]			i [j]	š ž
dental:	t	d	θ	n	r (l)	s z
labial:	p	b	f	m	ɸ [w]	

Notes:

1) proto-iranian diphthongs [ai, ai:, au, au:] are monophthongized to [e, o] during the Achaemenid period. OPers documents and transcriptions into Akkadian, Elamite and Greek show no evidence of diphthongs. Kent (p.14) suggests the diphthongs continue to be represented as short 'ai' and 'au'.

2) vowel length is expressed only in non word-initial position in the case of [a, a:]; long and short [i, u] are not distinguished, at least orthographically.

3) vocalic ɾ is represented as such in OPers, but was likely pronounced with a supporting vowel such as -ar-, as evidenced by Elamite transcriptions. E.g., mṛšiyuš (OPers), mərəθyu- (avestan), मृत्यु- mṛtyu- (sanskrit) (Kent p. 15)

4) the consonant inventory is very similar to that of proto-iranian.

5) nasals are not well represented in OPers texts, but appear in Elamite, Akkadian transcriptions.

6) in word-final position only the consonants, š and m, are admitted.

Notes: For a description of the OPers, see Skjærvø pp. 43-70, pp. Kent 6-49)

C.10. Retroflexion.

Retroflexion rules in sanskrit. By way of terminology, retroflexion, cerebralization, lingual articulation and coronalization are all synonyms of मूर्धन्य- (mUrdhanya- "formed on the roof [of the palate,

मूर्धन्- mUrdha'n- m. "the forehead, head, the top of anything, first"), the adjectives being retroflex, cerebral, lingual, coronal and मूर्धन्य- mUrdhanya-. Let us summarize the retroflexion rules in sanskrit.

1) The letter, स् [s], is retroflexed to ष [ʂ] when preceded by 'k', 'r' (any rhotic) or a non-'a' vowel, unless followed by a rhotic. (The rules surrounding retroflexion of sibilants was discussed with examples in B.7.Sibilants-the RUKI rule, since this rule has its origin in PIE.) So,

क्/र/V(non-अ) [+/- anusvara, visarga] स् [not ऋ र] --> ष

A rhotic (ऋ ऋ र) following the sibilant blocks the change. A lateral (ल् लृ लृ) neither causes nor blocks the change; in indian grammars the laterals, probably because of their similarity to rhotics, are included in causing the change, but this effect of laterals is not attested (as discussed in the section "merger of liquid resonants [r, l] > [r]) and the प्रातिषाख्यः Pratishakhyas do not include the laterals in this change. (and Wh 180b)

2) The letter न् {n} is retroflexed to ण् [ɳ] when preceded in the same word by any rhotic (ऋ ऋ र) or retroflex ष [ʂ] (conditioning phoneme) and followed by a vowel or [न् म् य् व्]. The preceding conditioning phoneme does not need to precede the न् {n} immediately. If the न् {n} is immediately preceded by a vowel, velar or labial consonant or य् व् ह्, the change still goes forward, but if the consonant immediately preceding न् {n} is a palatal, retroflex, dental consonant or [श स ल], the change is blocked. A word final न् {n} is not retroflexed. (Wh189, Kobyashi p. 147)

ऋ/ऋ/र/ष् [+/- L] + न् + [V न् म् य् व्] --> ण् ,

if L = [V (क्/प् वर्ग) य् व् ह् anusvAra], but NOT [(च/ट/त् नर्ग) श् स् ल्] or if 'n' is word-final.

This is referred to as "the NATI rule" by some authors. Ringe & Eska (Ringe-2013 pp.107-108) describe this rule thus, "The retroflex assimilation rule can be described informally as follows. When the dental nasal 'n' follows a retroflex continuant (i.e. ʂ, r or r) within the word and is itself immediately followed by a sonorant, it becomes retroflex ɳ -- that is, it assimilates to the preceding retroflex continuant in place of articulation -- unless another coronal intervenes."

e.g., पचनम्, भोजन-, सदनम् vs. कपणम्, कृपणम्, क्रामणम्

Blocking of retroflexion by coronals:

निवर्तनम् (blocked by 't'), नृषदनम् (blocked by 'd'), वृजनम् (blocked by 'j'), दर्शनम् (blocked by 'ʃ'), प्राणानम् (second 'n' blocked by first ण् separated by a vowel)

An interesting dilemma is presented by the examples of राष्ट्रानम् rASTraNAm and उष्ट्रानम् uSTraNAm (gen.pl of rASTra'- m. "kingdom", u'STra- m. "buffalo, camel") found in the RV. In the AV and later sanskrit, the 'n' is retroflexed even when the 'r' is in a cluster of retroflex stops. In both the RV and AV 'n' is retroflexed following '-tra-', as गात्राणम् gAtraNAm, वस्त्राणि va'straNi. Considering the more archaic PIE ruki rule in which a subsequent 'r' blocks retroflexion, as in तिस्र- tisra'-, one might imagine that the [-ant] feature of 'r' at the time of the RV is still linked to the preceding consonant cluster in rASTra'- and so fails to project retroflexion to the right. In other environments, even in the RV, and even across compound boundaries, retroflexion by 'r' is observed. (Kobyahashi pp.147, 154-156)

The root सद- sad- has passive past ppl. सन्न- sanna'-, but retroflexion of 'n' results when the 's' in sad- is retroflexed, as प्र-सद- pra-sad- > प्र-सन्न- pra-sanna'- "favored, gracious", नि-षद- ni-sad- -> ni-sad-na'- > niSadna'- > नि-षण्ण- niSaNNa'-, विषद- viSad- > विषण्ण- viSaNNa'- "sad, dejected".

Note that ण् 'N' causes the retroflexion of an न् 'n' that follows; but brings about no other retroflexion.

Only nasal stops, not oral stops, are the target of this rule. The vast majority of occurrences of ण् [ɳ] in sanskrit are the product of this rule.

3) Retroflex ष [ʃ] is formed before dentals with retroflexion of the dental from palatal obstruents (consonants originating from PIE palatal velars) -- namely, च् c, छ् ch, ज् j, झ् jh, ष S, श् Z -- as well as क्ष kS. (This phonological change was discussed with examples in B.7.Sibilants-palatal velars before dentals, since this rule too has its origin in PIE.)

[palatal obstruent or क्ष] + [dental consonant] > ष [ʃ] + [retroflex consonant]

e.g., दृश्- dRZ- "see" दृश्-त- dRZ-ta'- > दृष्ट- dRSTa'-
 प्रच्छ- pracch- "ask" पृच्छ-त- pRcch-ta' > पृष्ट- pRSTa'-
 चक्ष- cakS- "look" चक्ष-त- cakS-ta' > चष्ट- caSTa'-
 मृज्- mRj- "wipe" मृज्-त- mRj-ta'- > मृष्ट- mRSTa'-

4) Dentals preceded by retroflexes assimilate to retroflexes. (ट वर्ग) + (त वर्ग) --> (ट वर्ग) + (ट वर्ग)
 e.g., ईद्- ID- "praise": ईद्-ते I'D-te > ईट्टे I'TTe (parasm.pres.ind.3rd.sg.)(Mac451)

दा- dA- "give": अदिष्-ध्वम् adiS-dhvam > adiS-Dhvam > अदिद्ध्वम् adiDhvam (Atm.s-aor.2nd.pl.) In In inflections the ध् 'dh' is changed to द् 'Dh' after final ष S of a stem, with loss of the ष S or its conversion to इ D. (Wh197a, 228.c)

विषद्-न- viSad-na'- > विषण्ण- viSaNNa'- "sad, dejected" (retroflex ण् retroflexes the following न्.)

This rule is most consistently observed following ष 'S', which retroflexes a following dental including न् 'n'.

This sandhi behavior is not limited to retroflexes as dentals preceded by palatals similarly assimilate to palatals. (Wh196, 203) E.g., तद् श्रुत्वा tad ZrutvA -> तच्छ्रुत्वा tacchrutvA, हृद्- hRd- n. "heart" + शी- ZI- "lie" हृद्-शय- hRd-Zaya- > हृच्छय- hRcchaya- "residing in the heart"; स्वप्- svap- "sleep" + शी- ZI- "lie" स्वपन्-शेते svapan-Zete -> स्वपञ्चते svapaJ-chete "he lies sleeping," रजन्- rajan- "king" रज्ञी rajJi "queen".

In external sandhi, the assimilation of dentals to a subsequent retroflex is not consistently observed, at least not in the older language (vedic) and inconsistently in classical sanskrit. (Wh 199) E.g., तद्- tad- + डी- DI- "fly" तद् डयते tad Dayate -> तड्डयते taD Dayate. The rule remains that a word final dental should be assimilated to a word initial retroflex that follows. A word initial dental following a word final retroflex usually remains unchanged. (Kobayashi p. 141, Wh199b)

But in external sandhi a word-final dental 't' is assimilated to palatal 'c' or 'j' -- as ut carati -> उच्छरति uccharati, vidyut jAyate -> विद्यज् जायते vidyuj jAyate -- and a final न् 'n' is assimilated to ञ् 'J' before ज् 'j'. (Wh202)

Word boundary (external sandhi) retroflexion: (Kobayashi p. 142)

	s-	S-	t	T	n-	N-
-s	-s/H s-	-S/H S-	-s t-	-S T-	-r/∅ n-	-r/∅ N-
-t	-t s-	-t S-	-t t-	-T? T-	-n n-	-n N-
-T	-T s-	-T S-	-T t-	-T T-	-N n-	-N N-
-n	-n s-	-n S-	-n t-	-N T-	-n n-	-n N-
-N	-N s-	-N S-	-N t-	-N T-	-N n-	-N N-

(t represents any dental stop; T represents any retroflex stop; H is visarga)

5) In sanskrit sandhi retroflexion rules one encounters the phenomenon of retroflexion caused by some roots ending in ह् 'h', as lih- lih-ta'- > IIDha'-, This has been discussed above. (see B.7.Sibilants - Sanskrit roots ending in ह् 'h')

6) The verbal root, पिष्- piS- "crush" (nasal infixing 7th class, rudh-class), in the present system has stems -- पिनष्- pinaS- (strong stem), पिस्- piMs- (weak stem) -- forming पिनष्टि pina'STi (parasm.pres.ind.3rd.sg.) पिङ्शन्ति piGZanti (parasm.pres.ind.3rd.pl.). The parasmaipada present subjunctive in the 2nd and 3rd persons has the anomalous retroflexed form, पिणक् पिNak. (MWD, Wh190c) The anomalously retroflexed ण् 'N' in पिणक् might represent columnarization or a transfer of [-ant] from the root. (Kobayashi p. 159)

Phonemic propagation of retroflexion. The variability in extent and consistency of retroflexion is due to its multiple origins. The ruki rule in PIE and PIIr resulted in alveolopalatal sibilant which became retroflex only in early indic. Fortunatov's law operating in late PIIr relates only to one setting, the retroflexion of a dental following a lost lateral. The retroflexion of voiced dentals following a lost voiced sibilant with compensatory lengthening of a preceding vowel occurs in pre-vedic and produces unequivocally phonemic (non-allophonic) retroflexes.

In sanskrit the spreading of retroflexion is related to the degree of phonemicization of the retroflex. Starting at the low end of the spectrum, the retroflex nasal, ण् 'N', causes retroflexion only to a following न् 'n', and no regressive retroflexion. The retroflex nasal could almost be declared an allophone of the dental if it were not for a handful of contrasting minimal pairs, like अनु- anu- (verbal prefix) "after": अणु- aNu- (adj.) "minute." In the case of sibilants, while their allophonic aspect is illustrated by the ruki context, retroflex ष् 'S' appears in numerous other settings (e.g., षष् "6") and contrasting minimal pairs (अस्त- "home": अष्ट- "8") are not uncommon. The unvoiced dentals, त् 't' and थ् 'th', are partially allophonic with their corresponding retroflexes, as in sibilant environments, but there are numerous phonemically contrasting minimal pairs and occurrences of independent unvoiced retroflex stops. Finally, at the other end of the spectrum are the voiced retroflexes, ड् 'D' and ढ् 'Dh', which have a number of unique origins, namely 1) from lost alveolopalatal [ž] or retroflex [z] (vs); 2) from PIIr -j^ht- by Bartholomae's Law, resulting in ढ् 'Dh'. (Kobayashi p. 143-144); and 3) by way of Fortunatov's Law, yielding retroflex dentals from the sequence lateral + dental (see C.2.Merger of liquid resonants and Kobayashi pp. 145-146).

As described earlier (C.8.Sibilant consonants in PIIr - Retroflexion of sibilants in indic) retroflexion represents coronalization. As such, other coronals, i.e., the rhotics in the case of sanskrit, need to be included in phonemes causing coronalization-retroflexion. In other words, even though the rhotics [र् ऋ ॠ] are not "retroflexes" they are coronals in their articulation that cause coronalization-retroflexion like the similarly articulated retroflex consonants. Also in sanskrit retroflexion is blocked before a rhotic (coronal).

The retrograde phonemic propagation of retroflex stops was discussed in B.7.Sibilants - Six, the number, as retroflexion throwback.

Origin of retroflexion. The development of retroflexion-coronalization in indic is unique among ie languages. In pre-vedic the coronalized articulation of sibilants [š, ž] emerges as an articulatory alternative to palatalization [š̌, ž̌]. This coronalized articulation is extended to other consonants, allophonically at first and then phonemically. The reasons and mechanisms for its appearance have been discussed extensively without consensus.

Let us enumerate some of the major considerations.

1) Retroflex consonants are common to Dravidian and Munda languages in which they are phonemic. Only in the geographical region of India are retroflexes observed. Burrow (pp.96-99) notes that the Savara language (Mundan) has no retroflexes, suggesting Dravidian the likeliest candidate as a source of borrowing, or more accurately, substratum influence. Its spread to some of the easternmost iranian languages supports the geographical model. The idea that the coronalized-retroflexed articulation was borrowed from Dravidian or Munda has considerable support.

2) Retroflexion has many sources. The adoption of retroflexion likely occurred in stages, affecting only some phonemes at first, such as sibilants. The acquisition of Dravidian (and Mundan) borrowings further consolidated retroflexes as phonemes. Some native sanskrit words later develop retroflexes. (Fortson p. 188) The main processes yielding retroflexion in sanskrit are: ruki, nati, coronal assimilation (st>ṣt), sibilant laxing (Vzq>V:d), Fortunatov's Law.

3) The idea of a de novo and purely internal development of retroflexes in indo-european also has its supporters. Although no other group of early ie languages currently has retroflexes, their presence (and subsequent disappearance) in the development of the more recently attested languages, such as baltic, slavic and germanic, has occasionally been hypothesized. Swedish has retroflexes, and in most varieties of english the 'r' is pronounced coronally. The promoters of internal development of retroflexes maintain that retroflexion can be explained by purely indo-aryan phonology, citing the role and evolution of sibilants as a starting point.

4) The possibility of a joint Dravidian-Indo-Aryan retroflex development was examined by Hoch (Hoch, Hans. Subversion or convergence? the issue of pre-vedic retroflexion reexamined. Studies in the Linguistic Sciences, 23:2, 73-115, 1993.) Mundan phonology is not incorporated in his discussion. Hoch concedes in several instances that making inferences on the linguistic scene in south east asia three-four millenia ago is speculative and that "we simply do not have any reliable independent evidence that would permit a choice between these different possibilities."

5) Are there Dravidian or Mundan words with retroflex phonemes attested in sanskrit without their retroflexion? This might support the notion that borrowings occurred before sanskrit had a chance to develop retroflexes.

Our opinion: Retroflexes developed in OIA within the phonological framework of sanskrit itself. But the idea of articulating the alveolopalatal sibilants and other consonants coronally as retroflexes may have come from contact with Dravidian and Mundan. Once retroflexes were established in OIA, subsequent borrowings from Dravidian and Mundan containing retroflexes could take place without major phonological adaptation.

The sanskrit phonological inventory grid of voicing [voiced] and aspiration [spread glottis] and retroflexion [-ant, -distr] are among the most salient characteristics of sanskrit phonology. (Kob 103)

velars:	क	ख	ग	घ	ङ	
palatals:	च	छ	ज	झ	ञ	श
retroflexes:	ट	ठ	ड	ढ	ण	ष
dentals:	त	थ	द	ध	न	स
labials:	प	फ	ब	भ	म	

C.11. Various final notes.

Sandhi. Sanskrit sandhi rules are outlined in point form above in the unit preceding the historical phonology section. A description of sandhi rules can be found in Whitney and in standard sanskrit textbooks.

Three points worth reiterating, though, are as follows

- 1) many of the phonological changes in late PIIr-early OIA are preserved in sandhi;
- 2) the rules of sandhi are established in indic by the time of vedic;
- 3) sandhi between morphemes is older than sandhi between words and compounds.

Nasals. Although the nasals, [n, m], share many phonological similarities, their outcomes in indo-aryan show some divergence. Intervocalic 'n' is relatively stable in sanskrit and its subsequent development into prakrits, while 'm' shows some lenition towards 'v' in intervocalic position. The nasal 'm' before consonants more often undergoes deocclusion to anusvara before consonants than does 'n'. In external sandhi, word final 'n' does not undergo assimilation to the following consonant, unless it is retroflex or palatal, while 'm' is assimilated or deoccluded before any plosive. In word final position 'n' is geminated to 'nn' while 'm' does not show this behavior. (Kobayashi pp. 91, 96)

Asymmetry of व् 'v' and य् 'y'. Recall that PIE non-syllabic * υ [w] and * i [j] are allophones of vocalic *i and *u. But in Sanskrit they show some differences in behavior. In the RV the sequence [yr] is metrically disyllabic, while [vr] is monosyllabic. The sequence [rv] is stable, as in cakrvaMs-, while [ry] undergoes gemination or i-epenthesis to [riy], as in mriyate. The non-syllabic 'y' is attested as geminated in a number of words and in inflection, while 'v' is not. (Kobayashi pp. 98-99)

Edgerton. The format of the work by Edgerton (1946) consists of enumerating phonemes preserved in the PIE-Sanskrit interval; some of his submissions from the PIE side are dated, as with the inclusion of the unvoiced aspirates and the role of laryngeals, but the correlations gleaned from his outline are still valuable. His description of consonants is simple but consistent with what we have done in the PIE section, in particular the preservation of labials and dentals, the general development of the PIE velars to palatal affricates and fricatives, a note on the deocclusion of voiced aspirates, an honorable mention of the formation of -sk- -> -cch-, and the partial preservation of the PIE unvoiced dental sibilant. With the PIE vowels and resonants, he outlines their reflexes in Sanskrit, briefly discusses zero-grade and full-grade role in ablaut (with some good examples), addresses the general merger of 'r' and 'l', and tabulates the Sanskrit vowels with their PIE correlates as understood at that time. He attempts to reconcile recent work in European phonology with views held by "the Hindu grammarians."

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PIE consonant resonants

PIE	hittite	skt	avest	ocs	lith	alb	arm	gk	latin	celt	Gothic	Toch
*m	m	m	m	m	m	m	m	m	m	m	m	m
*n	n	n	n	n	n	n	n	n	n	n	n	n ñ
*r	r	r	r	r	r	r	r	r	r	r	r	r
*l	l	rl	r	l	l	l	l	l	l	l	l	l
*i (y)	y	y	y	j	j	gj	z ø	ø	i	ø	j ø	y
*u (w)	w	v	v uu	v	v	v	g	h zd ø u		f b	w	w
*h1	ø											
*h2-3	h											
*h4	ø					h						

PIE consonant stops

PIE	hittite	skt	avest	ocs	lith	alb	arm	gk	latin	celt	Gothic	Toch
*kw	ku	k c	k c	k č	k	k s	k c	k p t	qu	c	hw g	k s
*gw	ku	g j	g j	g ž z	g	g z	k c	g b d	gu u	b	q	k s
*gwh	ku gu	gh h	g j	g ž z	g	g z	g j	φ θ χ	f gu u	g	g b	k s
*k	k	k c	k c	k č	k	k q	k	k	c	c	h g	k s
*g	k	g j	g j	g z	g	g gj	k	g	g	g	q	k s
*gh	k g	gh h	g j	g ž z	g	g gj	g	kh	h g	g	h g	k s
*k̥	k	s	s	s	š	th	s	k	c	c	h g	k s
*g̥	g k	j	z	g ž z	g	dh	c	g	g	g	k	k s
*g̥h	g k	h	z	g z	g	d	j z	kh	h g f	g	g	k s
*t	t	t	t θ	t	t	t	t y	t	t	t	þ d	t c
*d	d t	d	d ð	d	d	d	t	d	d	d	t	t s
*dh	d t	dh	d ð	d	d	d	d	th	f d b	d	d	t c
*p	p	p	p f	p	p	p	h w ø	p	p	ø	f b	p
*b	b p	b	b β	b	b	b	p	b	b	b	p	p
*bh	b p	bh	b β	b	b	b	b	ph	f b	b	b	p

PIE consonant sibilant

*s	s	s š	s š h	s x	s š	gj sh	s ø	s h ø	s r	s ø	s z	s š
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Appendix B: Time and Place

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Introduction.

The methodology of historical phonology and linguistics allows us to describe what took place in the realm of language and phonological change and it allows us to describe the sequence of events to establish a relative chronology of these changes. But it does not attempt to provide any precise time or place for these changes. For that other historically or biologically oriented fields of study need to be incorporated.

Language borrowings provide evidence of intercultural contact. For the purpose of localizing and timing the earlier stages of ie languages, evidence of contact with speakers of non-ie languages can be particularly helpful. Names of plants, animals and other natural phenomena also provide evidence of location and time.

Otherwise, to localize a cultural group -- speakers of even one ie language or the group as a whole -- one needs to combine historical data with archaeology and even genetics. This represents a significant change of methodology. For that reason and for the sake of clarity, a discussion on localizing and placing in time the speakers of ie languages should be discussed separately from and after a relative historical chronology of language processes are to some degree understood.

In the last two hundred years numerous studies have addressed the indo-european original homeland problem. Simply stated, this effort is directed at determining when and where PIE was spoken -- in particular at a stage just before its differentiation into ie language families, i.e., the last common ancestor of all the ie languages. However, the time and location of more recent events is also important. That is, we are interested in the time and location of the full excursion from proto-indo-european (PIE) to old Indo-Aryan (OIA) -- starting with the time and location of common late PIE, the dialects of PIIr, the dialects of pre-vedic indic and its proto-iranian contemporary -- through to the arrival of sanskrit speakers in northern India.

PIE homeland.

There is an emerging consensus of the time and location of the original homeland of the speakers of common late PIE. Nonetheless, competing theories keep emerging. A full discussion would require in incorporation of a number of fields of discipline and fill several volumes. Our objective is to put the historical phonology section into perspective in terms of time and space and so only an outline with references will be provided.

Mainstream indoeuropeanists posit the homeland of PIE in the southern steppes of Ukraine and Russia (Pontic-Caspian steppe) approximately 4000-3500 BCE. The separation of Anatolian from PIE may have occurred just before this time and that of Tocharian during or soon after this time. The PIE group after the separation of Anatolian and Tocharian are referred to as late PIE. Italo-Celtic was the first to separate from late PIE, soon after Tocharian. There is a long tradition of support for this model, starting with Benfey (1869), Schrader (1855), Childe (1926), Gimbutas (1965), and more recently Mallory (1989) and Anthony (2007). (Parpola-2012 p. 122, Anthony-2012 p.202) There is strong additional recent support in the form of borrowings by uralic languages, the archeology of wheeled vehicles, and the discovery of metallurgical western siberian settlements, such as Arkhaim and Sintashta. The maximum temporal excursion of PIE -- from early common non-inflectional Indo-Hittite PIE to the dialectal differentiation of late common PIE -- is 4500 BCE to 2500 BCE. (Anthony-2007 p. 81) This is also referred to as the Kurgan or steppe hypothesis.

An Anatolian homeland in 7000-6000 BCE is proposed by Renfrew (1987) and Gamkrelidze and Ivanov (1984). The approach by Gamkrelidze and Ivanov is based on the problematic glottalic theory. Renfrew's approach is built on the model of the spread of agriculture, while minimizing the contribution of migrations, political domination, climate, and so on. Recent support for this model by Bouckaert (Atkinson, Gray) et. al. (2012) in a computer modelling study published in Science attests to its active

consideration. The work by Pereltsweig et al. puts the study by Bouckaert into perspective and systematically lays out its shortcomings. Archeologic and genetic evidence supports movement of farmers from Anatolia to Greece and the Balkans, but it is unclear whether or not these were indo-europeans. A serious obstacle to this theory arises in the form of Anatolian studies per se -- that is, Anatolia is considered to be inhabited by Hattic and Hurrian (non-ie, non-semitic) speakers of agglutinative-ergative languages long before the arrival of indo-europeans, and the arrival of Hittite and Luwian speakers is viewed by anatolian and middle eastern specialists as intrusive. The work of Melchert, Bryce and others suggests that ie (hittite) speakers entered anatolia during the third millenium BCE and encountered a well established substratum of speakers mainly of Hattic, but also Akkadian and Sumerian. (Pereltsweig p. 119) Accumulating evidence from uralic studies is also contrary to the anatolia homeland location and timeline. Perhaps the most significant obstacle to this theory resides in the timeline itself. Anatolian languages are sufficiently similar to other ie languages that their separation from common or late PIE by more than 500-1000 years is implausible. Renfrew's Anatolian-farming hypothesis converges with the steppe hypothesis in terms of time and place -- from the third millenium BCE onwards -- when addressing late PIE and the development of indo-iranians in the Pontic steppes. (Renfrew pp.3-20)

The "out-of-India" hypothesis maintains that sanskrit could not have originated in Europe and always existed in India, not elsewhere. Supporters of this hypothesis tirelessly aim to establish a relationship of Aryan culture with earlier Indian archeological societies. By this, the indic influence of the Mitanni culture came directly from India. Their consideration of other ie languages is of secondary importance and is dismissed as a group migration westwards. This approach enjoys great social and academic support in India.

The support for the mainstream steppe hypothesis is arrived at by more than just the deduction layed out in Mallory's work (1989). Additional recently elucidated ingredients in supporting the steppe hypothesis come from lexicology -- the vocabulary surrounding wheeled vehicles and attestations of borrowings into Finno-Ugric (uralic) languages. (Anthony & Ringe, 2015) The invention of the wheeled vehicle with a wheel and axle mechanism is attested from 4000-3500 BCE by radiocarbon dating, and became widespread in the ancient world between 3400-3000 BCE. No wheeled vehicles existed before 4000-3500 BCE. All branches of ie - except Anatolian - share elements of vocabulary pertaining to wheeled vehicles.

*k^wel- "to turn" (verbal root) -> *k^wek^wlos "wheel"

(reduplication + zero grade root + thematic vowel + nom.sg. ending)

*k^wek^wlos -> kokale (Toch B), kukal (Toch A) "chariot"; κυκλος (greek); колесъница (ocs) "chariot", колесо (ukr) "wheel", коло (ukr) "circle" (not reduplicated); hwēol (old english), चक्र- cakra- "wheel, circle" (sanskrit); čaxra-(avestan). Note: kekrā "circular" (proto-uralic)

*h₂ek^s- > *ak^s- "axle" -> αξων "axle" (greek); axis (latin); ось (ocs), eax (old engl.); अक्ष- a'kSa- m. "axle" (sanskrit)

*Hroteh₂- "wheel" -> rota (latin); ratas (lithuanian); rad (old high german), reth (old frisian); रथ- ra'tha- m. "chariot" (sanskrit); raθa- (avestan)

*ueǵh- "lead, convey in a vehicle" -> yakne (Toch B), wkam "way" (Toch A); vehit (latin); vega (old norse), wagon (english); वह- vah-, vahati (sanskrit), vazaiti (avestan)

*h₂eyH- *h₂iHseh₂- "thrill" -> hissas (hittite); ईश- ISA'- f. "shaft, pole of carriage or plough" (sanskrit), oje "shaft" (slovenian), вое, вiя (ukr), воë (russian, Vasmer)

The above correspondence sets support a single ie origin of these terms occurring no sooner than 3500 BCE, that is, the time occurrence of late PIE corresponding to 3500-3000 BCE (or later). The vocabulary for wheeled vehicles, i.e., the whole semantic field, is shared by all ie languages (save Anatolian), and archeologically wheeled vehicles are not attested before 4000-3500 BCE. This establishes a **terminus post quem** for the divergence of ie languages. The differentiation of ie languages (excluding anatolian) would have occurred after this date.

In the realm of uralic (Finno-Ugric) studies considerable recent advances contribute significantly to our view of proto-indo-european-proto-uralic contacts, notably the work of Kortlandt, Kuzmina, Parpola, Carpelan, Kallio, and others. In addition to the obvious baltic and slavic sources, borrowings into Finno-Ugric from PIIR are attested from eastern europe across the urals and well into the samoyedic regions. Late PIE borrowings are also proposed. These borrowings bear the phonological

characteristics of the ie source language at the time of borrowing. (see Kortlandt, Kuzmina pp.199-204, Parpola-1998, Parpola-2012) Harmatta (see refs) outlines the development of indo-iranian with examples of Finno-Ugric borrowings from each stage of indo-iranian development from PIE to PIIr. Finally, extending the contact line further back in time, Kortland and others have even hypothesized a common Indo-Uralic language stage (occurring in the timeframe 10000-6000 BCE) based on grammatical similarities -- shared morphemes in pronominal roots (*-m 1st pers., *-t- 2nd pers., *-i- 3rd pers.), case markings (*-m acc.sg., *-ta abl.), interrogative pronouns (*k^w- "who, what"), negative particle (*ne) -- and a number (eight) of common verbal roots. While it is common for unrelated languages to borrow words, deeper grammatical elements like grammatical paradigms are not as a rule borrowed. Their presence is evidence either of common descent or of prolonged, intimate contact.

In addition to the deduction by Mallory (1989) who continues a long tradition of indoeuropeanists, the nearly continuous temporospatial contact with uralic languages and the temporal localization of wheeled vocabulary persuasively supports the idea of the PIE homeland in the Pontic-Caspian steppe between 4500 BCE-2500 BCE. In that time frame, PIE undergoes a significant development from an uninflected early PIE, then the separation of the Anatolian group at an early inflectional stage, then a middle PIE during which the inflectional system develops and Tocharian separates (3500-3000 BCE), then a late PIE during which Italo-Celtic separates at an early stage and the "core" PIE group differentiates further into late PIE dialects, the proto-languages of indo-european.

PIIr time and place.

Proto-indo-iranian begins as a dialect of late PIE (3500-2500 BCE) in the Pontic-Caspian steppe (circum-Pontic interaction sphere) and is physically correlated with the Sretnyi Stog -> Yamnaya -> Abashevo culture in that time. That is, PIIr developed from the common ie proto-language spoken in the Srednii Stog culture (ca. 4500-3600 BCE, Средний Стог) in Ukraine and Southern Russia. The proto-ie language system is presently believed not to have developed from or existed as a static, unitary ie language that only disintegrated as the various ie language groups were formed, but instead existed in a state of geographical, dialectal and evolutionary dispersion. (Abrados, JIES, 2007, 35, 129).). Similarly, Trubachev in his work offers an analogy of the language system existing as a bush, not a tree, with preserved wholeness and implied mutual intelligibility and functionality. (He states (Trubachev, 152): "Более адекватной кажется сумма этногенезов, или образ более или менее близких параллельных стволов, идущих от самой почвы, т.е., подобие **куста**, а не дерева; этот образ неплохо передает древнюю полидиалектность, но и он не вполне удовлетворителен, поскольку недостаточно выражает то, что придает индоевропейскому характер **целого**.") At this stage, despite lexical and phonological differentiation, the "core" ie languages probably remain mutually intelligible. (Telegin, 2005)

Accordingly, the Aryan proto-language is also believed to have been dialectally differentiated from the start, as it is believed the Poltavka culture (ca. 2500 - 1900 BCE) in the steppe between the Volga and Ural rivers was ancestral to the Iranian group of languages and the Abashevo culture (ca. 2300 - 1900 BCE) in the forest steppe from the upper Don to mid-Volga rivers (and further north to the southern Urals) was ancestral to the Indo-Aryan group. (dates from Sims-Williams pp.79 - 80.) Continued contact with speakers of other ie language groups, such as Balto-Slavic in particular is likely. (Burrow.18, 31; Telegin; Sims-Williams. 82) The split of proto-Aryan from proto-Iranian is believed to have occurred ca. 1900 BCE, whereby the speakers of proto-Aryan had occupied the eurasian steppe east of the Ural river, while the proto-Iranians were located to the west (Sims-Williams p. 81).

The Yamnaya Culture (3200-2500 BCE) extending along the steppe from the Dniester to the Volga -- influenced by the Maikop culture in the Kuban -- evolved into the Catacomb Grave cultural complex (2500-1950 BCE) -- giving rise to the iranian branch of PIIr. This was contemporaneous with the late Yamnaya-Poltavka culture (2500-2100 BCE) of the Volga-Urals -- the earliest formation of the Indo-Aryan branch of PIIr -- extending from the upper Don to the Tobol river (branch of Irtysh-Ob rivers) -- that directly gave rise to the Abashevo culture (2200-1850 BCE) with the same geographical spread. (Parpola-2012 p.138-139, see Abashevo map on p. 139). The evolution of the proto-indo-aryan late Yamnaya-Poltavka culture from around 2200 BCE yielded the Potapovka culture of the mid-Volga (2100-1700 BCE) and the impressive metallurgical Sintashta culture (2100-1700 BCE) in the southeastern Urals. It was in the Sintashta culture that the first horse-drawn chariots were produced.

A branch of the Sintashta culture, the Petrovka culture (2100-1700 BCE) expanded southeastward to northwestern Kazakhstan giving rise to the earliest stage of the Andronovo complex. The earlier Alakul

Andronovo culture (2000-1700 BCE) occupied the forest steppe east of the Urals and western Kazakhstan to Khwarezm. But the later Fedorova Andronovo culture (1850-1450 BCE) came to occupy essentially all of Kazakhstan and Turkmenistan in the south.

The contemporaneous non-IE BMAC culture (Oxus civilization) (2200-1450 BCE) is believed to have been taken over by Indo-Aryans fairly early during their expansion southwards. Perhaps in a manner analogous to the BMAC takeover the Mitanni kingdom of Syria (1500-1300 BCE) was ruled by proto-Indo-Aryan nobles. In the case of BMAC, however, the Indo-Aryans actually expanded and settled in this area and then spread further to the Indus valley by 1200-1000 BCE. The BMAC Gandhara Grave culture (1600-900 BCE) were the first in that region to show evidence of the domesticated horse and use of the chariot.

On the Iranian side, the Catacomb Grave cultural complex (2500-1950 BCE) -- that had evolved from the Yamnaya Culture (3200-2500 BCE) -- in the area west of the Don developed into the KMK (культура многомаликовой керамики, aka Babino III culture) (2100-1850 BCE) and then was succeeded by the Timber Grave culture (Срубная культура, 1850-1450 BCE). This Srubnaya Culture succeeded not only the KMK but also the Abashevo culture over its entire area and expanded to the southern Urals where it coexisted with the Andronovo culture (2000-1850-1450 BCE). In the late Bronze age (1450-800 BCE) the Srubnaya culture was followed by cultures characterized by pottery with roller application (валиковая керамика). In the former KMK areas north of the Black Sea, the Valikovaya culture (валиковая культура) was represented by the Sabatrinovka and Belozerka cultures, while in the upper Don and lower Volga were the Late Srubnaya culture. It is conceivable that in this era proto-Iranian shares a number of phonological changes with Slavic and other IE groups, like the deaspiration of voiced consonants, (Parpola-1998 p. 132) The Srubnaya culture expanded significantly in its time span, north to the Kama river and eastwards to eventually cover the whole territory of the previous Andronovans, that is, Kazakhstan and Turkmenistan and became represented by the Alekseeva (or Surgary) culture. (1500-900 BCE) In southern central Asia (BMAC) the Valikovaya cultures formed the Yaz I - related cultures (1450-1000 BCE) (Parpola-2012 p.140)

It is the Yaz I fortifications that are probably referred to in the Rigveda, as those of the inimical Dāsas and Dasyus, encountered in the Iranian-Indic borderlands of that time. The tribal name, Daha (< *dasa- "man" (Iranian)), in OPers refers to the Saka (Indic name). Note: शक- Zaka- m. or खीक- ZAKa- adj. "Iranian, Scythian", but Zaka- n. "excrement"; सक्वृत्- sAkaMvRt- "rolling wheels". It is believed the verses of the Avesta were composed in the Yaz I area during this time. The PIIr proto-Iranians, over much time, sequentially replaced the migrating PIIr proto-Indo-Aryans as they moved east from the Volga region and then south through the BMAC. Finally, in the Iron Age of that region (850-650 BCE) the Valikovaya roller pottery cultures were succeeded by the Iranian-speaking Scythian, Sarmatian and Saka cultures.

Table of PIE to Indic:

Time	Place	Association	Language
4000-3500 BCE	Ukraine, Southern Russia	Yamnaia-Srednyi Stog	inflectional (late) PIE
3500-2500 BCE	above & some dispersal	Yamnaia Pit Culture	early dialectal PIE
2800-2300 BCE	steppe (from Dnieper to Volga)	Srednyi Stog culture	proto-Indo-Iranian
2300-1800 BCE	Volga-Uralic steppes	Abashevo culture	PIIr proto-Indic
2100-1800 BCE	East of Urals	Sintashta-Arkaim	PIIr proto-Indic
(2100-900 BCE)	Kazakhstan, Turkmenistan	Andronovo culture	proto-Indic)
2000-1700 BCE	northern Kazakhstan	Alakul Andronovo	proto-Indic
1850-1450 BCE	Kazakhstan, Turkmenistan	Fedorova Andronovo	proto-Indic
> 1900 BCE			Iranian-Indic dialect differentiation
1900 BCE	east of Ural r. & BMAC	earliest arrival in BMAC	Indo-Aryans
1500 BCE	northern Mesopotamia	Mitanni culture	Indo-Aryans (Vedic)
		terminus ante quem - for distinct devel of Indic languages	
1600-900 BCE	BMAC	Gandhara Grave culture	Indo-Aryans
1500-1350 BCE	BMAC, N. India	Rigvedic Aryans	Indo-Aryans
1200-1000 BCE	entry into Indus valley	Rigvedic Aryans	Indo-Aryans

Entry into India.

Readily gleaned from the above discussion is the impression that the Indo-Aryans entered northern

India as a dialectally differentiated group. Dialectal differentiation began already in late PIE and continued throughout the PIIR period. Indeed the entry of the Indo-Aryans into northern India is described in "waves," each having some distinct phonological and grammatical features, in turn forming the basis of prakrits in later times.

The Rigveda is itself temporally stratified, having been composed at somewhat different times.

Witzel (p.3) describes the stratification of vedic thus:

- I. Early Rgvedic c.1700-1500 BCE, books 4, 5, 6, (?2), with early hymns referring to the Yadu-Turvada, Anu-Druhyu tribes
- II. Middle (main) c.1500-1350 BCE, books 3, 7, 8 (1-66) and 15 (1-191), focus on Bharata chieftain sudAs and his ancestors, and his rivals, Trasadasyu, rel to PUru tribe.
- III. Late Rgvedic c.1350-1200 BCE, books 1 (1-50), 8 (67-103), 10 (1-854), 10 (85-191) with the descendant of the pUru chieftain Trasadasyu, KuruZravaNa and the emergence of the supertribe of the Kuru.

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Appendix C. Mitanni texts

The earliest form of attested Sanskrit appears in the texts of the Mitanni, who ruled over the upper Euphrates-Tigris basin (1500-1360 BCE) -- modern Syria, northern Iraq and eastern Turkey. While the Mitanni people spoke Hurrian, a non-IE, non-Semitic language, their texts reveal numerous personal names, the names of deities, technical terminology related to chariot warfare and numerals that are almost certainly Sanskrit of the Rigvedic period.

In the way of personal names, each of the Mitanni kings and many of the society's elites had Sanskrit names, like Purusa (पुरुष- pu'ruSa- m. "man"), Tusratta (तुप्रथ- tuS-ratha- m. "nice chariot"), Suvardata (स्वर्गदत्त- svarga'-data'- m. "heaven sent"), Indrota (इन्द्रोत्त- indra-Uta- "favored by Indra", av- "favor"), Subandhu (सुबन्धु- su-bandhu- m. "well-respected").

The Mitanni revered chariot warfare, like the Indo-Iranians. A Mitanni horse-training manual written down by Kikkuli in Hurrian uses a number of Sanskrit words, as asua (अश्व- aZva- m. "horse"), numerals in composition like aikawartanna, panzawartanna, sattawartana, nawawartanna "one, five, seven, nine laps" (एक- पञ्च- सप्त- नव- वर्तनमा eka- paJca- sapta'- nava- vartanam "turning"). (Fortson p. 184, Parpola-1998 pp.127-128) The military elite were referred to as Maryanna (मर्य- marya- m. "young man, warrior") and the Egyptians referred to the Mitanni as "Maryannu."

Furthermore, the Mitanni worshipped a number of deities of which most had names like Indra, Varuna, Mitra, Nasatyas (Ashvins), which were also among the most important deities in the Rigveda.

The Indo-Aryans at first probably played a military role for the Hurrian kings, but soon took over and went about founding the Mitanni kingdom. The sociopolitical configuration of the Mitanni kingdom based on extant texts is believed to have been composed of large majority (90 percent) of Hurrian speaking middle eastern people ruled over by a small elite (10 percent) of Indo-Aryan warriors and statesmen. (Cline p. 30) The Mitanni Aryans are thus identified with the rulers of the BMAC of that time, (Parpola-1998 p.128) and it is likely they originated from BMAC rather than vice versa (Sims-Williams pp.78-79), or even from the Andronovan area. Their entry into the near east may be analogous to their initial entry into the BMAC, but instead of being followed by waves of compatriots, the Indo-Iranian Mitanni elite eventually became assimilated, although preserving a number of their deities.

Contemporaries of the Mitanni were: Hittites, Egyptians, Kassites-Babylonians, Assyrians, Cypriots, Canaanites, Minoans and Mycenaeans. (Cline p. 61) The Mitanni kingdom under King Tushratta came to an end in 1360 when they were conquered by the Hittites led by Suppiluliuma and their capital city, Washukanni, was sacked and plundered. (Fortson p. 184, Cline p. 67)

As historical evidence, the Mitanni evidence does indeed represent a **terminus ante quem** for the distinct development of Indic in PIIr.

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