A fundamental characteristic of the rules discussed up to this point is that they have been totally predictable allophonic processes, such as aspiration in English or vowel nasalization in Sundanese. For such rules, the question of the exact underlying form of a word has not been so crucial, and in some cases a clear decision could not be made. We saw that in Sundanese every vowel becomes nasalized after a nasal sound, and every phonetic nasal vowel appears after a nasal. Nasality of vowels can always be predicted by a rule in this language: all nasal vowels appear in one predictable context, and all vowels are predictably nasal in that context. It was therefore not crucial to indicate whether a given vowel is underlyingly nasal or underlyingly oral. If you assume that vowels are underlyingly oral you can write a rule to derive all of the nasal vowels, and if you contrarily assume that vowels are all underlyingly nasal you could write a rule to derive all of the oral vowels. The choice of underlying sound may make a considerable difference in terms of simplicity and elegance of the solution, and this is an important consideration in evaluating a phonological analysis, but it is possible to come up with rules which will grind out the correct forms no matter what one assumes about underlying representations in these cases. This is not always the case.

4.1 The importance of correct underlying forms

Neutralizing rules, on the other hand, are ones where two or more underlyingly distinct segments have the same phonetic realization in some context because a rule changes one phoneme into another – thus the distinction of sounds is neutralized. This means that if you look at a word in this neutralized context, you cannot tell what the underlying segment is. Such processes force you to pay close attention to maintaining appropriate distinctions in underlying forms.

Consider the following examples of nominative and genitive forms of nouns in Russian, focusing on the final consonant found in the nominative.

(1)

Nominative singular	Genitive singular	
vagon	vagona	'wagon'
avtomobilʲ	avtomobilʲa	'car'
večer	večera	'evening'
muš	muža	'husband'
karandaš	karandaša	'pencil'
glas	glaza	'eye'
golos	golosa	'voice'
ras	raza	'time'
les	lesa	'forest'
porok	poroga	'threshold'
vrak	vraga	'enemy'
urok	uroka	'lesson'
porok	poroka	'vice'
tˢvet	tˢveta	'color'
prut	pruda	'pond'
soldat	soldata	'soldier'
zavot	zavoda	'factory'
xlep	xleba	'bread'
grip	griba	'mushroom'
trup	trupa	'corpse'

To give an explanation for the phonological processes at work in these data, you must give a preliminary description of the morphology. While morphological analysis is not part of phonology per se, it is inescapable that a phonologist must do a morphological analysis of a language, to discover the underlying form.

In each of the examples above, the genitive form is nearly the same as the nominative, except that the genitive also has the vowel [a] which is the genitive singular suffix. We will therefore assume as our initial hypothesis that the bare root of the noun is used to form the nominative case, and the combination of a root plus the suffix -a forms the genitive. Nothing more needs to be said about examples such as vagon ~ vagona, avtomobilʲ ~ avtomobilʲa, or večer ~ večera, where, as it happens, the root ends with a sonorant consonant. The underlying forms of these noun stems are presumably /vagon/, /avtomobilʲ/ and /večer/: no facts in the data suggest anything else. These underlying forms are thus identical to the nominative form. With the addition of the genitive suffix -a this will also give the correct form of the genitive.

There are stems where the part of the word corresponding to the root is the same: karandaš ~ karandaša, golos ~ golosa, les ~ lesa, urok ~ uroka, porok ~ poroka, tˢvet ~ tˢveta, soldat ~ soldata and trup ~ trupa. However, in some stems, there are differences in the final consonant of the root, depending on whether we are considering the nominative or the genitive. Thus, we find the differences muš ~ muža, glas ~ glaza, porok ~ poroga, vrak ~ vraga, prut ~ pruda, and xlep ~ xleba. Such variation in the phonetic content of a morpheme (such as a root) are known as alternations. We can easily recognize the phonetic relation between the consonant found in the nominative and the consonant found in the genitive as involving voicing: the consonant found in the nominative is the voiceless counterpart of the consonant found in the genitive. Not all noun stems have such an alternation, as we can see by pairs such as karandaš ~ karandaša, les ~ lesa, urok ~ uroka, soldat ~ soldata and trup ~ trupa. We have now identified a phonological problem to be solved: why does the final consonant of some stems alternate in voicing? And why do we find this alternation with some stems, but not others?

The next two steps in the analysis are intimately connected; we must devise a rule to explain the alternations in voicing, and we must set up appropriate underlying representations for these nouns. In order to determine the correct underlying forms, we will consider two competing hypotheses regarding the underlying form, and in comparing the predictions of those two hypotheses, we will see that one of those hypotheses is clearly wrong.

Suppose, first, that we decide that the form of the noun stem which we see in the nominative is also the underlying form. Such an assumption is reasonable (it is, also, not automatically correct), since the nominative is grammatically speaking a more "basic" form of a noun. In that case, we would assume the underlying stems /glas/ 'eye,' /golos/ 'voice,' /ras/ 'time' and /les/ 'forest.' The problem with this hypothesis is that we would have no way to explain the genitive forms *glaza, golosa, raza* and *lesa*: the combination of the assumed underlying roots plus the genitive suffix *-a* would give us *glasa, golosa, *rasa* and *lesa*, so we would be right only about half the time. The important step here is that we test the hypothesis by combining the supposed root and the affix in a very literal-minded way, whereupon we discover that the predicted forms and the actual forms are different.

We could hypothesize that there is also a rule voicing consonants between vowels (a rule like one which we have previously seen in Kipsigis, chapter 3):

(2)   C → voiced / V _ V

While applying this rule to the assumed underlying forms /glas-a/, /golos-a/, /ras-a/, and /les-a/ would give the correct forms *glaza* and *raza*, it would also give incorrect surface forms such as **goloza* and **leza*. Thus, not only is our first hypothesis about underlying forms wrong, it also cannot be fixed by positing a rule of consonant voicing.

You may be tempted to posit a rule that applies only in certain words, such as *eye, time* and so on, but not *voice, forest,* etc. This misconstrues the nature of phonological rules, which are general principles that apply to all words of a particular class – most generally, these classes are defined in terms of phonological properties, such as "obstruent," "in word-final position." Rules which are stated as "only applying in the following words" are almost always wrong.

The "nominative is underlying" hypothesis is fundamentally wrong: our failure to come up with an analysis is not because we cannot discern an obscure rule, but lies in the faulty assumption that we start with the nominative. That form has a consistent phonetic property, that any root-final obstruent (which is therefore word-final) is always voiceless, whereas in the genitive form there is no such consistency. If you look at the genitive column, the last consonant of the root portion of the word may be either voiced or voiceless.

We now consider a second hypothesis, where we set up underlying representations for roots which distinguish stems which have a final voiced obstruent in the genitive versus those with a final voiceless obstruent. We may instead assume the following underlying roots.

(3)   *Final voiced obstruent*   *Final voiceless obstruent*

/muž/	'husband'	/karandaš/	'pencil'
/glaz/	'eye'	/golos/	'voice'
/raz/	'time'	/les/	'forest'
/porog/	'threshold'	/porok/	'vice'

/vrag/	'enemy'	/urok/	'lesson'
/prud/	'pond'	/tsvet/	'color'
/zavod/	'factory'	/soldat/	'soldier'
/grib/	'mushroom'	/trup/	'corpse'
/xleb/	'bread'		

Under this hypothesis, the genitive form can be derived easily. The genitive form is the stem hypothesized in (3) followed by the suffix *-a*. No rule is required to derive voiced versus voiceless consonants in the genitive. That issue has been resolved by our choice of underlying representations where some stems end in voiced consonants and others end in voiceless consonants. By our hypothesis, the nominative form is simply the underlying form of the noun stem, with no suffix.

However, a phonological rule must apply to the nominative form, in order to derive the correct phonetic output. We have noted that no word in Russian ends phonetically with a voiced obstruent. This regular fact allows us to posit the following rule, which devoices any word-final obstruent.
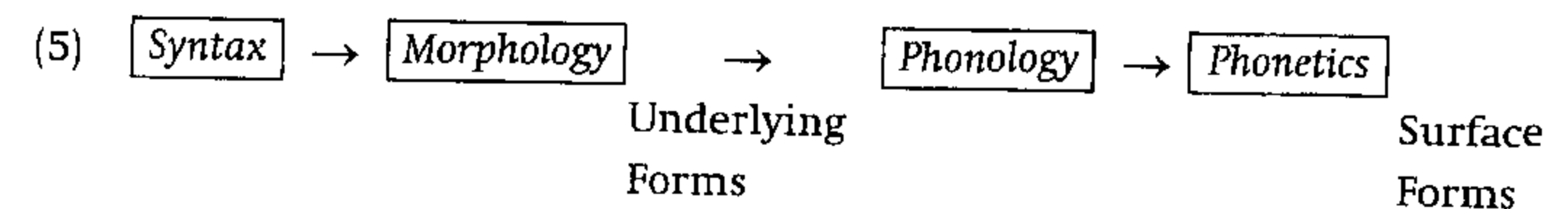
(4)   *Final devoicing*
        obstruent → voiceless / _ #

By this rule, an obstruent is devoiced at the end of the word. As this example has shown, an important first step in doing a phonological analysis for phenomena such as word-final devoicing in Russian is to establish the correct underlying representations, which encode unpredictable information.

Whether a consonant is voiced cannot be predicted in English ([dɛd] *dead*, [tɛd] *Ted*, [dɛt] *debt*), and must be part of the underlying form. Similarly, in Russian since you cannot predict whether a given root ends in a voiced or a voiceless consonant in the genitive, that information must be part of the underlying form of the root. That is information about the root, which cannot always be determined by looking at the surface form of the word itself: it must be discovered by looking at the genitive form of the noun, where the distinction between voiced and voiceless final consonants is not eliminated.

4.2 Refining the concept of underlying form

It is important to understand what underlying forms are, and what they are not. The nature of underlying forms can be best appreciated in the context of the overall organization of a grammar, and how a given word is generated in a sentence. The structure of a grammar can be represented in terms of the standard block model.

(5) $\boxed{Syntax} \rightarrow \boxed{Morphology} \rightarrow \boxed{Phonology} \rightarrow \boxed{Phonetics}$

         Underlying   Surface
         Forms   Forms

This model implies that the output of one component forms the input to the next component, so the phonological component starts with whatever the morphological component gives it, and applies its own rules (which are then subject to principles of physical interpretation in the phonetic component). The output of the morphological component, which is the input to the phonology, is by definition the underlying form, so we need to know a little bit about what the morphological component does, to understand what is presented to the phonology.

The function of the morphological component is to assemble words, in the sense of stating how roots and affixes combine to form a particular word. Thus the morphological component is responsible for combining a noun root [dag] and a plural affix [z] in English to give the word *dog-s* (i.e. /dag-z/), or in Russian the morphology combines a noun root [vagon] with an inflectional ending [a] according to rules of inflection for Russian, to give the genitive word *vagon-a*. Each morpheme is assumed to have a single constant phonetically defined shape coming out of the morphology (there are a few exceptions such as the fact that the third-person-singular form of the verb *be* in English is [ɪz] and the first-person-singular form of that verb is [æm]). The phonetic realization of any morpheme is subject to rules of phonology, so while the morphology provides the plural morpheme *z* (spelled <s>), the application of phonological rules will make that that morpheme being pronounced as [s] as in *cats* or [ɨz] as in *bushes*.

It is very important to understand that the grammar does not formally derive one word from another. (Some languages seem to have special morphological processes, which we will not be discussing here, that derive one word from another – clipping such as *Sally* → *Sal* would be an example.) Rather, one word derives from a given abstract root plus whatever affixes are relevant, and a related word derives by adding a different set of affixes to the same abstract root. Accordingly, the plural of a noun in English does not derive from the singular, rather, both the singular *and* the plural forms derive from a common root: no suffix is added to the root in the singular, and the suffix /z/ is added to the root in the plural. The Russian genitive [vagona] also does not derive from the nominative, nor does the nominative derive from the genitive. Rather, both derive from the root /vagon/, where the nominative adds no affix and the genitive adds the affix *-a*.

The underlying form of a word is whatever comes out of the morphology and is fed into the phonology, before any phonological rules have applied. The underlying form of the word [kæts] is /kæt-z/, since that is what results in the morphology by applying the rule that combines a noun root such as *cat* with the plural suffix. The underlying form of the plural word [kæts] is *not* /kæt/, because the plural word has to have the plural morpheme. However, /kæt/ *is* the underlying form of the singular word [kæt]. There is no phonological rule which inserts *z* or *s* in order to form a plural. The principles for combining roots and affixes are not part of the phonology, and thus there is no need to include rules such as "insert [z] in the plural." Be explicit about what you assume about morphology in a language, i.e. that there is a plural suffix *-z* in English or a genitive suffix *-a*

in Russian. As for the mechanics of phonological analysis, you should assume, for example, that the plural suffix is already present in the underlying form, and therefore do not write a rule to insert the plural suffix since that rule is part of morphology. A phonological analysis states the underlying forms of morphemes, and describes changes in the phonological shape of the root or suffix.

We have concluded that the underlying form of the Russian word [prut] 'pond' is /prud/. In arriving at that conclusion, we saw how important it is to distinguish the phonological concept of an underlying form from the morphological concept "basic form," where the singular form, or an uninflected nominative form would be the morphological "basic form." An underlying form is a strictly phonological concept and is not necessarily equivalent to an actually pronounced word (even disregarding the fundamental fact that underlying forms are discrete symbolic representations whereas actually pronounced words are acoustic waveforms). It is a representation that is the foundation for explaining the variety of actual pronunciations found in the morpheme, as determined by phonological context.

The morphologically basic form of the Russian word for pond is the unmarked nominative, [prut], composed of just the root with no inflectional ending. In contrast, as we have seen, if we assume the underlying form is /prud/, for as we have seen, if we assume the underlying form to be */prut/, we cannot predict the genitive [pruda]. The word */[prud], with a voiced consonant at the end of the word, does not appear as such in the language, and thus the supposition that the underlying form is /prud/ is an abstraction, given that [prud] by itself is never found in the language – it must be inferred, in order to explain the actual data. The basis for that inference is the genitive form [pruda], which actually contains the hypothesized underlying form as a subpart. It is important to understand, however, that the underlying form of a root may not actually be directly attested in this way in any single word, and we will discuss this point in section 4.6.

4.3 Finding the underlying form

A similar problem arises in explaining the partitive and nominative forms of nouns in Finnish. The first step in understanding the phonological alternation seen here is to do a standard preliminary morphological analysis of the data, which involves identifying which parts of a word correlate with each aspect of word structure (such as root meaning or grammatical case). The following examples illustrate that the nominative singular suffix is Ø (i.e. there is no overt suffix in the nominative singular) and the partitive singular suffix is *-æ*, which alternates with *-a* if there is a back vowel somewhere before it in the word (we will not be concerned with that vowel alternation in the partitive suffix).

(6)	*Nominative sg*	*Partitive sg*	
a.	aamu	aamua	'morning'
	hopea	hopeaa	'silver'

katto	kattoa	'roof'
kello	kelloa	'clock'
kirya	kiryaa	'book'
külmæ	külmææ	'cold'
koulu	koulua	'school'
lintu	lintua	'bird'
hüllü	hüllüæ	'shelf'
kömpelö	kömpelöæ	'clumsy'
nækö	næköæ	'appearance'

b.

yoki	yokea	'river'
kivi	kiveæ	'stone'
muuri	muuria	'wall'
naapuri	naapuria	'neighbor'
nimi	nimeæ	'name'
kaappi	kaappia	'chest of drawers'
kaikki	kaikkea	'all'
kiirehti	kiirehtiæ	'hurry'
lehti	lehteæ	'leaf'
mæki	mækeæ	'hill'
ovi	ovea	'door'
posti	postia	'mail'
tukki	tukkia	'log'
æiti	æitiæ	'mother'
englanti	englantia	'England'
yærvi	yærveæ	'lake'
koski	koskea	'waterfall'
reki	rekeæ	'sledge'
væki	vækeæ	'people'

We might assume that the underlying form of the root is the same as the nominative (which has no suffix). The problem which these data pose is that in some nouns, the partitive appears to be simply the nominative plus the suffix -æ ~ -a (for example *muuri* ~ *muuria*), but for other nouns the final vowel alternates, with [i] in the nominative and [e] in the partitive (e.g. *yoki* ~ *yokea*). It is obvious that the nature of the following vowel does not explain this alternation, since the same surface-quality suffix vowel can appear after either *e* or *i* – compare *yokea, nimeæ* where [e] appears before both [a] and [æ], versus *muuria, kiirehtiæ* where [i] appears before these same vowels. Nor can the preceding consonant be called upon to predict what vowel will appear in the partitive, as shown by pairs such as *tukkia, kaikkea* versus *lehteæ, æitiæ.*

This is an area where there is (potentially) a difference between language-learning pedagogy and a formal linguistic analysis. Faced with the problem of learning the inflectional distinction *muuri* ~ *muuria* versus *yoki* ~ *yokea*, a second-language class on Finnish might simply have the student memorize a list of words like *yoki* ~ *yokea* where the vowel changes in the inflectional paradigm. From the point of view of linguistic analysis

this is the wrong way to look at the question, since it implies that this is not a rule-governed property of the language. However, second-language learning is not the same as linguistic analysis: a class in foreign-language instruction has a different goal from a class in analysis, and some students in a language class may receive greater practical benefit from just memorizing a list of words. Thus it is important to distinguish the teaching method where one learns arbitrary lists, and a theoretically based analysis. One simply cannot predict what vowel will appear in the partitive form if one only considers the pronunciation of the nominative. This means: nominative forms are not the same as underlying forms (something that we also know given the previous Russian example). The underlying representation must in some way contain that information which determines whether there will be a vowel alternation in a given word.

In looking for the phonological basis for this vowel alternation, it is important to realize that the alternation in stem-final vowels is not chaotic, for we find precisely two possibilities, either *i* in the nominative paired with *i* in the partitive, or *i* in the nominative paired with *e* in the partitive – never, for example, *i* paired with *u* or *i* paired with *o*. Moreover, only the vowel *i* enters into such a vowel alternation in Finnish, so there are no nouns with *o* in the nominative which is replaced by *u* in the partitive, nor is *u* in the nominative ever replaced by *o* or any other vowel in the partitive. One final fact about the data in (6) suggests exactly how the right underlying representations can explain this alternation: of the eight vowels of Finnish (*i, ü, e, ö, æ, u, o, a*), all of them appear at the end of the word except the vowel *e*. Now, since the stem of the word for 'name,' which appears as *nimi* in the nominative, actually appears on the surface as *nime-* in the partitive, it is not at all unreasonable to assume that the underlying form of the stem is in fact /nime/. It would be a bit bizarre to assume an underlying form such as /nima/, since the vowel [a] never appears in that position in any form of this word: the most natural assumption to make is that the underlying form of a morpheme is actually composed of segments found in some surface manifestation of the morpheme. On the other hand, the stem of the word for 'wall' is pronounced *muuri* in both the nominative and the partitive, and therefore there is no reason to assume that it is underlyingly anything other than /muuri/.

We will then assume that the underlying vowel at the end of the stem is actually reflected by the partitive form, and thus we would assume underlying representations such as /yoke/, /nime/, /kive/, /lehte/, /ove/ and so on, as well as /muuri/, /naapuri/, /kaappi/, /tukki/ and so on. The underlying form of partitive [yoke-a] would thus be /yoke-a/, that is, no rule at all is required to explain the partitive. Instead, a rule is needed to explain the surface form of the nominative [yoki], which derives from /yoke/. A very simple neutralizing rule can explain the surface form of the nominative: underlying word-final *e* is raised to *i*.

(7) *Final vowel raising*

e → i / _#

This rule is neutralizing since the distinction between /i/ and /e/ is neutralized by applying this rule: an underlying /e/ becomes phonetic [i].

Apart from illustrating how important correct underlying forms are, these two examples have also shown that it is dangerous, and incorrect in these two cases, to assume that the "most basic" form of a word according to morphological criteria is also the underlying form of the word. To reiterate: the underlying form of a morpheme is a hypothesis set forth by the analyst, a claim that by assuming such-and-such an underlying form, plus some simple set of rules (which need to be discovered by the analyst), the observed variation in the shape of morphemes can be explained.

Kerewe. To better understand the reasoning that leads to correct underlying forms, we investigate other examples. Consider the following data from Kerewe.

(8)

	Infinitive	1sg habitual	3sg habitual	Imperative	
	kupaamba	mpaamba	apaamba	paamba	'adorn'
	kupaaŋga	mpaaŋga	apaaŋga	paaŋga	'line up'
	kupima	mpima	apima	pima	'measure'
	kupuupa	mpuupa	apuupa	puupa	'be light'
	kupekeča	mpekeča	apekeča	pekeča	'make fire with stick'
	kupiinda	mpiinda	apiinda	piinda	'be bent'
	kuhiiga	mpiiga	ahiiga	hiiga	'hunt'
	kuheeka	mpeeka	aheeka	heeka	'carry'
	kuhaaŋga	mpaaŋga	ahaaŋga	haaŋga	'create'
	kuheeba	mpeeba	aheeba	heeba	'guide'
	kuhiima	mpiima	ahiima	hiima	'gasp'
	kuhuuha	mpuuha	ahuuha	huuha	'breath into'

We notice that every infinitive begins with *ku-*, which we surmise is the prefix for the infinitive; the third-singular habitual form has the prefix *a-*, and the first-singular habitual has the prefix *m-*; the imperative involves no prefix. In addition to segmental prefixes, there is a change in the first consonant of the stem in some verbs, in some contexts. The initial consonant of the verb meaning 'guide' alternates between [h] and [p], with [p] appearing in the first-singular habitual after [m] and [h] appearing elsewhere. Since this stem appears in two surface variants, [heeba] and [peeba], two plausible hypotheses are immediately possible: the stem is underlyingly /peeba/, or the stem is underlyingly /heeba/. If we assume that the stem is underlyingly /heeba/, we require a rule to explain the divergence between the predicted form of the first-singular habitual form – we would expect *[mheeba], *[mhiima], etc. – and the actual form of the verb, [mpeeba], [mpiima] and so on. Since in fact we do not see the sequence /mh/ anywhere in the data, we might assume the following neutralizing rule.

(9) *Postnasal hardening*

     h → p / nasal __

In this example we only have direct evidence for the change after m, so it would be possible to restrict our rule to the more specific context "after m." But this would run counter to basic assumptions of science, that we seek the most general explanations possible, not the most restricted ones.

If, on the other hand, we assume that the root is underlyingly /peeba/, we would need a rule which changes /p/ into [h] when not preceded by a nasal – in other words, when preceded by a vowel or by nothing. There is no single property which groups together word-initial position and vowels. Thus, the supposed rule changing /p/ to [h] would have to be a disjunction of two separate environments.

$$(10) \quad p \rightarrow h / \left\{ \begin{matrix} \# \\ V \end{matrix} \right\} \underline{\quad}$$

This suggests that rule (10) is wrong.

More important than the greater complexity of the rule entailed by assuming that the word for 'guide' is underlyingly /peeba/, it is empirically wrong: rule (10) implicitly claims that /p/ should always become [h] word initially or after a vowel, but this is falsified by forms such as *kupaamba, apaamba, paamba* 'adorn' and *kupaaŋga, apaaŋga, paaŋga* 'line up.' If we assume the stems uniformly begin with /p/, then we cannot predict whether the imperative or infinitive has [h] (*kuhaaŋga*) or [p] (*kupaaŋga*). On the other hand, if we assume an underlying contrast between initial /h/ and initial /p/ – i.e. *haaŋga* 'create', *paaŋga* 'arrange' – then we can correctly distinguish those stems which begin with /h/ from those which begin with /p/ when no nasal precedes, as well as correctly neutralizing that distinction just in case the stem is preceded by a nasal (*mpaaŋga* 'I create'; 'I arrange').

English plurals. A further illustration of how to determine the correct underlying representation comes from English. As the following examples illustrate, the surface form of the plural suffix varies between [s] and [z] (as well as [iz], to be discussed later).

(11)

kæps	caps	kæbz	cabs	klæmz	clams
kæts	cats	kædz	cads	kænz	cans
kaks	cocks	kagz	cogs	karz	cars
pruwfs	proofs	hʊvz	hooves	gəlz	gulls
		fliyz	fleas		
		plæwz	plows		
		pyrez	purees		

The generalization regarding distribution is straightforward: [s] appears after a voiceless segment, and [z] appears after a voiced one (be it an obstruent, a liquid, nasal or a vowel).

This same alternation can be found in the suffix marking the third singular present-tense form of verbs.

(12)

slæps	slaps	stæbz	stabs	slæmz	slams
hɪts	hits	haydz	hides	kænz	cans
powks	pokes	dɪgz	digs	hæŋz	hangs