WORD ROOTS AND BRANCHES

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Take a word, remove a letter, and rearrange the remaining letters to form another word; the shorter word is known as a transdeletion of the longer one. Conversely, the longer word is called a transaddition of the shorter. This process can be continued, and a chain of successive transdeletions or transadditions formed; let us define the roots of a word to be all those words that can be reached by successive transdeletions, and the branches of a word to be all those words that can be reached by successive transadditions. Naturally, the roots and branches depend upon the dictionary specified; the larger the dictionary, the more flourishing the word tree consisting of roots and branches combined.

Sometimes it is possible to form a word from another by merely removing or adding a letter; rearrangement of the remaining letters is not necessary. If an internal letter is removed, the new word has been formed by a deletion; if the first letter is removed this is a beheadment, and if the last letter is removed, a curtailment. The corresponding terms describing the addition of a letter to a word to form another word are insertion, hydration, and caudation.

If we form roots and branches both with and without letter-rearrangement, we have an enlarged word tree (with enlarged roots and branches).

Roots and branches can form a lush structure, with branchings and recombinations occurring. On the next page, the word tree for WORD is illustrated, using boldface words (or inferred forms, such as past tenses and plurals) from the Merriam-Webster Pocket Dictionary.

For convenience, the tree is shown on its side, with roots to the left and branches to the right of the word WORD, forming the trunk. Note that it is impossible to go below two-letter words without having beheadment or curtailment; we allow one-letter words as a special case.

There are many words containing the letters of WORD which are not in the tree; for example, TOWARD cannot be reached because there are no intermediate words using the letters OWARD or TWORD. Many seven-letter words are unreachable:

<table>
<thead>
<tr>
<th>forward</th>
<th>widower</th>
<th>working</th>
<th>dowager</th>
</tr>
</thead>
<tbody>
<tr>
<td>outward</td>
<td>windrow</td>
<td>workday</td>
<td>towards</td>
</tr>
<tr>
<td>doorway</td>
<td>warlord</td>
<td>worldly</td>
<td>roadway</td>
</tr>
<tr>
<td>worried</td>
<td>wording</td>
<td>bowlder</td>
<td>lowered</td>
</tr>
</tbody>
</table>
The enlarged word tree for WORD is considerably more complex; for example, two new main branches appear, one with WORLD and WORLDs and the other with SWORD, which furnishes a second connection to DROWSY. In addition, numerous inflected forms appear for the first time: POWDERS, POWDERY, DROWNS, CROWDS, CROWED, REDWOODS, ONWARDS, COWARDS, CROWED. But the most dramatic change occurs in the many new connecting branches that make the tree resemble a thicket.

Most trees of short words are, in fact, so dense that it is difficult to diagram them. Trees of long words are far thinner, and harder to construct. On the next page, I show the enlarged branches of SIDERATION, based on Webster's Second Edition. To make it a bit easier to follow, each added letter is underlined, and insertions/hydrations/caudations are parenthesized.

Note that the standard tree contains one branch which extends from SIDERATION to DICTATORIALNESS, a fifteen-letter word. It is not hard to find a root of SIDERATION which goes back to a one-letter word, so that I have exhibited a tree branch (not using insertions/hydrations/caudations) extending from a one-letter word to a fifteen-letter word.

Is it possible to find even longer branches -- or, equivalently, is it possible to find roots extending down to one-letter words for words of sixteen letters or more? This is an example of a logological investigation which is almost impossible to carry out by hand, but made much easier with the aid of a computer. In particular, I found it feasible to investigate only after receiving a computer printout of the Air Force list (most of the words in Webster's Second Edition) arranged in anagrammatic form by word length; I am much indebted to Thomas Kurtz of Dartmouth College for performing the anagrammatic sorting. (In a list arranged in anagrammatic form, the words are first written with their letters in alphabetic order, as CEORST for ESCORT, and these "words" then alphabetized.)
Enlarged Branches of SIDERATION
A nearly complete survey of seventeen-letter and sixteen-letter words in the Air Force list, omitting only those containing the rare letters FJKQVWXZ, revealed that no seventeen-letter words exist for which roots can be developed down to one letter with no deletions/beheadments/curtailments. However, since the Air Force list does not ordinarily contain inflected forms (plurals, past tenses, participles and the like), it is not clear from this survey that an enlarged root of this length cannot be found.

A similarly complete survey of sixteen-letter and fifteen-letter words proved too tedious to carry out, but it was possible to examine a substantial fraction of these: all words containing at most one of the letters BDGMY, at most two of the letters CHLNOPRSU, and at most three of AEIT. I succeeded in finding one sixteen-letter word with roots extending to one letter; two of the thousands of different roots are given below:

<table>
<thead>
<tr>
<th>representational</th>
<th>representational</th>
</tr>
</thead>
<tbody>
<tr>
<td>transperitoneal</td>
<td>transperitoneal</td>
</tr>
<tr>
<td>presentational</td>
<td>pretranslation</td>
</tr>
<tr>
<td>septentrional</td>
<td>planirostrate</td>
</tr>
<tr>
<td>steprelation</td>
<td>Leptinotarsa</td>
</tr>
<tr>
<td>interseptal</td>
<td>aeroplanist</td>
</tr>
<tr>
<td>eternalist</td>
<td>senatorial</td>
</tr>
<tr>
<td>reinstation</td>
<td>rationale</td>
</tr>
<tr>
<td>interest</td>
<td>oriental</td>
</tr>
<tr>
<td>entries</td>
<td>latrine</td>
</tr>
<tr>
<td>insert</td>
<td>rental</td>
</tr>
<tr>
<td>reins</td>
<td>later</td>
</tr>
<tr>
<td>rise</td>
<td>rate</td>
</tr>
<tr>
<td>sir</td>
<td>tar</td>
</tr>
<tr>
<td>is</td>
<td>at</td>
</tr>
<tr>
<td>I</td>
<td>a</td>
</tr>
</tbody>
</table>

A full diagram of the upper root of REPRESENTATIONAL is given on the next page; to avoid complexities, all deletions/curtailments/beheadments have been left out. At the ten-letter level, the root includes the isogram (no repeated letters) INTERPOSAL, and the four-way transposal ALPESTRINE/EPISTERNAL/INTERLAPSE/PRESENTIAL.

In searching for my roots, I was able to estimate the probabilities that a seventeen-letter word can be transdeleted to a sixteen-letter one, and a sixteen-letter word to a fifteen-letter one, in the Air Force list:

\[
\text{Prob (17 to 16)} = \frac{15}{1235} = 0.012 \\
\text{Prob (16 to 15)} = \frac{23}{533} = 0.043
\]

The corresponding probabilities for shorter transdeletions are not known precisely, but they increase rapidly; I estimate that Prob (15 to 14) = 0.1, Prob (14 to 13) = 0.25, Prob (13 to 12) = 0.5, and Prob (12 to 11) = 0.8. Multiplying these together, the probability of a seventeen-letter word having roots down to one letter is quite small -- only 0.000005. However, there may, perhaps, be another sixteen-letter
word besides REPRESENTATIONAL awaiting discovery in Webster's Second, for the corresponding probability increases to 0.0004, and there are 3374 sixteen-letter solid Websterian words in the Air Force list (however, the transdeletion probability is likely much less than 0.0004 for words containing rare letters or excessive repetition of common letters). If the word stock is enlarged by allowing inferred forms, plus words from Webster's Third, the OED, the Random House Dictionary, Funk & Wagnalls, and the like, all these transdeletion probabilities are increased.

One seventeen-letter word in the Air Force list was transdeleted twice: ANTICEREMONIALIST to NONMATERIALISTIC to RECITATIONALISM. No fourteen-letter transdeletion of RECITATIONALISM could be found, but three thirteen-letter double transdeletions were located: MATERIALISTIC (lacking n, o), ANTIREALISTIC (lacking m, o) and REMASTICATION (lacking i, l). Jeff Grant of Hastings, New Zealand searched the OED for a fourteen-letter transdeletion without success, but suggested the plausible coinage RECLAMATIONIST which in turn transdeletes to REMASTICATION. The Oxford University Press did not have any citations for RECLAMATIONIST in its file, but the G. & C. Merriam Company did: an article entitled "What You Can Believe About MVA" by Wesley Price in the January 19 1946 issue of the Saturday Evening Post used the word twice.

Trouble was, the Army didn't want its plan modified by reclamationists so putting irrigation first, navigation last, in use of water arising west of the 98th meridian.

In the article, "reclamationists" were members of the Reclamation Bureau, various upper Missouri Valley leaders and members of the National Reclamation Association, all opposing a river modification plan sponsored by the Army Corps of Engineers. If RECLAMATIONIST is admitted as a word, even though it has not appeared in any dictionary, the seventeen-letter ANTICEREMONIALIST can be successively transdeleted down to a single letter, as demonstrated above.

Since seventeen-letter transdeletions are quite rare, it is worth listing the other fourteen I found:

chorographically - chronographically
anopisthographic - anthropophagistic *
admonistrational - maladministration
interpenetration - preterintentional *
intermediateness - indeterminateness

microphotonuclear
ultracountermeasuring
electrooptical
contraceptible
uncreditable
reconcilable
biopsychological
biophysiological

Several of these probably the most likely to transdeletion

electrometric
psychothermal
palaeoedodentary

As word entailments to scientific terms, if the seventeen-letter word for this reason, can be reduced down to a oneteen-letter word, the root of PAL.
Several of these are only slightly rearranged; the asterisked ones are probably the most interesting. There are a handful of eighteen-letter transdeletions, but none are particularly noteworthy:

- microphotography - chromatotypographic *
- countermigration - trigonometrical *
- ultraceremonious - peritoneomuscular *
- electrooptically - photoelectromuscular
- contraceptionist - antistreptococcin *
- uncredibleness - unpredictableness
- reconciliability - irreconciliability
- biopsychological - physicobiological

As words become longer, the ratio of deletions/beheadments/curtailments to transdeletions rises rapidly in the Air Force list; many scientific terms have slightly variant spellings. For example, for seventeen-letter words the ratio is $72/15 = 4.8$, not counting plurals; for this reason, there is some hope that an enlarged root stretching down to an eighteen-letter word can be found for an eighteen-letter or nineteen-letter word. A near-miss is provided by the following enlarged root of PALAEONTOGRAPHICAL:

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palaeontographical
palaeontographical
paleoanthropic paleontographic
paleoanthropic paleaeanthropic
paleoanthropic
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Two similar enlarged roots based on the same prefix are:

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palaeoethnologists
palaeoethnologist
paleoethnologist paleothnologist
paleoethnologist paleoethnologist
paleoethnologic paleoethnological
paleoethnologic paleothnologist
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Finally, a short but complex root based on the nineteen-letter word PHYSICOTHERAPEUTICS:

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physiotherapeutics physicotherapeutic psychotherapeutics physiotherapeutic physiotherapeutic
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In Webster's New International Dictionary, 1946 edition, the Air Force list was less than the National Reclamation Bureau, with 17- and 18-letter words being inferred. Random transdeletions were inferred in the Air Force list, but none were particularly noteworthy:

- electrometrically - thermoelectrically
- psychotherapeutic - physicotherapeutic
- palaeodendrologic - paleodendrological

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palaeontographic
paleoanthropic
palaeothnologist
paleoethnologic
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