

A Lyndon word is a word lexicographically smaller than all of its proper right factors; see <http://katlas.math.toronto.edu/drorbn/bbs/show?shot=Chu-071214-182203.jpg>

```
LyndonQ[w_String] := And @@ (
  OrderedQ[{w, #}] & /@ Table[StringDrop[w, i], {i, 1, StringLength[w] - 1}]
);
AllWords[0, _List] = {" "};
AllWords[n_ /; n > 0, ab_List] := AllWords[n, ab] = Flatten[Outer[
  StringJoin[#1, #2] &,
  AllWords[n - 1, ab],
  ab
]];
AllLyndonWords[n_, ab_List] := Select[AllWords[n, ab], LyndonQ]

LyndonQ["abba"]
False

LyndonQ["ababb"]
True

AllWords[1, {"1", "2"}]
{1, 2}

AllWords[3, {"1", "2"}]
{111, 112, 121, 122, 211, 212, 221, 222}

AllLyndonWords[3, {"1", "2"}]
{112, 122}

Table[Length[AllLyndonWords[k, {"1", "2"}]], {k, 10}]
{2, 1, 2, 3, 6, 9, 18, 30, 56, 99}

Table[Length[AllLyndonWords[k, {"1", "2", "3"}]], {k, 8}]
{3, 3, 8, 18, 48, 116, 312, 810}

LyndonToLie[w_String /; StringLength[w] == 1] := w;
LyndonToLie[w_String /; StringLength[w] > 1] := Module[
  {rf},
  rf = First[Sort[Table[StringDrop[w, i], {i, 1, StringLength[w] - 1}]]];
  LyndonToLie /@ b[StringDrop[w, -StringLength[rf]], rf]
]
```

```
LyndonToLie["12122"] // TreeForm
```

