**Exercise 10.1.** Consider the following program $P$:

\[
T(x) \leftarrow e(x)
\]
\[
T(x) \leftarrow a(x, y) \land T(y) \land b(x, z) \land T(z)
\]

1. Describe, in your own words, the kind of structures that the query $\langle T, P \rangle$ recognises.

2. Compute the semi-naive evaluation of $P$ for the database that contains the following facts:

\[
e(1) \quad e(2) \quad e(6) \quad a(3, 1) \quad a(4, 3) \quad a(5, 3) \quad a(7, 5) \quad b(3, 2) \quad b(5, 3) \quad b(7, 6)
\]

Specify for each newly derived fact which of the rule(s) of (b) will produce it at the given point in the derivation.

**Exercise 10.2.** Consider the “Same generation” Datalog program given in the lecture (predicates: $S$ for “same generation”, $p$ for “parent”, $h$ for “human”):

\[
S(x, x) \leftarrow h(x)
\]
\[
S(x, y) \leftarrow p(x, w) \land S(v, w) \land p(y, v)
\]

and the adorned version for query $S(1, x)$:

(Rule $a$) \quad Query^I(x) \leftarrow S^{bf}(1, x)

(Rule $b$) \quad S^{bf}(x, x) \leftarrow h(x)

(Rule $c$) \quad S^{bf}(x, y) \leftarrow p(x, w) \land S^{fb}(v, w) \land p(y, v)

(Rule $d$) \quad S^{fb}(x, x) \leftarrow h(x)

(Rule $e$) \quad S^{fb}(x, y) \leftarrow p(x, w) \land S^{fb}(v, w) \land p(y, v)

Together with the database that contains the following facts for predicate $p$:

\[
h(1) \quad h(2) \quad h(3) \quad h(4) \quad h(5) \quad h(6) \quad h(7)\]
\[
p(1, 2) \quad p(2, 3) \quad p(4, 3) \quad p(5, 4) \quad p(6, 1) \quad p(7, 1).
\]

Sketch the database as a tree. What are the expected answers to the query? Apply the QSQR algorithm to compute the answer to the query.

**Exercise 10.3.** Consider the following modified version of the same generation program:

\[
S(x, x) \leftarrow h(x)
\]
\[
S(x, y) \leftarrow p(x, w) \land p(y, v) \land S(v, w)
\]

What is the adorned version of this program for query $S(1, x)$? Use this program to show that it is possible that some tuples in an input-relation are not copied to the $\sup_0$ relation of a rule during the execution of the QSQR algorithm.

**Exercise 10.4.** (Abiteboul, Hull and Vianu; Exercise 13.14)

Consider the following program:

\[
Sv(x, y) \leftarrow \text{flat}(x, y)
\]
\[
Sv(x, y) \leftarrow \text{up}(x, z_1) \land Sv(z_1, z_2) \land \text{flat}(z_2, z_3) \land Sv(z_3, z_4) \land \text{down}(z_4, y)
\]

Give the magic set transformation for this program and query $Sv(a, y)$, where $a$ is a constant.