function POLYTREE-ASK(X, E) **returns** $\mathbf{P}(X|E)$, a distribution over X given evidence E
inputs: X, a random variable
E, a set of random variables with known values

SUPPORT-EXCEPT($X, \{\}, E$)

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function SUPPORT-EXCEPT(X, V, E) **returns** $\mathbf{P}(X|E_{X \setminus V})$, a distribution over X given all evidence except that reachable via V

if $X \in E$ **then return** observed point distribution for X
else
calculate $\mathbf{P}(E^{-}_{X \setminus V}|X)$ = EVIDENCE-EXCEPT(X, V, E)
$\mathbf{U} \leftarrow$ PARENTS[X]
if U is empty **then return** NORMALIZE($\mathbf{P}(E^{-}_{X \setminus V}|X)\ \mathbf{P}(X)$)
else
for each U_i **in** U
calculate and store $\mathbf{P}(U_i|E_{U_i \setminus X})$ = SUPPORT-EXCEPT($U_i, \{X\}, E$)
return NORMALIZE$\left(\mathbf{P}(E^{-}_{X \setminus V}|X) \sum_{\mathbf{u}} \mathbf{P}(X|\mathbf{u}) \prod_i \mathbf{P}(U_i|E_{u_i \setminus X}) \right)$

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function EVIDENCE-EXCEPT(X, V, E) **returns** $\mathbf{P}(E^{-}_{X \setminus V}|X)$, probability of downstream evidence (except evidence reachable via V) for each value of X

$\mathbf{Y} \leftarrow$ CHILDREN[X] $-\ V$
if Y is empty **then return** a vector of 1s */* No downstream evidence—true for all X! */*
else
for each Y_i **in Y do**
if $Y_i \notin E$ **then** calculate $\mathbf{P}(E^{-}_{Y_i}|Y_i)$ = EVIDENCE-EXCEPT($Y_i, \{\}, E$)
$\mathbf{Z}_i \leftarrow$ PARENTS[Y_i] $- X - E$; $\mathbf{Z}'_i \leftarrow$ (PARENTS[Y_i] $- X) \cap E$
for each Z_{ij} **in** $\mathbf{Z}_i$
calculate $\mathbf{P}(Z_{ij}|E_{Z_{ij} \setminus Y_i})$ = SUPPORT-EXCEPT($Z_{ij}, \{Y_i\}, E$)
return $\prod_i \Big[$ **if** $Y_i \in E$ **then** $\sum_{\mathbf{z}_i} \mathbf{P}(y_i|X, \mathbf{z}_i, \mathbf{z}'_i) \prod_j P(z_{ij}|E_{Z_{ij} \setminus Y_i})$
else $\sum_{y_i} P(E^{-}_{Y_i}|y_i) \sum_{\mathbf{z}_i} \mathbf{P}(y_i|X, \mathbf{z}_i, \mathbf{z}'_i) \prod_j P(z_{ij}|E_{Z_{ij} \setminus Y_i}) \Big]$

Figure 15.8 A backward-chaining algorithm for solving probabilistic queries on a polytree. Notice the special treatment of evidence; in EVIDENCE-EXCEPT, when Y_i and $\mathbf{Z}'_i$ are evidence variables, we use y_i and $\mathbf{z}'_i$ respectively to denote their observed values. The probabilities $\mathbf{P}(X|\mathbf{u})$ in SUPPORT-EXCEPT and $\mathbf{P}(y_i|X, \mathbf{z}_i, \mathbf{z}'_i)$ in EVIDENCE-EXCEPT are available from the CPTs for X and Y_i respectively.