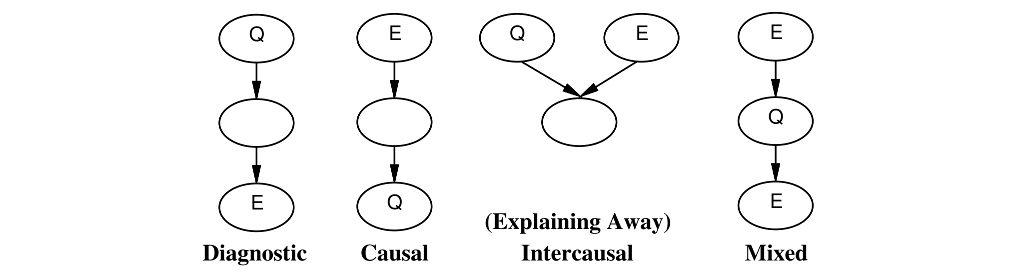

Figure 15.6 Simple examples of four patterns of reasoning that can be handled by belief networks. E represents an evidence variable and Q is a query variable.

POLYTREES

networks, also known as **polytrees**. In such networks, there is at most one undirected path between any two nodes in the network. Algorithms for general networks (Section 15.4) will use the polytree algorithms as their main subroutine.

Figure 15.7 shows a generic singly connected network. Node X has parents $\mathbf{U} = U_1 \ldots U_m$, and children $\mathbf{Y} = Y_1 \ldots Y_n$. For each child and parent we have drawn a box that contains all the node's descendants and ancestors (except for X). The singly connected property means that all the boxes are disjoint and have no links connecting them. We are assuming that X is the query variable, and that there is some set of evidence variables E. The aim is to compute $\mathbf{P}(X|E)$. (Obviously, if X is itself an evidence variable in E, then calculating $\mathbf{P}(X|E)$ is trivial. We will assume that X is not in E.)

In order to derive the algorithm, it will be helpful to be able to refer to different portions of the total evidence. The first distinction we will need is the following:

CAUSAL SUPPORT

E_X^+ is the the **causal support** for X—the evidence variables "above" X that are connected to X through its parents.

EVIDENTIAL SUPPORT

E_X^- is the **evidential support** for X—the evidence variables "below" X that are connected to X through its children.

Sometimes we will need to exclude certain paths when considering evidence connected to a certain variable. For example, we will use $E_{U_i \backslash X}$ to refer to all the evidence connected to node U_i *except* via the path from X. Similarly, $E^+_{Y_i \backslash X}$ means all the evidence connected to Y_i through its parents *except* for X. Notice that the total evidence E can be written as E_X (all the evidence connected to X) and as $E_{X\backslash}$ (all the evidence connected to X with no exceptions).

Now we are ready to compute $\mathbf{P}(X|E)$. The general strategy is roughly the following:

- Express $\mathbf{P}(X|E)$ in terms of the contributions of E_X^+ and E_X^-.
- Compute the contribution of E_X^+ by computing its effect on the parents of X, and then passing that effect on to X. Notice that computing the effect on each parent of X is a recursive instance of the problem of computing the effect on X.
- Compute the contribution of E_X^- by computing its effect on the children of X, and then passing that effect on to X. Notice that computing the effect on each child of X is a recursive instance of the problem of computing the effect on X.