b. To say that a pit causes all adjacent squares to be breezy:

$$\forall s \;\; Pit(s) \;\Rightarrow\; [\forall r \;\; Adjacent(r,s) \;\Rightarrow\; Breezy(r)]\;.$$

This axiom allows for breezes to occur spontaneously with no adjacent pits. It would be incorrect to say that a non-pit causes all adjacent squares to be non-breezy, since there might be pits in other squares causing one of the adjacent squares to be breezy. But if *all* adjacent squares have no pits, a square is non-breezy:

$$\forall s \;\; [\forall r \;\; Adjacent(r,s) \;\Rightarrow\; \neg Pit(r)] \;\Rightarrow\; \neg Breezy(s)\;.$$

8.14 Make sure you write definitions with $\Leftrightarrow$. If you use $\Rightarrow$, you are only imposing constraints, not writing a real definition. Note that for aunts and uncles, we include the relations whom the OED says are more strictly defined as aunts-in-law and uncles-in-law, since the latter terms are not in common use.

$$\begin{array}{l}
Grandchild(c,a) \;\Leftrightarrow\; \exists\, b \;\; Child(c,b) \wedge Child(b,a)\\
Greatgrandparent(a,d) \;\Leftrightarrow\; \exists\, b,c \;\; Child(d,c) \wedge Child(c,b) \wedge Child(b,a)\\
Ancestor(a,x) \;\Leftrightarrow\; Child(x,a) \vee \exists\, b \;\; Child(b,a) \wedge Ancestor(b,x)\\
Brother(x,y) \;\Leftrightarrow\; Male(x) \wedge Sibling(x,y)\\
Sister(x,y) \;\Leftrightarrow\; Female(x) \wedge Sibling(x,y)\\
Daughter(d,p) \;\Leftrightarrow\; Female(d) \wedge Child(d,p)\\
Son(s,p) \;\Leftrightarrow\; Male(s) \wedge Child(s,p)\\
FirstCousin(c,d) \;\Leftrightarrow\; \exists\, p_1,p_2 \;\; Child(c,p_1) \wedge Child(d,p_2) \wedge Sibling(p_1,p_2)\\
BrotherInLaw(b,x) \;\Leftrightarrow\; \exists\, m \;\; Spouse(x,m) \wedge Brother(b,m)\\
SisterInLaw(s,x) \;\Leftrightarrow\; \exists\, m \;\; Spouse(x,m) \wedge Sister(s,m)\\
Aunt(a,c) \;\Leftrightarrow\; \exists\, p \;\; Child(c,p) \wedge [Sister(a,p) \vee SisterInLaw(a,p)]\\
Uncle(u,c) \;\Leftrightarrow\; \exists\, p \;\; Child(c,p) \wedge [Brother(a,p) \vee BrotherInLaw(a,p)]
\end{array}$$

There are several equivalent ways to define an mth cousin n times removed. One way is to look at the distance of each person to the nearest common ancestor. Define $Distance(c,a)$ as follows:

$$\begin{array}{l}
Distance(c,c) = 0\\
Child(c,b) \wedge Distance(b,a) = k \;\Rightarrow\; Distance(c,a) = k+1\;.
\end{array}$$

Thus, the distance to one's grandparent is 2, great-great-grandparent is 4, and so on. Now we have

$$\begin{array}{l}
MthCousinNTimesRemoved(c,d,m,n) \;\Leftrightarrow\\
\qquad \exists\, a \;\; Distance(c,a) = m+1 \wedge Distance(d,a) = m+n+1\;.
\end{array}$$

The facts in the family tree are simple: each arrow represents two instances of $Child$ (e.g., $Child(William, Diana)$ and $Child(William, Charles)$), each name represents a sex proposition (e.g., $Male(William)$ or $Female(Diana)$), each "bowtie" symbol indicates a $Spouse$ proposition (e.g., $Spouse(Charles, Diana)$). Making the queries of the logical reasoning system is just a way of debugging the definitions.

8.15 Although these axioms are sufficient to prove set membership when x is in fact a member of a given set, they have nothing to say about cases where x is not a member. For