IV. $\forall x(\text{love}(\text{Mary},x) \rightarrow \text{happy}(x))$ vs. Everyone who Mary loves is happy.

(a)

```
                    Form, R7, S7
        ∀x(love(Mary,x) → happy(x))
              q            p
        Basic, SA       Form, R5, S5
        x               (love(Mary,x) → happy(x))
                                 e        i
                    Form, R1, S1            Form, R1, S1
                    love(Mary,x)            happy(x)
                          9                      2
                Bas., SB Bas., SB Bas., SA   Bas., SB  Bas., SA
                    love Mary   x            happy      x
```

(b) Annotate each line by identifying the semantic rule that was applied anywhere within that line (show where), and the node of the tree to which it corresponds.

Semantic derivation of truth conditions:

1. $\| \forall x(\text{love}(\text{Mary},x) \rightarrow \text{happy}(x)) \|^{M1,g} = 1$ iff for each d in D, $\| \text{love}(\text{Mary},x) \rightarrow \text{happy}(x) \|^{M1,g[d/x]} = 1$. (**S7; R7**)
2. That will hold iff for each d in D, $\| \text{love}(\text{Mary},x) \|^{M1,g[d/x]} = 0$ or $\| \text{happy}(x) \|^{M1,g[d/x]} = 1$. (**?; Is this step really necessary? It's simply an application of the equivalence law for conditionals, but it doesn't appear anywhere in the syntactic composition.**)
3. That will hold iff for each d in D, if $<\| \text{Mary} \|^{M1,g[d/x]}, \| x \|^{M1,g[d/x]}> \in \| \text{love} \|^{M1,g[d/x]}$, then $\| x \|^{M1,g[d/x]} \in \| \text{happy} \|^{M1,g[d/x]}$. (**S5; R5**)
4. And that will hold iff for each d in D, if $<\| \text{Mary} \|^{M1,g[d/x]}, d> \in \| \text{love} \|^{M1,g[d/x]}$, then $d \in \| \text{happy} \|^{M1,g[d/x]}$. (**S1; R1**)
5. I.e., if $<I(\text{Mary}),d> \in I(\text{love})$, then $d \in I(\text{happy})$. (**Rules A and B**)