I.

a) & b) One way to solve this problem is to work out the genotypes of the individuals in the pedigree.

\[
\frac{A +}{B +} \quad \frac{O -}{O -} \\
\text{(the only possibility)}
\]

\[
\frac{B +}{O -} \\
\text{(the only possibility)}
\]

\[
\frac{A -}{B +} \quad \frac{O -}{O -} \\
\text{(the only possibility)}
\]

\[
\frac{A -}{O +} \\
\text{(the only possibility)}
\]

\[
\frac{A -}{O -} \\
\text{(the only possibilities)}
\]

\[
\frac{A -}{B +} \quad \frac{B +}{A -} \quad \frac{O -}{O -} \\
\text{(the only possibilities)}
\]

\[
\frac{A -}{B +} \quad \frac{B +}{A -} \quad \frac{O -}{O -} \\
\text{(the only possibilities)}
\]

c) Individual 3 received an \( O - \) chromosome from dad and the \( B + \) chromosome from mom.

d) To have type B blood, the child must have gotten an \( O - \) chromosome from mom and a \( B + \) chromosome from dad.

The recombination frequency (RF) gives the probability of crossover (genetic exchange) between two genes. In the case of individual (3), he can produce 4 types of gametes:

\[
\cdot \frac{B -}{O +} \quad \text{recombinant} \quad \cdot \frac{B +}{O -} \quad \text{parental}
\]

In order to be diseased and \( B \), recombination must have occurred and since the recombination frequency is 11% (see first paragraph), the chance of being \( B \) and diseased is 11%.
II.

a) What are the genotypes of Phil and Ryan with respect to these two genes. Use the letter E for ear wiggling and the letter R for tongue rolling.

<table>
<thead>
<tr>
<th></th>
<th>Phil</th>
<th>Ryan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$E +$</td>
<td>$+ +$</td>
</tr>
<tr>
<td></td>
<td>$+ R$</td>
<td>$+ +$</td>
</tr>
</tbody>
</table>

b) How do you account for the fact that Ryan is unable to roll his tongue or wiggle his ears?

*During meiosis in Phil, there was recombination between the chromosome carrying the ability to wiggle gene and the one carrying the ability to roll gene.*

\[
\begin{array}{c}
E + \\
+ R
\end{array} \rightarrow \begin{array}{c}
E R \\
+ +
\end{array}
\]

*Ryan received the wildtype chromosome from his mother and the recombined completely wildtype chromosome from his father.*