1. Since a_1 has only one slot available, we can partition the entire subset of possible combinations into those with a_1 and those with out it. Where a_1 is not chosen, you have (k-1) baskets thus (k-2) sticks and r crosses. So it would be $\binom{(k-1)-r-1}{r}$ which equals $\binom{k-r-2}{r}$. Then we have to find the number of ways in which we use a_1. In this case, we place 1 cross in the a_1 basket. Now we again have (k-1) baskets to choose from, but now we only have (r-1) crosses. So we are left with combination of $\binom{k+r-3}{r-1}$
   Thus the answer $\binom{k+r-3}{r-1} + \binom{k-r-2}{r}$

2. the mistake is to assume that $x - 3$ is divisible by 3 simply because $x - 3 < x$. This is not logical. We already assumed that x is a counterexample therefore it is not divisible by 3. But then we arrive at the conclusion that $x - 3$ IS divisible by 3, from the simple fact that $x - 3 < x$. This is the mistake.

3. To prove by contradiction, we will assume that $\sqrt{a}$ is rational. Therefore we can write it as $\sqrt{a} = \frac{p}{q}$ such that $p, q \in \mathbb{Z}$, $q \neq 0$, and p, q are relatively prime.
   by squaring both sides we get $a = \frac{p^2}{q^2}$
   $p^2 = a * q^2$ and since we know that $a = 2c^2$ then, $p^2 = 2c^2q^2$
   According to the fundamental law of arithematic,
   $S(p^2) = 2S(p)$ therefore $S(p^2)$ is even
   but we also know that $p^2 = 2c^2q^2$ so $S(p^2) = S(2c^2q^2)$
   According to the fundamental Law of arithametic,
   $S(2c^2q^2) = 1 + 2S(q) + 2S(p)$=2(S(c)+S(q))+1
   thus $S(p^2)$ is now odd which contradicts our statement that it is even. Thus proving that $\sqrt{a}$ must be irrational.