$\boxed{\cancel{X} \text{ is } Rh^-}$ ~~Rh Rh~~ (1)

$rh^- \; rh$

Rh ~~Rh~~ rh
4

rh rh

x^2

$$\frac{1}{f}\left(\frac{1}{2}x\right)^2$$

$$xN + yN = 2N$$

$$2\,\frac{N}{2}\left(\frac{x}{2}\right)^2 \frac{1}{f} \times$$ ~~loss~~ ~~cost for having~~ Number of 1 Rh and 1 rh lost.

$$\frac{N}{2}\left(\frac{y}{2}\right)^2$$

$$= 2\,\frac{N^2 x^2 y^2}{64}\,\frac{1}{f}$$ is number of each type lost per generation from Rh Rh fathers $= \delta$

$$2\,\frac{N}{2}\left(\frac{x}{2}\right)^2 \frac{1}{f} \times \cancel{2}\,\frac{N}{2}\,\frac{y}{2}\,\frac{x}{2} \times \cancel{\frac{1}{2}} =$$

$$= 2\,\frac{N^2}{64}\,x^3 y\,\frac{1}{f}$$

$$\text{Total} = \frac{N^2}{32}\,\frac{1}{f}\left\{(x^2y^2) + x^3 y\right\} = \delta$$

$$\Delta \frac{x}{x+y} = \frac{\Delta x(x+y) - x(\Delta x + \Delta y)}{(x+y)^2} = \frac{1}{4}\,\frac{2\Delta x - x\Delta x - x\Delta y}{2}$$

$$\Delta \frac{xN}{xN + yN}$$ let $\Delta x = \Delta y = \delta$

$2\delta(1-x)$

$$\boxed{\Delta \frac{x}{x+y} = 2\delta(1-x)}$$

$$\Delta \frac{y}{x+y} = \frac{\Delta y(x+y) - y(\Delta x+\Delta y)}{(x+y)^2}$$

$$= 2\delta - y\,2\delta$$

$$= 2\delta(1-y)$$ Bad!

for small y (Rh^+) selection against is stronger! —

Mutation

(2)

$$dx = \lambda y N$$

$$4\frac{x}{x+y} = \frac{1}{4}\; 2\lambda y - \cancel{xxy} + \cancel{xxy} = \frac{1}{2}\lambda y$$

$$\boxed{\frac{1}{2}\lambda y N = 2\delta(1-x)}$$

~~small~~ $\cancel{x}$, $\cancel{y \approx 2}$

$$\delta = \frac{N^2}{32}\frac{1}{f}\left\{x^2 y^2 + x^3 y\right\}$$

---

small x; $y = 2$

$$N\lambda = 2\delta = 2\,\frac{N^2}{32}\frac{1}{f}\,x^2\,4 = \frac{N}{4}\frac{1}{f}\,x^2$$

$$\cancel{x = \sqrt{\lambda}}$$

$$\boxed{\sqrt{4\lambda f} = x}$$

$\cancel{10^{-5}}$ 100

$\cancel{4 \cdot 10^{-3}}$

$\lambda = 10^{-4}$; $x = 20\%$

$$\frac{1}{2}\lambda\cancel{(2-x)} = \frac{1}{f}\frac{2}{32}(1-x)\left\{x^2(2-x)^2 + x^3(2-x)\right\}$$

$$\cancel{\tfrac{1}{2}}\lambda = (1-x)\left\{x^2(2-x) + x^3\right\}\cancel{\frac{1}{16}}\,\frac{1}{f}\,\frac{1}{8}$$

for $x = 0.2$

$$\lambda = 0.8\left\{\frac{4}{100}(1.8) + \frac{8}{1000}\right\}\frac{1}{f}\frac{1}{8}$$

$$\lambda \approx 10^{-4}$$

$$dx = \lambda y - kx \qquad \text{Mutarotation} \qquad 3$$

$$\Delta \frac{x}{x+y} = \frac{1}{4}\left(2\,\Delta x - x\,\Delta x - x\,\Delta y\right)$$

$$= \frac{1}{4}\left(2\lambda y - 2kx\right) \cancel{\lambda x y + k x^2 \pm x \Delta x}$$

$$= \frac{1}{2}(\lambda y - kx)$$

$$\boxed{\frac{1}{2}(\lambda y - kx) = 2\delta(1-x)}$$

$$\cancel{\tfrac{1}{2}}\{\lambda(2-x) - kx\} = 4\delta(1-x)$$

$$\cancel{\lambda} - \frac{x(\lambda + k)}{2} = 2\delta(1-x)$$

√ √

~~dx~~

$$\lambda = 2\times 2\,\delta(1-x) + kx$$

$$\boxed{\lambda = \cancel{4}\times 2\delta\frac{(2-2x)}{2-x} + \frac{kx}{(2-x)}}$$

$$\boxed{k = 2\times 2\,\delta\frac{(x-1)}{x} + \frac{\lambda y}{x}}$$

$$\delta = \frac{1}{32}\frac{1}{f}\left\{x^2 y^2 + x^3 y\right\}$$

for $\boxed{y = 0.2}$

$$k \approx \frac{1}{8}\frac{1}{f}\left\{(1.8)^2\frac{4}{100} + (1.8)^3\frac{2}{10}\right\} + \frac{\lambda y}{x}$$

$$k \approx \frac{1.5}{800}$$

for $y = \frac{2}{100}$

$$k = \frac{1}{8}\frac{1}{f}\left(4\,\text{m} + 8\,\frac{2}{100}\right) \approx 2\,10^{-4}$$

$y = \frac{1}{100}$

$$k \approx 10^{-4}$$