# Chain Rule

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$f(x) = \frac{1}{1+e^{-x}}$ $\quad \frac{df}{dx} = ??$

$f(q) = \frac{1}{q} \rightarrow (II)$

Let take $p = -x \Rightarrow \frac{dp}{dx} = -1$

$\Rightarrow 1+e^{x} = 1+e^{p}$

Let's take $q = 1+e^{p} =$

$= \frac{dq}{dp} = 0+e^{p} = e^{p}$

$\Rightarrow f(x) \Rightarrow f(q(p(x)))$

$\frac{df}{dq} = -1/q^2 \rightarrow (I) \quad \frac{dq}{dp} = e^{p} \rightarrow (II) \quad \frac{dp}{dx} = -1 \rightarrow (III)$

$\frac{df}{dx} = \frac{df}{dq} \cdot \frac{dq}{dp} \cdot \frac{dp}{dx} \rightarrow (IV)$

$= -1/q^2 \cdot e^{p} \cdot -1 \Rightarrow \frac{-1}{(1+e^{p})^2} \cdot e^{p} \cdot (-1) = \frac{e^{p}}{(1+e^{p})^2} = \frac{e^{-x}}{(1+e^{-x})^2}$

$= \frac{1+e^{x}-1}{(1+e^{-x})^2} \Rightarrow \frac{1+e^{x}}{(1+e^{-x})^2} - \frac{1}{(1+e^{-x})^2}$

$= \frac{1}{(1+e^{-x})} - \frac{1}{(1+e^{-x})^2}$

$= \frac{1}{(1+e^{-x})}\left(1 - \frac{1}{(1+e^{-x})}\right)$

$$\boxed{\frac{df}{dx} = f(x)(1-f(x))} \rightarrow (I)$$

$$\tanh = \frac{e^{z} - }{e^{z} + e^{-z}}$$

$$\boxed{d\tanh = 1 - q^2} \rightarrow (I)$$