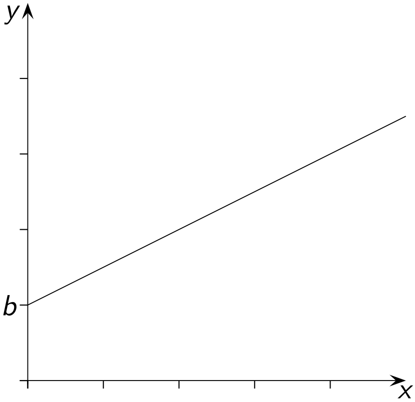
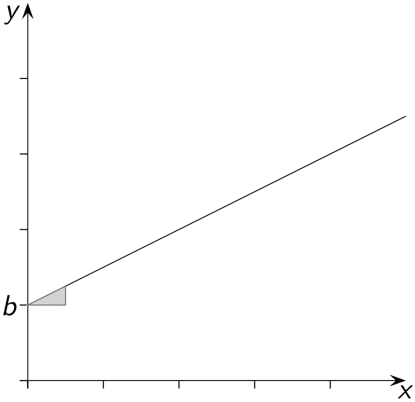
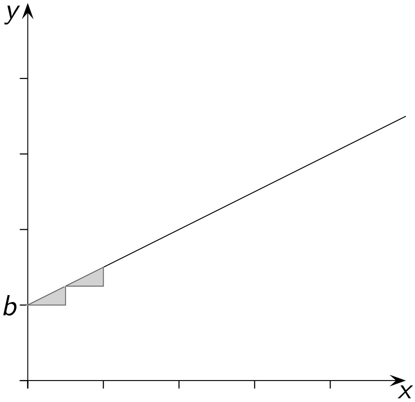
Wachstumsprozesse

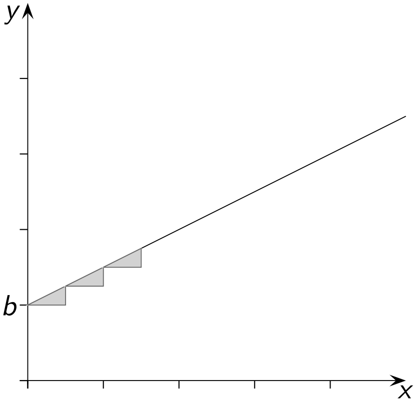
G.Roolfs

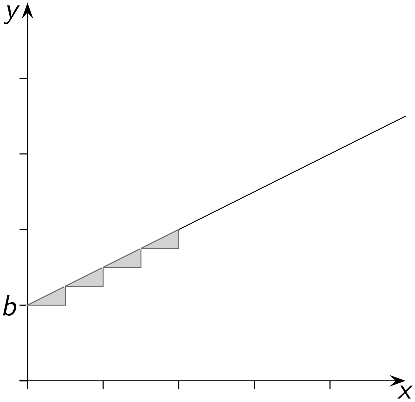

y
b
x

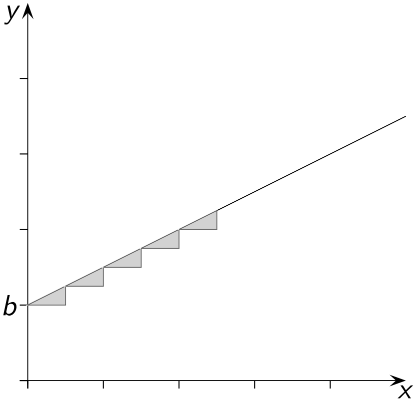


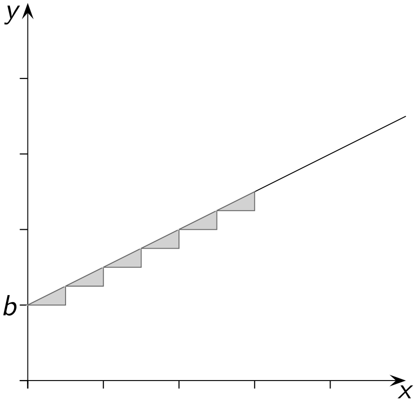
y
b
x


y
b
x

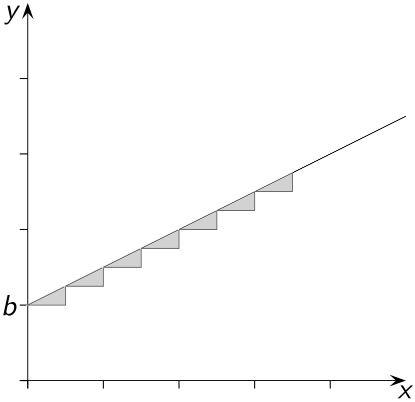

y
b
x

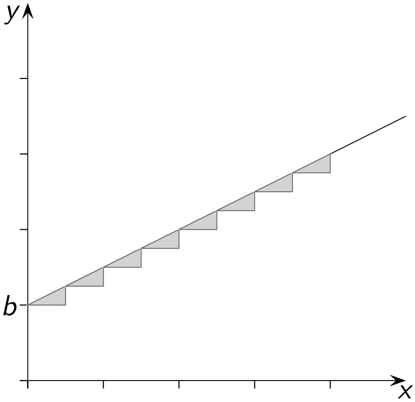

y
b
x


y
b
x

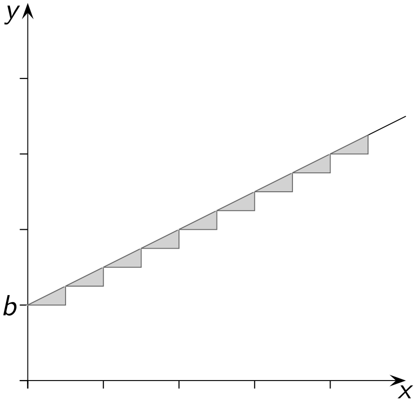


y
b
x

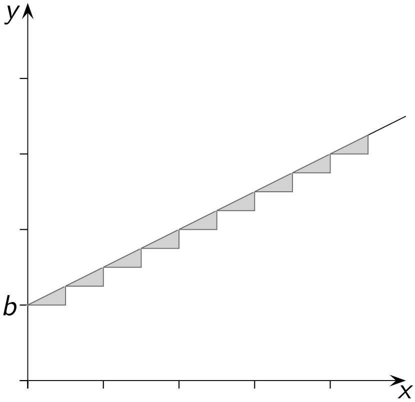

y
b
x



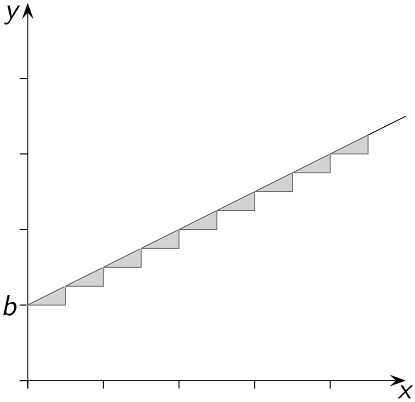
y
b
x



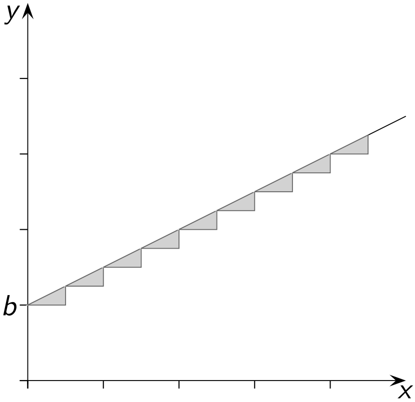
$f'(x) =$



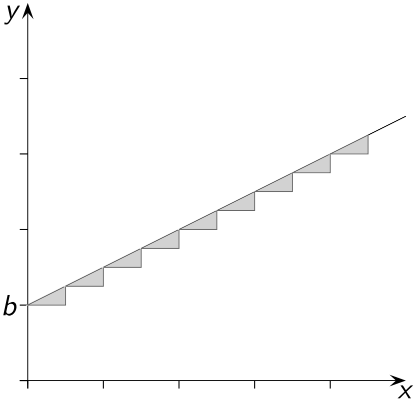
$$f'(x) = m$$



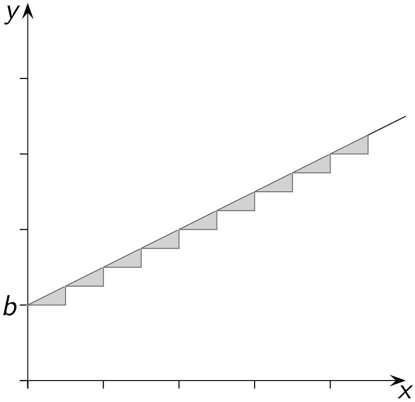
$$f'(x) = m \qquad\qquad f(x) =$$



$$f'(x) = m \qquad\qquad f(x) = mx + b$$

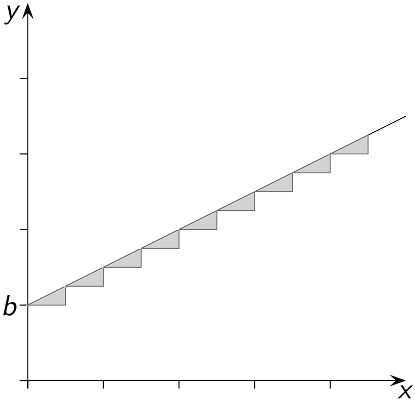


$$f'(x) = m \qquad\qquad f(x) = mx + b \quad \text{mit} \;\; f(0) =$$



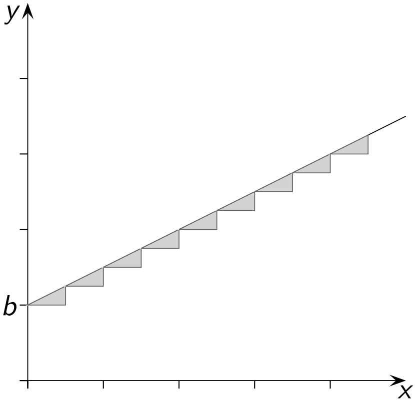
$f'(x) = m$

$f(x) = mx + b$ mit $f(0) = b$



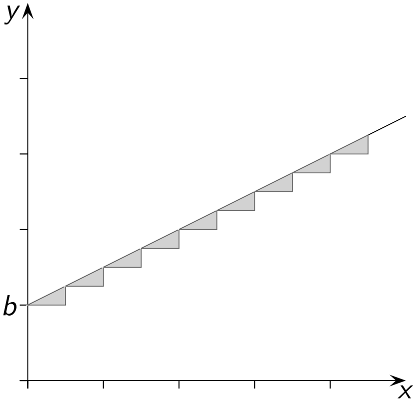
$$f'(x) = m \qquad\qquad f(x) = mx + b \quad \text{mit } f(0) = b$$

Lineares Wachstum,



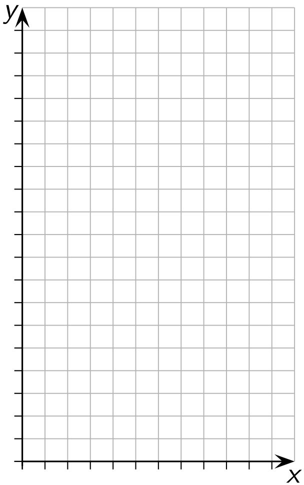
$$f'(x) = m \qquad\qquad f(x) = mx + b \quad \text{mit } f(0) = b$$

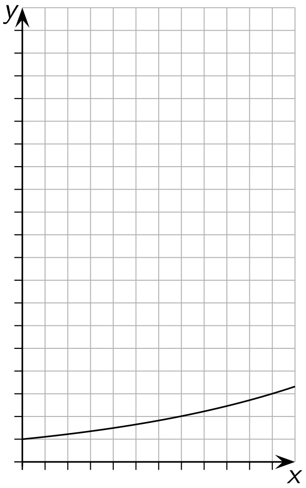
Lineares Wachstum, die Änderung ist

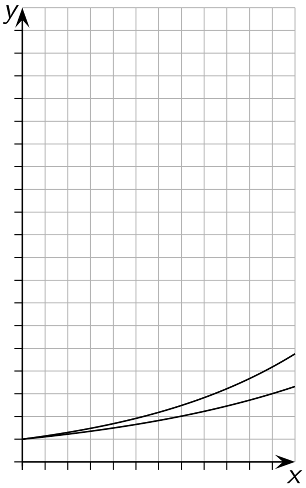


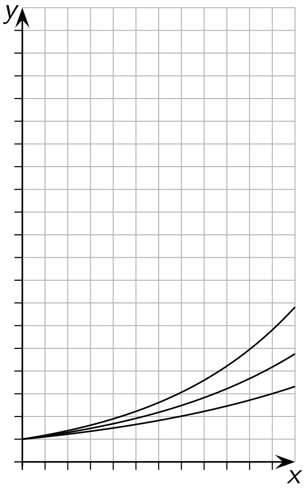
$f'(x) = m$ $\qquad$ $f(x) = mx + b \quad \text{mit} \quad f(0) = b$

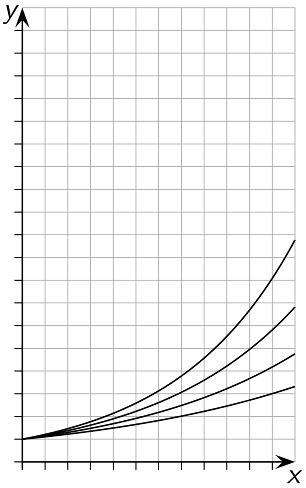
Lineares Wachstum, die Änderung ist konstant.

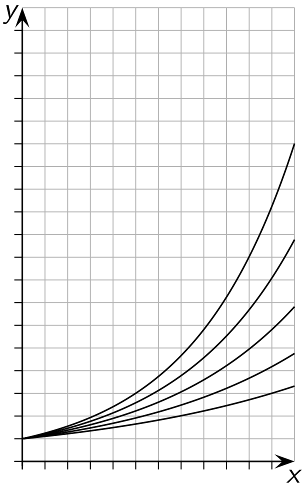

y
x

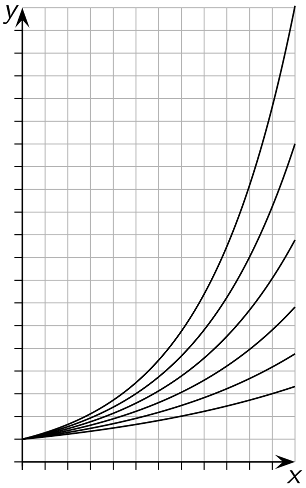

y
x


y
x

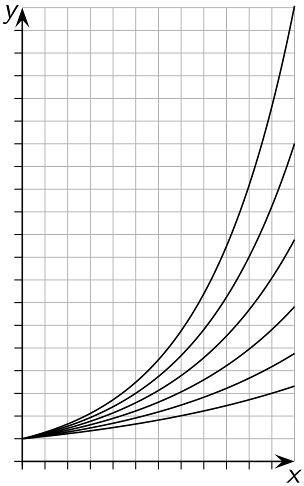

y
x


y
x

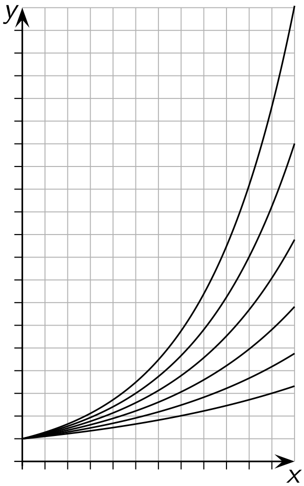

y
x



$$f'(x) =$$

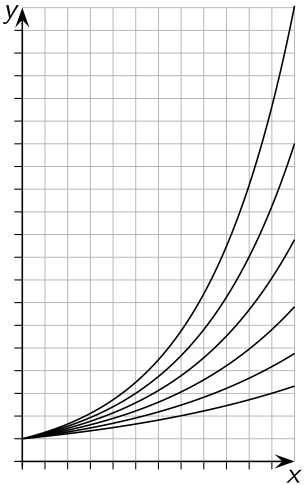


$$f'(x) = k \cdot f(x)$$



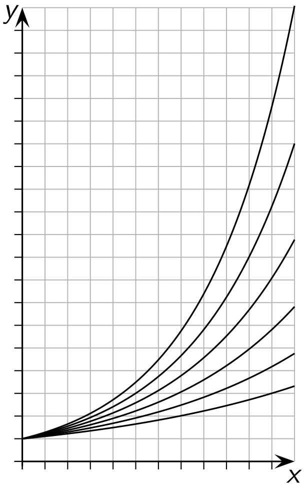
$f'(x) = k \cdot f(x)$

$f(x) =$



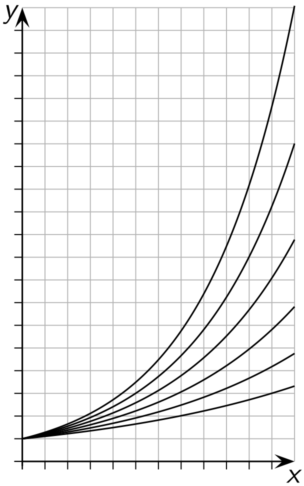
$$f'(x) = k \cdot f(x)$$

$$f(x) = a\, e^{kx}$$



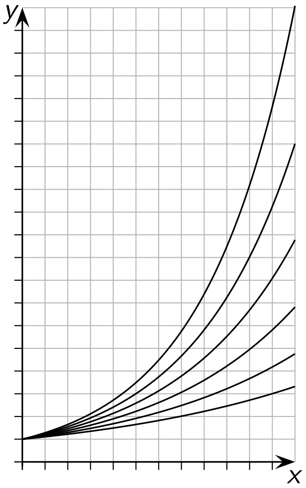
$f'(x) = k \cdot f(x)$

$f(x) = a\, e^{kx}$ mit $f(0) =$



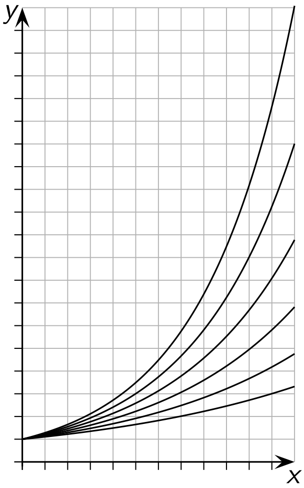
$$f'(x) = k \cdot f(x)$$

$$f(x) = a\,e^{kx} \quad \text{mit} \quad f(0) = a$$



$$f'(x) = k \cdot f(x) \qquad f(x) = a\,e^{kx} \;\text{ mit }\; f(0) = a$$

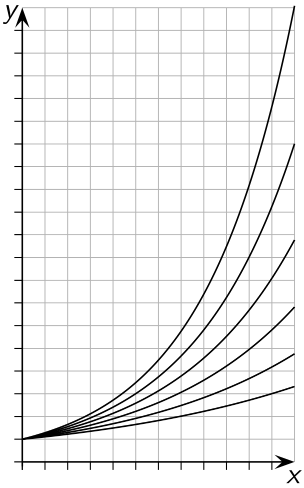
Exponentielles Wachstum,



$$f'(x) = k \cdot f(x)$$

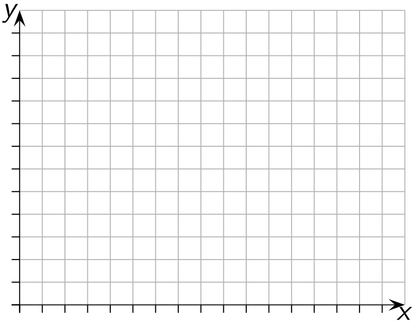
$$f(x) = a\, e^{kx} \quad \text{mit} \quad f(0) = a$$

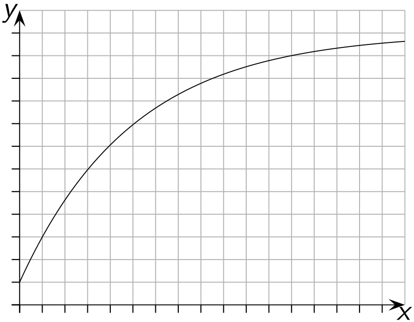
Exponentielles Wachstum, der Zuwachs ist

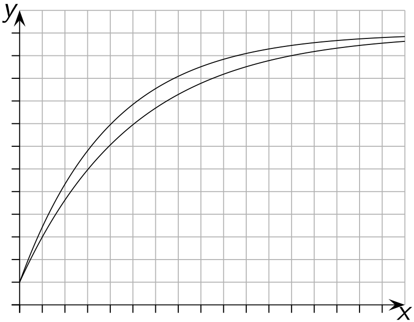


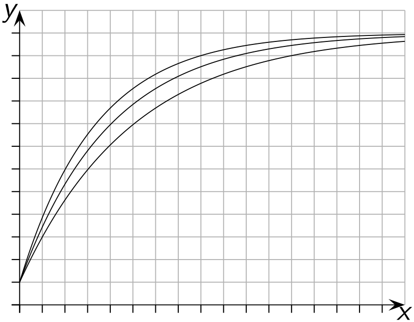
$f'(x) = k \cdot f(x)$ $\qquad$ $f(x) = a\, e^{kx}$ mit $f(0) = a$

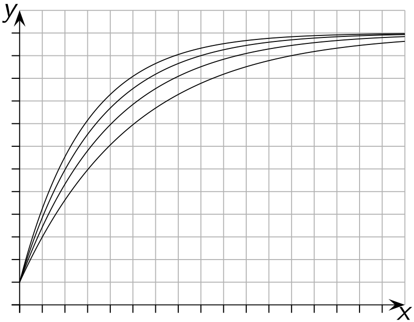
Exponentielles Wachstum, der Zuwachs ist proportional zum Bestand.

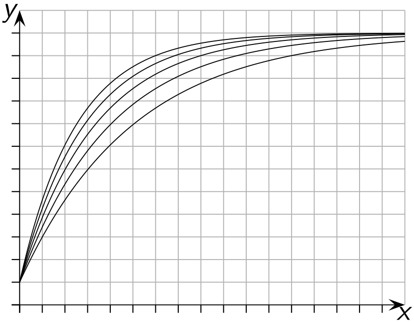

y
x

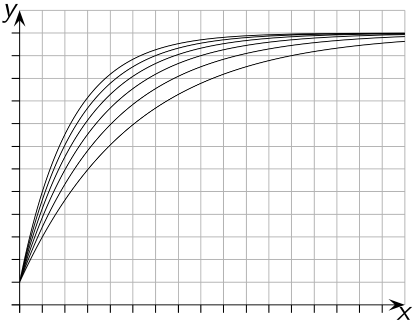

y
x


y
x

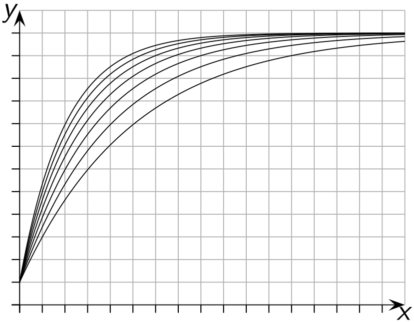

y
x

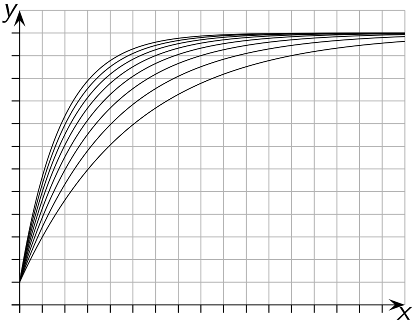

y
x


y
x

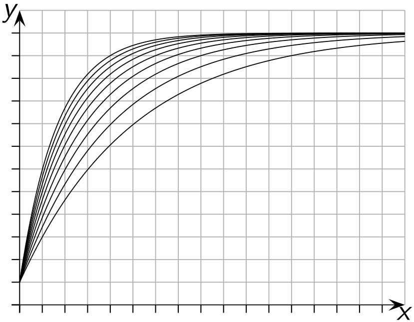


y
x

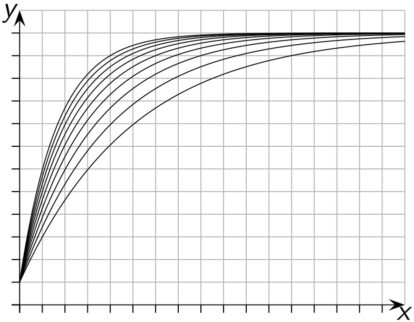

y
x



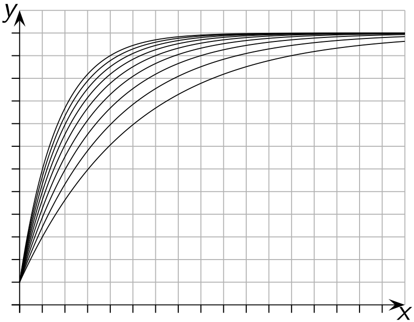
y
x



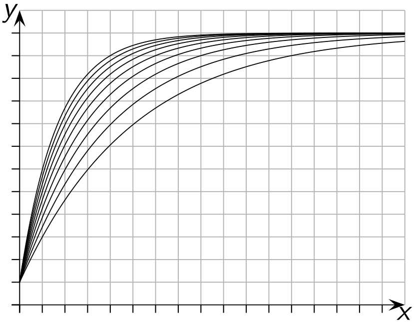
$f'(x) =$



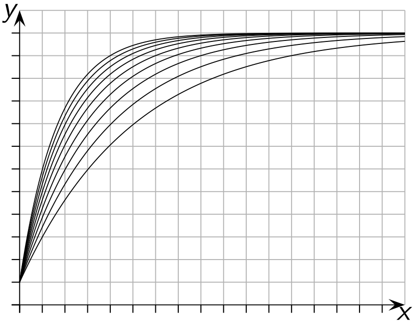
$$f'(x) = k \cdot (G - f(x))$$



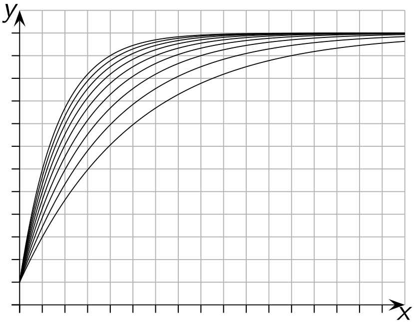
$$f'(x) = k \cdot (G - f(x)) \qquad f(x) =$$



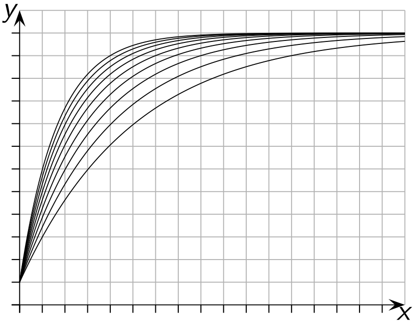
$$f'(x) = k \cdot (G - f(x)) \qquad f(x) = G - a\,e^{-kx}$$



$$f'(x) = k \cdot (G - f(x)) \qquad f(x) = G - a\,e^{-kx} \text{ mit } f(0) =$$

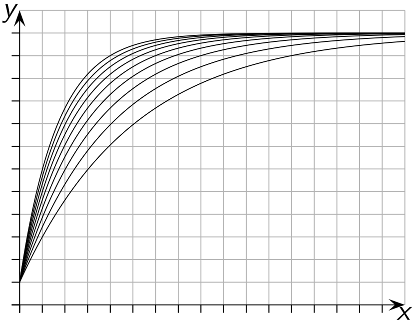


$$f'(x) = k \cdot (G - f(x)) \qquad f(x) = G - a\,e^{-kx} \text{ mit } f(0) = G - a$$



$$f'(x) = k \cdot (G - f(x)) \qquad f(x) = G - a\,e^{-kx} \text{ mit } f(0) = G - a$$

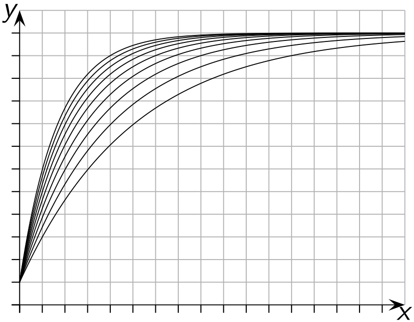
Begrenztes (beschränktes) Wachstum,



$$f'(x) = k \cdot (G - f(x)) \qquad f(x) = G - a\,e^{-kx} \text{ mit } f(0) = G - a$$

Begrenztes (beschränktes) Wachstum,

der Zuwachs ist

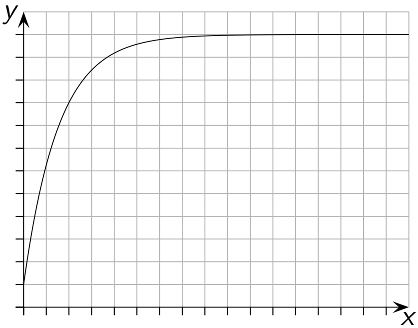


$$f'(x) = k \cdot (G - f(x)) \qquad f(x) = G - a\,e^{-kx} \text{ mit } f(0) = G - a$$

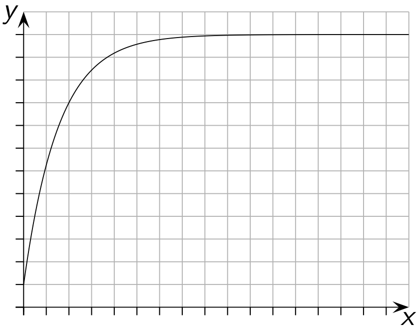
Begrenztes (beschränktes) Wachstum,

der Zuwachs ist proportional zum Sättigungsmanko (Differenz: Grenze G minus Bestand).

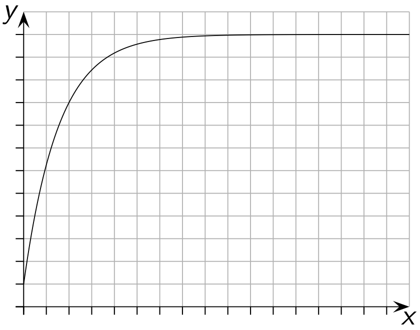
Begrenztes Wachstum, 2. Sichtweise (Klammern werden aufgelöst)



$$f'(x) = k \cdot (G - f(x))$$



$$f'(x) = k \cdot (G - f(x)) \qquad f(x) =$$

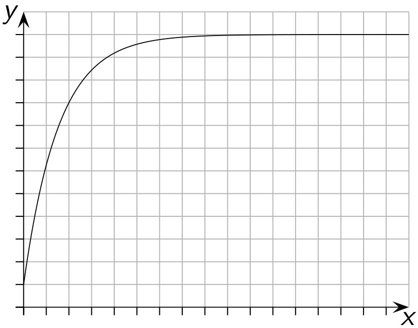


$$f'(x) = k \cdot (G - f(x))$$

$$f(x) = G - \underbrace{(G - f(0))}_{a} e^{-kx}$$

$$f'(x) =$$

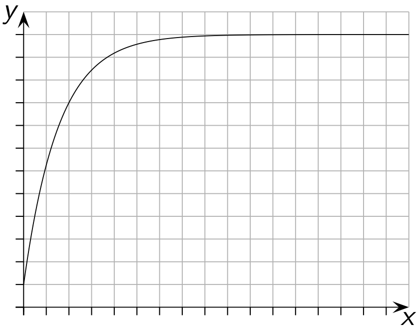
Begrenztes Wachstum, 2. Sichtweise (Klammern werden aufgelöst)



$$f'(x) = k \cdot (G - f(x))$$

$$f(x) = G - \underbrace{(G - f(0))}_{a}\, e^{-kx}$$

$$f'(x) = \underbrace{k \cdot G}_{m} - k \cdot f(x)$$



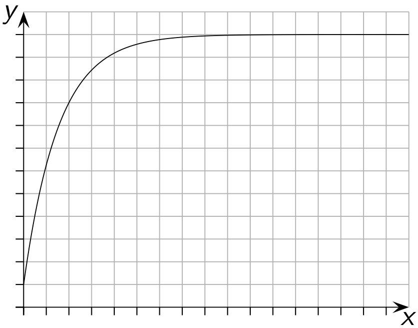
$$f'(x) = k \cdot (G - f(x))$$

$$f'(x) = \underbrace{k \cdot G}_{m} - k \cdot f(x)$$

$$f(x) = G - \underbrace{(G - f(0))}_{a}\, e^{-kx}$$

$$f(x) =$$

Begrenztes Wachstum, 2. Sichtweise (Klammern werden aufgelöst)

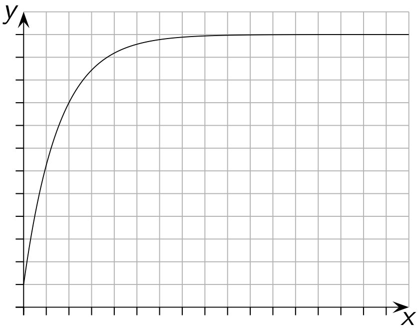


$$f'(x) = k \cdot (G - f(x))$$

$$f'(x) = \underbrace{k \cdot G}_{m} - k \cdot f(x)$$

$$f(x) = G - \underbrace{(G - f(0))}_{a}\, e^{-kx}$$

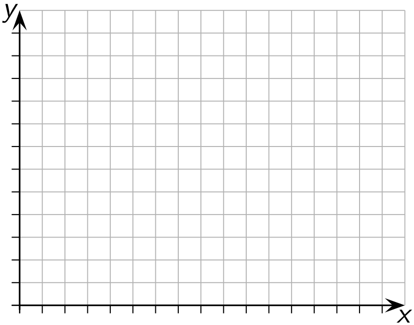
$$f(x) = \frac{m}{k} - \dots$$

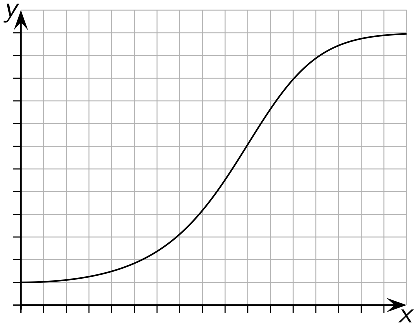


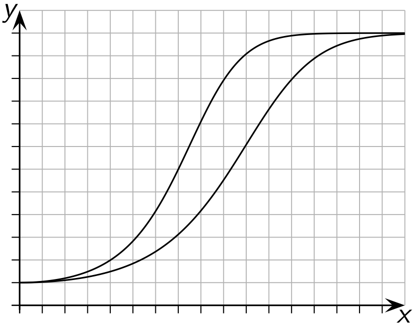
$$f'(x) = k \cdot (G - f(x)) \qquad f(x) = G - \underbrace{(G - f(0))}_{a}\, e^{-kx}$$

$$f'(x) = \underbrace{k \cdot G}_{m} - k \cdot f(x) \qquad f(x) = \frac{m}{k} - \dots$$

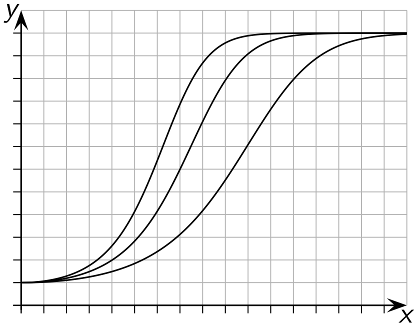
Ein konstanter Zuwachs wird um einen zum Bestand proportionalen Betrag verringert (siehe Tropfinfusion).

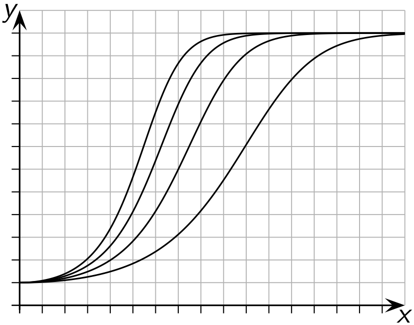

y
x

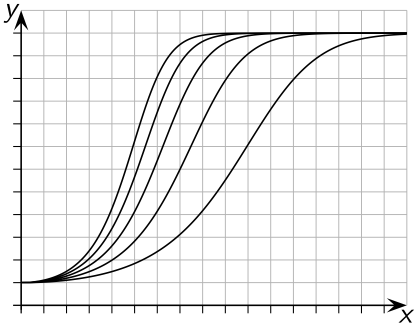

y
x

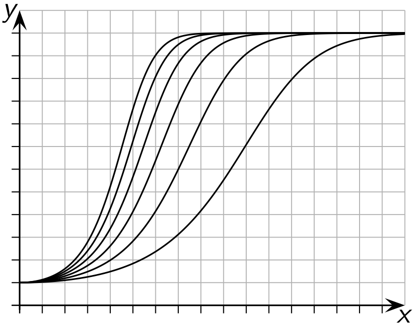


y
x

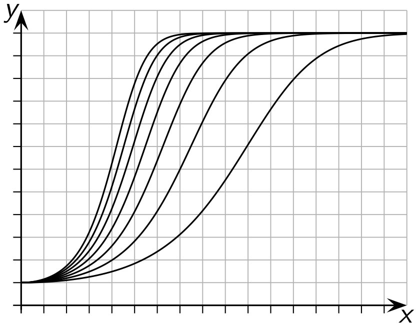

y
x

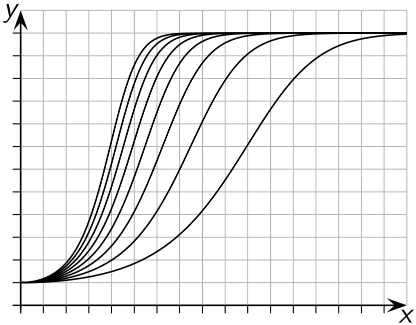

y
x

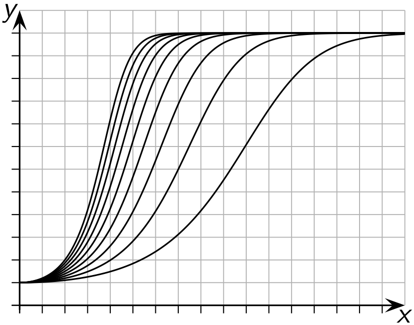

y
x

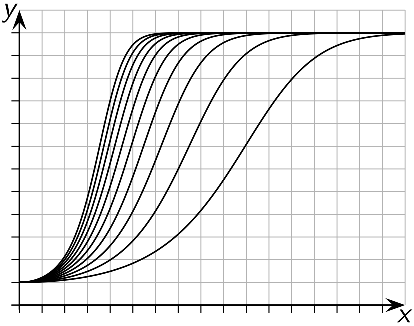


y
x

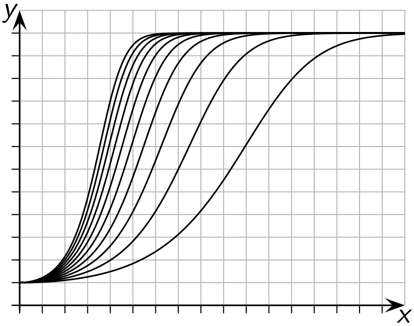

y
x


y
x

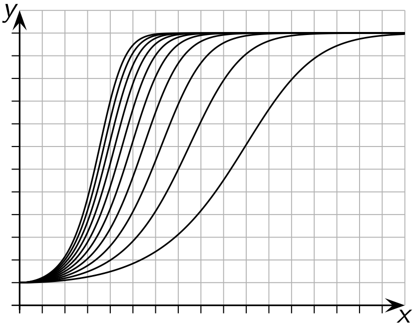

y
x



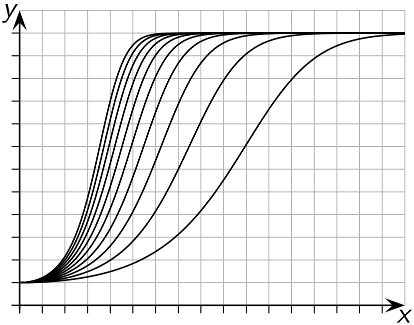
$$f'(x) =$$



$$f'(x) = k \cdot (G - f(x)) \cdot f(x) \qquad f(x) =$$

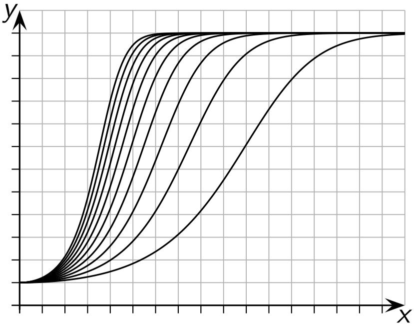


$$f'(x) = k \cdot (G - f(x)) \cdot f(x) \qquad f(x) = \frac{G}{1 + ae^{-kGx}}, \quad a = \frac{G - f(0)}{f(0)}$$



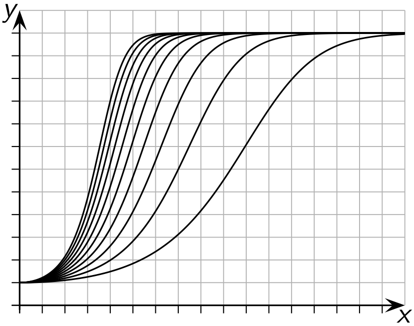
$$f'(x) = k \cdot (G - f(x)) \cdot f(x) \qquad f(x) = \frac{G}{1 + ae^{-kGx}}\,, \quad a = \frac{G - f(0)}{f(0)}$$

Logistisches Wachstum,



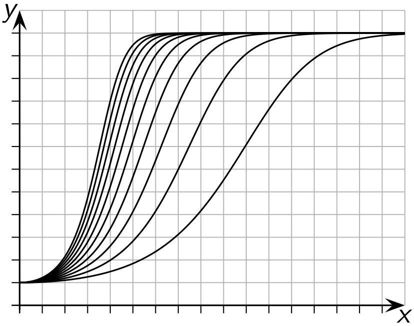
$$f'(x) = k \cdot (G - f(x)) \cdot f(x) \qquad f(x) = \frac{G}{1 + ae^{-kGx}}, \quad a = \frac{G - f(0)}{f(0)}$$

Logistisches Wachstum, der Zuwachs ist



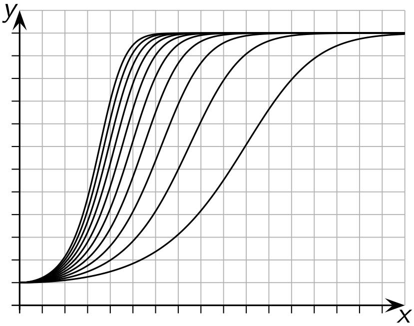
$$f'(x) = k \cdot (G - f(x)) \cdot f(x) \qquad f(x) = \frac{G}{1 + ae^{-kGx}}, \quad a = \frac{G - f(0)}{f(0)}$$

Logistisches Wachstum, der Zuwachs ist proportional zum



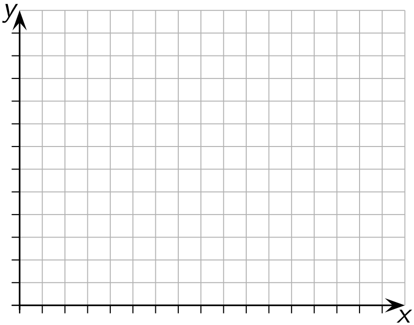
$$f'(x) = k \cdot (G - f(x)) \cdot f(x) \qquad f(x) = \frac{G}{1 + a e^{-kGx}}, \quad a = \frac{G - f(0)}{f(0)}$$

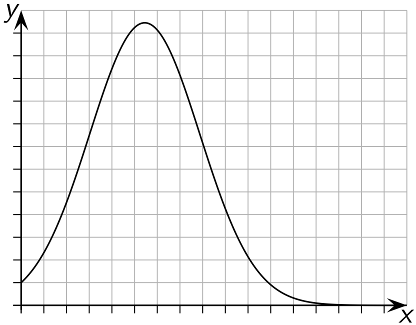
Logistisches Wachstum, der Zuwachs ist proportional zum Bestand und zum

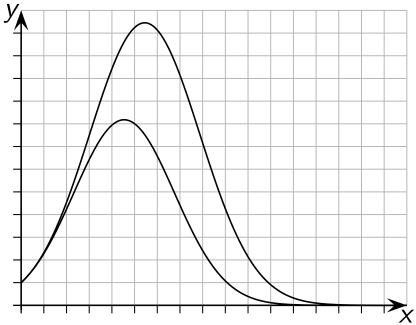


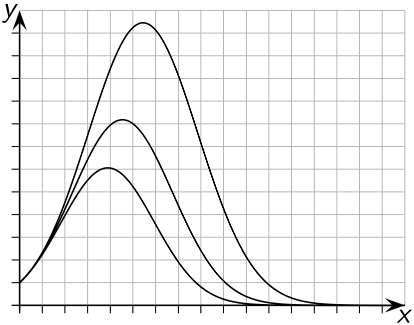
$$f'(x) = k \cdot (G - f(x)) \cdot f(x) \qquad f(x) = \frac{G}{1 + ae^{-kGx}}, \quad a = \frac{G - f(0)}{f(0)}$$

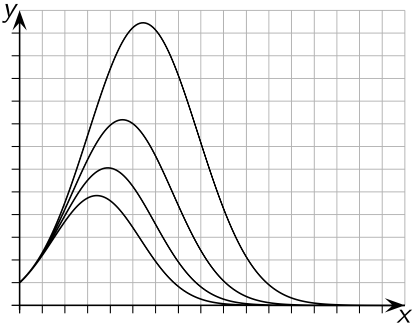
Logistisches Wachstum, der Zuwachs ist proportional zum Bestand und zum Sättigungsmanko (Differenz: Grenze G minus Bestand).

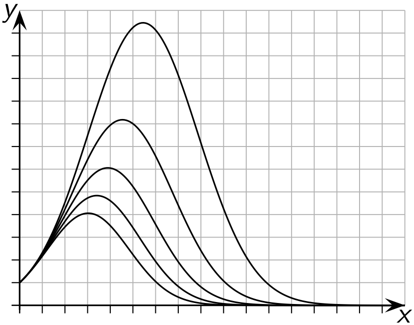

y
x

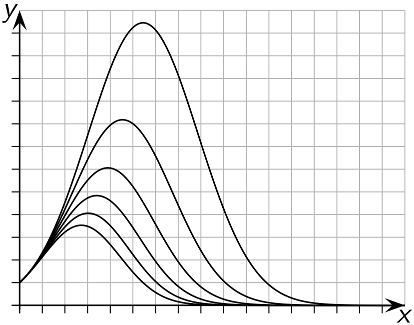

y
x

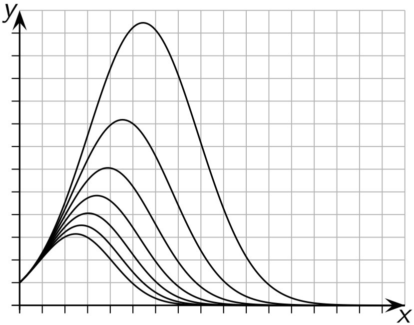

y
x

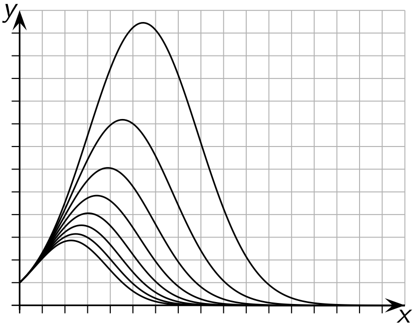

y
x

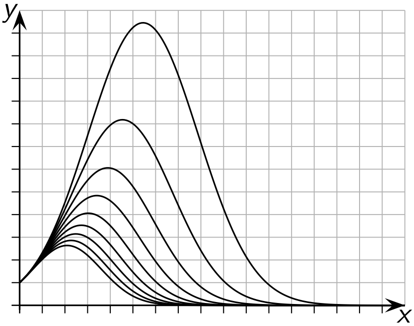

y
x


y
x

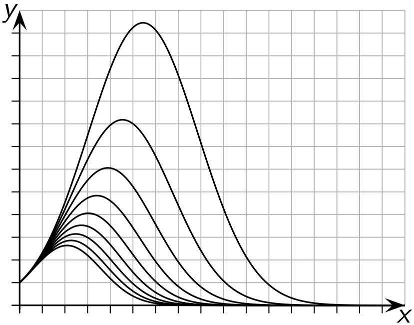

y
x


y
x

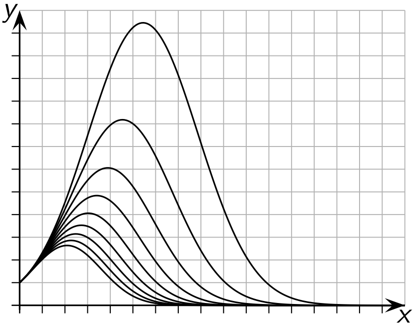

y
x



$$f'(x) \;=\; (g - s\,x)\cdot f(x)$$

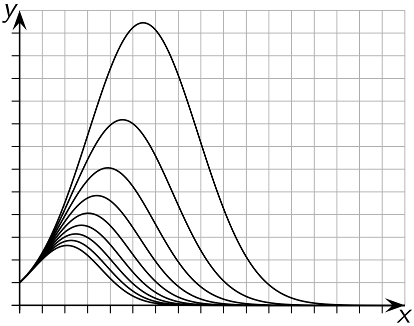


$$f'(x) \; = \; (g - s\,x) \cdot f(x) \qquad\qquad f(x) \; = \; a\,e^{gx \,-\, \frac{1}{2} s x^2}$$



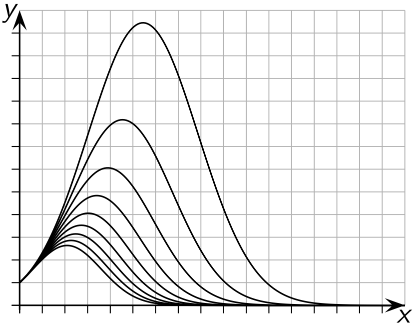
$$f'(x) \;=\; (g - s\,x)\cdot f(x) \qquad\qquad f(x) \;=\; a\,e^{gx \,-\, \frac{1}{2}sx^2}$$

Vergiftetes Wachstum,



$$f'(x) \;=\; (g - s\,x)\cdot f(x) \qquad\qquad f(x) \;=\; a\,e^{gx\,-\,\frac{1}{2}sx^2}$$

Vergiftetes Wachstum, der Wachstumsfaktor



$$f'(x) = (g - s\,x) \cdot f(x) \qquad f(x) = a\,e^{gx - \frac{1}{2}sx^2}$$

Vergiftetes Wachstum, der Wachstumsfaktor nimmt mit der Zeit ab.