$$\frac{(x+h)^{-m}-x^{-m}}{h} = -\frac{(x+h)^m - x^m}{h\,x^m(x+h)^m}$$

gives nx^{n-1}. For a real exponent a on $x>0$, write $x^a = e^{a\log x}$. In the difference quotient set $u = a\log(1+h/x)$. The limits $(e^u-1)/u \to 1$ and $\log(1+t)/t \to 1$ give $(x^a)' = ax^{a-1}$. This also specifies the necessary domains.

Structural or analytic derivation

The coefficient of h in $f(x+h)$ is the derivative whenever the remaining terms are $o(h)$. The preceding calculations establish the expansions

$$c = c + 0h, \quad (x+h)^n = x^n + nx^{n-1}h + O(h^2),$$