1.

$$y = 2\ln\left(\frac{x\sqrt[3]{x^2+9}}{\sin(x)}\right)$$

$$= 2\left(\ln(x) + \frac{1}{3}\ln(x^2+9) - \ln(\sin(x))\right)$$

$$y' = 2\left(\frac{1}{x} + \frac{1}{3}\frac{1}{x^2+9}\cdot 2x - \frac{1}{\sin(x)}\cdot\cos(x)\right)$$

$$= \frac{2}{x} + \frac{4x}{3(x^2+9)} - 2\cot(x)$$

2. Since the tangent line to $f(x)$ at $\frac{\pi}{4}$ is $y = 3x - \frac{3\pi}{4} + e$,

we know:

$$f'\left(\frac{\pi}{4}\right) = \text{Slope of Tangent Line at } x=\frac{\pi}{4} = 3$$

$$f\left(\frac{\pi}{4}\right) = \text{y-value of Tangent Line at } x=\frac{\pi}{4} = e$$

Now:

$$y = f(x)^{\tan(x)}$$

$$\ln(y) = \tan(x)\cdot\ln(f(x))$$

$$\frac{1}{y}\cdot\frac{dy}{dx} = \sec^2(x)\cdot\ln(f(x)) + \tan(x)\cdot\frac{1}{f(x)}\cdot f'(x)$$

$$\frac{dy}{dx} = f(x)^{\tan(x)}\cdot\left(\sec^2(x)\cdot\ln(f(x)) + \frac{\tan(x)f'(x)}{f(x)}\right)$$

@ $x = \frac{\pi}{4}$

$$\frac{dy}{dx} = e^1\cdot\left(2\cdot\ln(e) + \frac{1\cdot 3}{e}\right)$$

$$= 2e+3$$