$$\left(\sqrt[3]{\sqrt{125}}\right)^4 = \left(\sqrt[6]{5^3}\right)^4 = \sqrt[6]{5^{12}} =$$

$5^6 \cdot 5^6$

$$= 5^2 = \boxed{25}$$

$$\left(\sqrt{\sqrt{\frac{a^3 \cdot b^4}{c^2}}}\right)^3 = \sqrt[4]{\frac{a^9 \cdot b^{12}}{c^6}} =$$

$a^4 \cdot a^4 \cdot a$ $b^4 \cdot b^4 \cdot b^4$ $c^4 \cdot c^2$

$$= \boxed{\frac{a^2 \cdot b^3}{c} \sqrt[4]{\frac{a}{c^2}}}$$

$$\sqrt{a^3 \sqrt[3]{a^2 \sqrt[4]{a^5}}} = \sqrt[6]{a^9 \cdot a^2 \sqrt[4]{a^5}} =$$

$$= \sqrt[6]{a^{11} \sqrt[4]{a^5}} = \sqrt[24]{a^{44} \cdot a^5} =$$

$a^{24} \cdot a^{24} \cdot a$

$$= \sqrt[24]{a^{49}} = \boxed{a^2 \sqrt[24]{a}}$$