$$F_C(U) = \operatorname{Hom}_C(V,U) \xrightarrow{F_M(U)=f_*} F_C(W) = \operatorname{Hom}_C(V,W)$$

$$\varphi(U) \downarrow \qquad \circlearrowright \qquad \downarrow \varphi(W)$$

$$G_C(U) = U \xrightarrow[G_M(f)=f(underlying)]{} G_C(W) = W$$