Studies of nervous system connectivity, in a wide variety of species and at different scales of resolution, have identified several highly conserved motifs of network organization. One such motif is a heterogeneous distribution of connectivity across neural elements, such that some elements act as highly connected and functionally important network hubs. These brain network hubs are densely interconnected and forming a so-called rich-club. Recent work in mouse has identified a distinctive transcriptional signature of neural hubs, characterized by tightly coupled expression of oxidative metabolism genes, with similar genes characterizing macroscale inter-modular hub regions of the human cortex. Here, we sought to determine whether hubs of the neuronal C. elegans connectome also show tightly coupled gene expression. Using open data on the chemical and electrical connectivity of 279 C. elegans neurons, and binary gene expression data for each neuron across 948 genes, we computed a correlated gene expression score for each pair of neurons, providing a measure of their gene expression similarity. We demonstrate that connections between hub neurons are the most similar in their gene expression while connections between nonhubs are the least similar. Genes with the greatest contribution to this effect are involved in glutamatergic and cholinergic signalling, and other communication processes. We further show that coupled expression between hub neurons cannot be explained by their neuronal subtype (i.e., sensory, motor, or interneuron), separation distance, chemically secreted neurotransmitter, birth time, pairwise lineage distance, or their topological module affiliation. Instead, this coupling seems to be intrinsically linked to the identity of most hubs as command interneurons, a specific class of interneurons that regulates locomotion. Our results suggest that neural hubs may possess a distinctive transcriptional signature, preserved across scales and species, that is related to the involvement of hubs in regulating the higher-order behaviors of a given organism.