Despite that coherence is a familiar concept in various fields of science, there is no general theory of (quantum) coherence. Here I try to answer briefly what quantum coherence is and how it should be seen within the framework of physics, metatheory of physics and terminology related to them. The chain of deduction has been published in detail in [1].

Coherence can be defined as ”correlation of wave-like entities”. In a way, quantum coherence is a measure of the strength of quantum correlations. Quantum correlations (entanglement, superposition states) cannot be explained within the framework of classical correlations. In the density matrix formalism, quantum correlations appear as off-diagonal elements of the density matrix. However, the number, location and value of these elements depend on the chosen basis vector set. Favouring one basis vector set over the others often results in the preferred basis problem. As a result, coherence cannot be uniquely defined by using off-diagonal elements.

In the physical reality, various coherence phenomena have been observed. It is reasonable to assume that occurrence or unoccurrence of a certain coherence phenomenon is not dependent on the basis vector set in which the phenomenon is considered. Thus, according to Noether theorem, coherence of the system is a conserved quantity, since corresponding a particular symmetry of the system (invariance under the change of basis vector sets), there exists a conserved quantity (coherence).

According to the previous reasoning, I end up to the following mathematical formulation for coherence \( \Xi \) of a particular density matrix \( \rho \):

\[
\Xi(\rho) = \frac{N}{N-1} \left( \lambda_{\max,\rho} - \frac{1}{N} \right),
\]

where \( N \) is the dimension of the density matrix \( \rho \). Subtraction of the term \( 1/N \), which represents the classical probability, is a background correction that sets the minimum coherence to zero. The prefactor \( \frac{N}{N-1} \) normalises the maximum coherence to 1.

The conclusion of the previously mentioned premises and deductions is that quantum coherence is an intensive, probability-like, conserved quantity.

From this formulation of coherence it is possible to derive, e.g., the decoherence time of a quantum system. The definition is unique and can be used to define coherence of all quantum systems. Moreover, with the help of coherence it may be possible to define mutual entanglement generally for all quantum systems.