

[1] It may seem surprising, and satisfying, that the famous French biochemist and humanist Jacques Monod, Nobel Prize-winning author of *Chance and Necessity* (1970), defined life by three essential characteristics (autonomous morphogenesis, reproductive invariance, and teleonomy) quite similar to the above quartet, emphasizing autonomous self-assembly and self-organization over contextuality and wholism with respect to life's environs.

[2] Quantum physics brings us back into sharp contact with the subjective through the measurement problem. Whatever role consciousness plays in the universe, it is certainly involved in the formulation, selection, and answering of questions which shape the design of our measurements and observations. Consciousness, then, should be emergent, relational, and interactionist - with "objective" apperceptions emerging as a result of (cor)relational encounters between subjective observers interacting with physical objects, including measuring devices, via physical forces. Relational, Bohmian, and QBist views of quantum mechanics acknowledge this essentially perspectival nature of measurement, where facts are always relative to observers but can be confirmed and verified via classical communication channels.

[3] Protocols designed to dynamically cool target qubits at the expense of heating up auxiliary qubits have been extended also to open systems, thereby achieving so-called "heat bath algorithmic cooling" beyond Shannon's bound. Applying the formula, in the thermodynamic limit, for the minimal value of work that must be invested to maximally cool a target qubit to the ultraviolet superradiant states of biology at 310 K, the minimal work is completely negligible ($\sim 10^{-55}$ eV) and far outpaces state-of-the-art values for superconducting ($\sim 10^{-9}$ eV), neutral-atom ($\sim 10^{-9}$ eV), and trapped-ion ($\sim 10^{-10}$ eV) qubits in contemporary quantum computers.

[4] Google Quantum AI's Willow chip uses a lattice-based surface code of distance $d=7$, combining just over 100 superconducting transmon physical qubits into a logical qubit and exponentially suppressing the logical error rate with the addition of more qubits. Willow's error-correcting cycle time is 1.1 μ s, and one can extrapolate from their performance measurements that a much larger surface code ($d=27$) is required for fault-tolerant error rates (10^{-6}). For comparison, biological qubit architectures in eukaryotic protein fibers frequently consist of $\gg 10^5$ molecular qubits, far exceeding the $d=27$ logical qubit required to achieve fault tolerance in the Willow chip. Biomolecular qubit networks also exhibit superradiant error-correcting cycle times of about 1 ps, six orders of magnitude faster than Willow and consistent with the conventional Landauer bound to avoid overheating the biosystem, as entropy in the form of bit errors is expelled to the local environment.

[5] The philosopher David Chalmers, in his 2010 book *The Character of Consciousness*, presents three main arguments against strict materialism, establishing the epistemic and ontological gaps between physical truths and phenomenal truths. Schrodinger infamously equated his mental map of the physical world with reality itself, ignoring the epistemic and ontological gaps.