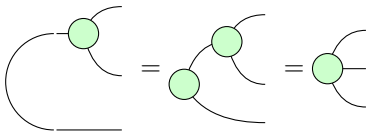
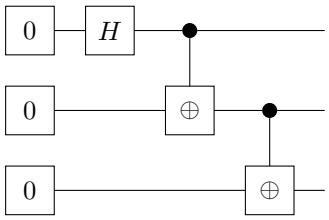
The GHZ Experiment

- **Description.** You may recall that in 2022 the three physicists Alain Aspect, John F. Clauser, and Anton Zeilinger received the Nobel prize for their work on entangled states. In particular, one of Zeilinger's contributions to this major result involved the discovery and experimental demonstration of the GHZ (Greenberger-Horne-Zeilinger) state. Intuitively, the GHZ state consists of three qubits which are maximally entangled. More precisely, the GHZ state is a uniform superposition of $|000\rangle$ and $|111\rangle$. In the ZX-calculus, we can write a GHZ state by first taking a Bell pair, and then copying one of the qubits in the Z-basis.



To demonstrate to your stakeholders that quantum computing really does work, you have decided to do a demonstration of the GHZ experiment using the following quantum circuit to prepare a GHZ state.



In this exercise, you will start by using the ZX-calculus to verify that this circuit really prepares a GHZ state. Once you have finished your calculations with the ZX-calculus, you will then upload the circuit into IBM Composer and use the **Probabilities** window to further validate the circuit. Ultimately, we would want to make sure that our GHZ circuit really prepares a GHZ state before we spend time and resources running it on a real quantum computer. You can find the GHZ circuit here.

- **Submission.** An equation of ZX-diagrams, a screenshot of the circuit in IBM Composer, and an explanation of why the data in the **Probabilities** window matches the measurement outcomes for the GHZ state.