What is string theory?

It is amazing to know so much about a theory, yet feel one has so little idea what it really is.

Two useful systematic statements that capture a fair part of what we know:

- A classical solution of string theory corresponds to a 2d superconformal field theory with $\widehat{c} = 10$ (and some simple general properties).
- Quantum gravity with negative cosmological constant corresponds to a Conformal Field Theory on the boundary of spacetime.

Let me elaborate a little concerning the first statement: "a classical solution is a 2d superconformal field theory." This (and its elaboration to string perturbation theory where one uses the superconformal field theory to compute quantum corrections to the classical solution) is actually one of the most fundamental statements about string theory, but I think there is a huge gap in our understanding of what the statement means – that is because we have very little understanding of *time-dependent* superconformal field theories. Once negative dimension vertex operators $f(X, \partial X, \cdots) \exp(ikX_0)$ enter the game, we are going to get derivatives of all orders in the action and I am skeptical that we are still in the world of *local* QFT. But we cannot just throw away locality without something to replace it. Is the $T\overline{T}$ deformation a clue?

Anyway, it is notable that neither of the two statements at all fits the traditional paradigm "find a set of fields, a symmetry principle, and an action." I suspect the reason we have trouble with the question "What is String Theory?" may be that the answer is more abstract than we are accustomed to. More abstract than something in the traditional paradigm fields/symmetries/action.

Another clue, or at least another fact worth mentioning, is that our understanding of the relation of string theory to quantum mechanics has gone through several changes. Before the era of nonperturbative dualities, it was reasonable to think that the truth, in some sense, might consist of finding, as I said a moment ago, the right new fields, symmetry, and action – which would then be quantized in a (possibly) relatively conventional way. The important role of nonperturbative dualities seems to contradict that idea; the theory seems to be, in some sense, intrinsically quantum mechanical, or at least to have crucial symmetries and properties that only come to light quantum mechanically.

Hopefully, the current developments involving quantum information theory and gravity will lead to a new general lesson about what string theory and quantum gravity are – maybe including a new understanding of the sense in which the theory is intrinsically quantum mechanical.