# 50th Anniversary

John H. Schwarz

California Institute of Technology

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# MY ASSIGNMENT:

## Discuss important lessons we have learned and your hopes for the future

# THREE LESSONS

**Lesson #1: If a theory developed for purpose A turns out to be better suited for purpose B, modify your goal accordingly.**

The original goal of string theory was a theory of hadrons, but it turned out to work better as a theory of quantum gravity and unification. The massless particles should be identified as gauge particles and a graviton rather than vector mesons and a Pomeron.

When Yang and Mills formulated gauge theory in 1954, they identified SU(2) gauge fields with $\rho$ mesons. 15 years later theorists developing dual models (the original name of string theory) made the same "mistake".

In 1974 we proposed to change the goal of string theory. It took another decade for the advantages of this interpretation to be widely appreciated. Perhaps there is a lesson in that, as well.

## Lesson #2: **Take "coincidences" seriously.**

Example 1: The massless states of type IIA superstring theory correspond to the massless states of 11d supergravity on a circle. This was known for more than a decade before it was taken seriously.

Example 2: It was well known that the Lorentzian conformal group in $d$ dimensions is the same as the Anti de Sitter isometry group in $d+1$ dimensions many years before AdS/CFT duality was proposed.

**Lesson #3**: **When working on hard problems explore generalizations with additional parameters.**

This lesson seems to be widely appreciated. There are many examples in the literature.

A couple of well-known examples are the $\Omega$ background for $\mathcal{N} = 2$ gauge theories and the $\mathbb{Z}_k$ orbifold generalization of $AdS_4 \times S^7$, which plays an important role in ABJM theory.

# TOPICS WHERE I EXPECT FUTURE PROGRESS

- Holographic dualities
- Relation between entanglement and geometry
- Quantum behavior of black holes
- 6d SCFTs
- String phenomenology
- String cosmology
- New formulas for scattering amplitudes

The preceding list is a safe bet, since these are currently active topics. It is more challenging to predict progress in topics that are not currently active. Perhaps a more fundamental formulation of the theory will be found.

The discovery of gravitational waves is an amazing breakthrough. It would be great if they could probe gravity beyond classical GR. This has been discussed, but there is not yet a compelling idea. The experimental discovery of supersymmetry or dark matter would be fantastic. Either of these would influence our thinking.

# MY ASSESSMENT OF THE STATUS OF THE FIELD

- The field is thriving; it continues to attract extremely talented young people
- Impressive progress is being made on many fronts and there is much enthusiasm
- String theory *techniques* are stimulating progress in fundamental mathematics and other areas of physics

**Thank you for your attention.**