

P. W. Anderson (1972). *More Is Different*. Science, New Series, Vol. 177, No. 4047, pp. 393-396

Philip Anderson was a theoretical physicist who won the 1977 Nobel Prize in Physics. His work was mainly in the field of condensed matter physics but his work on emergence and symmetry breaking lead to breakthroughs in particle physics too. This article, entitled 'More Is Different' is more of a philosophical essay on the nature of physics in the modern day.

The article can be found

here: http://robotics.cs.tamu.edu/dshell/cs689/papers/anderson72more_is_different.pdf

Remember, reading a paper isn't like reading a piece of fiction or a newspaper article. Don't get frustrated if it doesn't immediately make sense - you might need to do a little research of your own to understand some of the ideas.

Below are some questions to consider when reading the article. Each question refers to a specific part of the paper e.g. Page 2, Column 3 is written as (P2, C3).

At the end are some summary questions, submit your answers to the summary questions to thomas.millichamp@warwick.ac.uk

Next week, we'll publish solutions to the questions and the best submitted summaries from students across the country.

<p>(P1, C1) What is the reductionist hypothesis?</p> <p>(P1, C1&2) What areas of physics would you consider to be 'intensive research' and which would be 'extensive research'? Why?</p> <p>(P1, C2) What is the constructionist hypothesis?</p> <p>(P1, C3) According to the hierarchy presented in the third column of the first page, what would be the 'most' and 'least' fundamental areas of study?</p>	
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(P1, C3) Why might the constructionist hypothesis not be valid?

(P2, C1) What laws govern the universe on the cosmological scale and what laws govern the universe on the atomic scale?

(P2, C1) What is the chemical formula for ammonia?

(P2, C1) Why does Anderson say that the Nitrogen in Ammonia is negatively charged and the Hydrogens in Ammonia are positively charged?

(P2, C1) What is an electric dipole moment?

(P2, C1&2) Why is it said that there's no such thing as an electric dipole moment in a stationary system of ammonia?

(P2, C2) What does Anderson mean by symmetry when discussing ammonia?

.(P2, C2&3) Why does Anderson say that sugar breaks the parity symmetry?

.(P2, C3) What is different about sugar molecules that are produced by humans?

.(P2, C3) What is Anderson's definition of symmetry?

.(P2, C3) What is Anderson trying to explain in the last paragraph on P2?

.(P3, C1) Draw a diagram of an atom (a circle) and a molecule (two circles joined by a line) to prove that a 'crystal' has less symmetry than the underlying structure.

.(P3, C2) New properties come, according to Anderson, from broken symmetries. What macroscopic examples does he give?

.(P4, C1) Why does decreasing symmetry imply increasing complication? Are they synonymous?

(P4, C2) Given the first few paragraphs of the article, why does Anderson talk of the 'arrogance of the particle physicist'?

Summary

Why do you think Anderson chose to call the piece "More Is Different"?

How would you summarise this paper in:

1 paragraph:

1 sentence:

(Optional) Do you have any criticisms of this article?