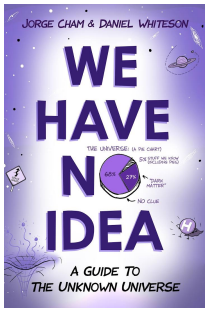
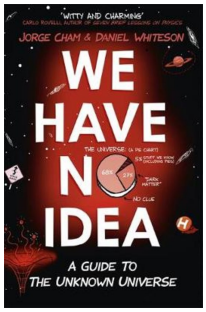
We have no idea, *Jorge Cham and Daniel Whiteson*, Riverhead Books / Penguin Random House, (2017) ISBN 978-0-7352-1151-3 (hbk), 368 pp.










Jorge Cham Daniel Whiteson

If you think du Sautoy's *What we cannot know* is too boring, too much philosophy and too much about God, and if you are in for a fun-approach, this book is exactly what you need.

Jorge Cham has a PhD in robotics from Stanford but he is now free-lance cartoonist and science entertainer while Daniel Whiteson is professor in physics and astronomy at the UC Berkeley. Cham is creator of phdcomics.com where you find more of his work, a link to two PhD movies, and also links to YouTube for animated cartoons related to this book.

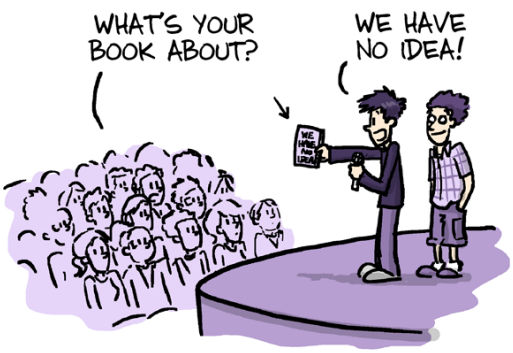


Many of the topics discussed by du Sautoy or by other authors of popular books on particle physics and cosmology, appear also in this strip, or whatever you call a book containing text amply illustrated with cartoons. It is brought like a comedian would bring it in a show, but nevertheless, it discusses all the appropriate subjects and the right questions are asked. In fact the title of every chapter is a question: What is the Universe made of? What is dark matter and dark energy? What is the most basic element of matter and what mysteries does it entail? Why is gravity so different from the other three fundamental forces? What is space, and what is time? How many dimensions are there? Why is there a speed limit for light? Who is shooting superfast particles at us? What is the Big Bang and how big is the universe? The shortest chapter is chapter 13. It is entitled "What happened to chapter 13?" and it has only one sentence: "We have no idea". This is also the most recurrent answer to many of the questions asked as you may have guessed from the title.

Of course there is no mathematics here, but for a lay person, I think this is the clearest possible introduction to the subject you may wish for. The strong point is that the authors are well aware of how a lay person will think about these matters. They keep repeating the question an 8-year old keeps asking: Why is it like this? The answer is most of the time the usual one: We have no idea. But while trying to answer, they explain all that we do know.

One of the more confusing chapters in other books that I read about these topics was the one on particles. That subject is introduced here by saying that any atom of matter we can observe (although that is only 5% of what the universe contains) can be made of only three particles: the electron which has a negative charge while the kernel needs up and down quarks to form positrons and neutrinos. Gradually these are extended to 6 quarks and 6 leptons, all of them called fermions. Only then enter the force carriers or bosons like photon, gluon, the Higgs boson, and the yet unconfirmed graviton.

The authors also bust some stereotype ideas most people have like imagining the kernel or the electrons as little balls. They carry some charge but we do not think of charge as being located at a particular place in the electron. It is more like a property, a label, attached to it. In fact this is also how we should think about mass. The kernel and electron are like dimensionless points that have properties like a charge and a mass. So how come we feel resistance when hitting a table? Why can't we walk through walls? What do we measure when we weigh something? We do not add the sum of the masses of the electrons, but we actually measure the force that is binding everything together.



In this way we are introduced to all the elements of particle physics, relativity theory, and cosmology, and of course the holy grail of theoretical physicists: the Theory of Everything. It is not only explained what this ToE is, but also why it is so freakingly difficult to link general relativity and quantum mechanics into a common package and have a theory of quantum gravity.

Most of all the book is just fun. Lots of fun, cartoons and gags. Animals, pets and marshmallows are returning fun elements. The problem of weight mentioned above is illustrated that when cutting up a llama in pieces, then the weight of the llama is the sum of the weight of the pieces, unless you cut the llama into 10^{23} pieces. Then you have to add to the mass of all the pieces also the binding energy. Ferrets are employed dropping water balloons to explain some aspects of relativity theory and Bertha the hamster is using two photon guns (a.k.a. flashlights) pointing in opposite directions standing on the Earth while Larry the cat is flying by approaching the speed of light and you are floating in space and you all observe the same speed for the photons from the flashlights. That is until the hamster's arms are getting tired.
A quote from early in the book to illustrate the kind of language used:

> If there is a fundamental equation of the universe —whatever it is— we can be sure it doesn't have a variable Nllamas because llamas, like atoms, are not a fundamental element in the universe. They don't define its essential nature; they are just the aggregate result (the emergent phenomenon) of the deeper reality (sorry, llamas) the same way tornados are an emergent phenomenon of wind or stars an emergent phenomenon of gas and gravity.

Of course the cartoons are funny elements too and there are usually several per page. And there are many footnotes which are fun remarks like this example:

> Scientists hundred years from now might think that we had the clues staring us in the face, that it was *so bloody obvious*, but currently it is a mystery.*

*Future physicists apparently have a condescending British accent.

In short I can recommend this book strongly. You may read it just for the fun of it, and you will probably learn something on top.

Adhemar Bultheel