Student questions: George Cooper colloquium on "The Analysis of Carbonaceous Meteorites: Unusual Mirror-image Properties of Organic Compounds from the Early Solar System"

4/19/18

Question 1: Did the DNA and RNA come from the meteorite itself or from an organism on it?

There is no DNA or RNA in meteorites (at least no one has reported it), the sugar acids are present in meteorites. The DNA I mentioned is from lab experiments by the scientist at Scripps (San Diego).

Question 2: Could the life source or DNA on the meteor have been the reason life started to grow here on Earth?

See above answer - there is also no life in meteorites. However, there are plenty of interesting compounds in meteorites - who knows the very early chemistry that they performed.

Question 1: Why did various sugars not separate into D & L peaks within your meteorite data?

Not all compounds (D and L) can be separated with a single chromatography column (it's just the properties of the columns). Sometimes you have to use more than one column on the same sample to separate other D-L pairs.

Question 2: What are the primary reasons for the rarity of the majority of the 6-Carbon sugars on Earth?

Scientist think that the more common ones (glucose, galctose and mannose) have the right structure to perform their biological roles. Also, the rare ones are less stable than the above three.

Question 1: Due to an apparent misunderstanding, I've spent the last few years thinking that mirror-image DNA would be how we establish life as extraterrestrial. What might be an indicator that life found elsewhere in the solar system does not have the same origin as us?

That's a good question because if someone finds DNA (or RNA) elswhere in the solar system and they are composed of the "D" sugars, then it could have been transported there from Earth by collisions or as contaminants form Earth ships, etc. But because it is so difficult to make even one of these polymers in the first place, if you find them and they're made of the "L" sugars then that might be a reason to think maybe there is life there. Maybe that is what you meant in your question.

Question 2: Is there any chance that, rather than the early universe preferring D-compounds, L-compounds are less resilient?

All experiments done in labs to date have shown no difference in stability between D and L polymers such as nucleic acids (DNA, RNA) and proteins (scientists can make polymers of both mirror images).

Question 1: Does the process of formation of a galaxy from a collapsing molecular cloud or the process of formation of a solar system have any properties that may already pre-select D or L before magnetic field effects?
I don't know. People who advocate circular polarized light might say that would do it.

Question 2: Are there any property differences between D or L molecules that may account for the complete absence of L in life?

No, polymers made of either mirror image have the same reaction properties, so life could have had the opposite mirro-image preference of today's life. That's why there's a chance that the mirror images were preferentially formed before life. Also, there are a few L sugars and derivatives in biology, just not in the polymers.

Question 1: How do you account for the low temperatures and pressures of space in the enantiomer excess experiments?

We haven't yet done enough experiments to account for temperature and pressure differences in results.

Question 2: Are there any characteristics of particular amino acids from Earth that could be used to identify them as contamination on a meteorite?

Yes, that's done quite a bit. If the protein amino acids in meteorites have a large "L" exceess then it's probably contamination. Only the rare non-protein amino acids in meteorites ahve been verified to contain L excesses. (Life prefers mostly L amino acids and mostly D sugars)

Question 1: Is there any evidence of RNA or DNA in these meteorites?

No.

Question 2: Do these meteorites originate from the Kuiper Belt?

Probably not the ones I use (from the asteroid belt) but some could be from father out in the solar system.

Question 1: I'm still a little confused, when you mentioned were referring to the "sugar acid" not just the sugar, you meant the amino acids that produce sugar, is that correct?

No, the sugar acids might have originally come from the oxidation of sugars. Amino acids are separate.

Question 2: You mentioned that the carboxylic acids we know as citric acid and vinegar have been found in meteorites. Does that mean that if one were to taste the meteorite it would taste like citric acid or vinegar (amongst other things like metals)?

No, there's plenty of other compounds in meteorites including a lot of sulfur and other bitter stuff. (now I have to go and taste one)

Question 1: How exactly do you determine whether a sample contains L or D molecules?

By putting the compounds through special "asymmetric" columns. These columns are also mostly made of only one mirror image of a large (unrelated) polymer, so they interact a little more with one of your mirror-image sample compounds than the other. The mirror image that interacts more with the coulmn is therefore slowed down a little more while passing through the coulmn: that's how we can separate the two morror mages of sugars acids and other compounds. However, first you have to run a known compound (usually you just buy it) through the same system so you will see the match with your unknown sample (a meteorite, soil, etc).

Question 2: Does the handedness of an organic molecule affect how it functions?

If you mean how it functions in biology, yes. Often (but not always) cells just get rid of the wrong mirror image of a compound.

Question 1: Is the enantiomer ratio conducive to the amount of water or ice that the formaldehyde and or ammonia or cyanide? Or would the ratio depend more on the amount of these small interstellar molecules?

So far, there's no evidence that such normal and unbiased chemical conditions affect enantiomer ratios.

Question 2: If this mirrored chain of amino acids and other sugars are similar to the structures of RNA and DNA are they able to self-replicate? If they do then what limits their growth?

I don't think other long polymers can self replicate.

Question 1: On your “results” slide, why is it that when you changed the magnetic field from +b to -b, the abundance of the D and L dropped by almost a factor of 1000?

The scales are not representative of the total amounts in a sample. For one example, less could have beeen injected between the two experiments.

Question 2: If you receive the grant you are hoping for to further you work, what will be your next attempted magnetic value if your last one was .1 Tesla? How far do you think you'll be able to drop that value and still see the results you are hoping for?

We have the grant and will do a range of conditions - we'll see what happens.

Question 1: With meteorites of identical composition, is it safe to assume that they would have relatively the same percentile of organic compounds in them?

Assuming that you mean the same composition except for the organic part. No, organics in meteorites vary a lot - even within the same meteorites.

Question 2: How common are these Carbonaceous Meteorites in the Milkyway Galaxy and is their indication of where they originated from?

The asteroid belt has quite a few carbonaceous asteroids (the parents of the meteorites). I don't know about the whole galaxy, although astronomers see a lot of the same chemicals (in the gas phase) in a lot of extraterrestrial locations. So maybe the same chemicals make up similar asteroids elsewhere.

Question 1: On these asteroid bodies has there been any evidence of water, frozen CO2, or any type of phreato(steam) type of activity can been seen if the asteroid comes into contact with heat from the sun, and can this produce an extreme biome for an environment for life to grow?

Yes, check out the Ceres asteroid on the NASA home page (or Goggle). Bacteria are so tough I bet they could grow there. There seems to be organics and bacteria might like that.

Question 2: Of all the differernt (types of asteroid) compositions, which of these compositions would be best set to support some type of life, ammino acids, proteins? Is there only one composition or variety of asteroids that have this possibility for compunds/proteins/ammino acids and what are the processes for collecting these samples, to be able to studied?

Many "carbonaceous" meteorites have such molecules and bacteria can definitely grow on them: museums are always trying to keep microoraganisms form infecting their meteorites. Mostly I simply request meteorites form museums, ASU, and a few other places.

Question 1: When doing carbon tests, is there any way to determine what the contamination is based on the results of the experiment to try and mitigate contamination in future tests?

Some contaminants, such as amino acids, can often be seen by their D/L ratios. Since researchers are now aware of contamination there are many standard procedures for guarding against it. Most contamination is now already in meteorites that we get form various sources, not added by the researcher.

Question 2: I'm still unsure why the excesses of a certain enantiomers are significant, could you please elaborate a little more?

I assume you mean meteorite enantiomers. Life's polymers such as DNA, proteins, etc., can only form (at least in lab experiments) if one mirror image of a compound is used as the building blocks - if both are present the polymers don't form very well. So some researchers think that there had to be a preference for one of the mirror images **before** life could start. The trouble is that there is no known way to perform a "normal" chemical sythesis that favors one mirror image over the other - you get 50:50 amounts. An example is flipping a coin many times, you'll eventually end up with about equal amounts of heads and tails. So if we can identify any potential ancient sources of mirror-images excesses that might finally lead to answers of this long-time question.

Question 1: Does interstellar formaldehyde differ at all on a molecular level then formaldehyde found on earth as a product of Temperature and Pressure?

No, if they are same molecular compound then they have the same properties if they are in the same environment.

Question 2: How is this Interstellar Formaldehyde formed? Combustion of methane? I know that Formadelhyde breaks down rather quickly with sunlight; how does that affect your study work?

Astrochemists are the best to answer the first question. In my experiments, most of the formaldehyde is reacted to form products before it decomposes.

Question 1: You listed a number of compounds that comprise meteorites. Can I ask what other compounds comprise meteorites that you didn't mention?

There are literally thousands of compounds - many unknown.

Question 2: Throughout the talk you mentioned “homochiral” a number of times. Can I ask what this is.

That is the use of only one of the two possible mirror images (enantiomers) of a given compound to build chemical species. For example, DNA is homochiral - it only uses D ribose. Proteins are also homochiral - they are only made of L mirror images.

Townsend, Kambray
Question 1: Why are mirror images important, what do they tell us?

See above answers.

Question 2: What would happen at high-temperature extraction?

Some compounds might be more sensitive to high temperatures - they might degrade. Researchers who use higher temperatures usually know that the compounds they are seeking are stable at those tempertures.