

CLASSIC EXPERIMENTS IN MOLECULAR BIOLOGY

Meselson and Stahl Experiment: The Nature of DNA Replication

by

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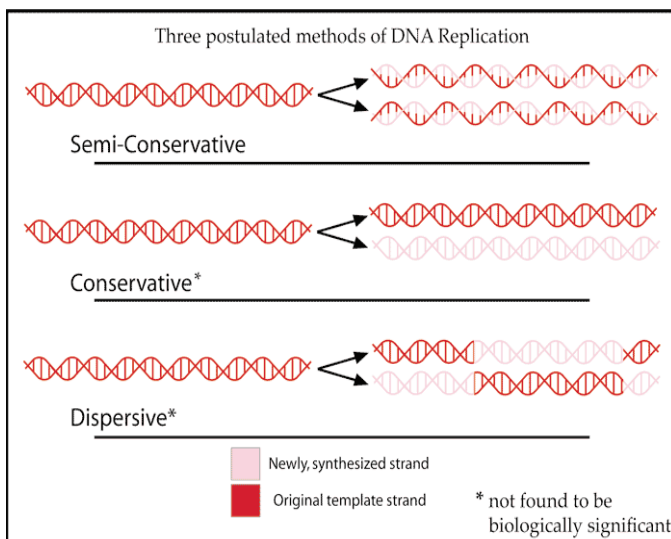
Benedictine University, Lisle, IL

Part I – Three Possibilities

How did you spend New Year’s Day this year? In 1958, Matthew Meselson and Frank Stahl celebrated the first day of the new year by having breakfast with college friends in Chicago and passing a photograph around the table, not of a girlfriend or a new baby, but of the data behind what is sometimes called the “most elegant experiment in molecular biology”—the experiment that first demonstrated how DNA replication occurs (Judson 1996, p612). Others followed (and won Nobel prizes too) by giving us details about the enzymes involved, but Meselson and Stahl’s experiment is so important and well designed that it has become necessary knowledge for one to be called an educated biologist.

Here are three different possibilities for DNA replication. Only one really happens, but until Meselson & Stahl conducted their experiment, each of these was plausible.

To the right of each diagram below, write two or three sentences describing how the starting DNA molecule differs from the molecule after replication. Do this for each of the three postulated methods of replication.



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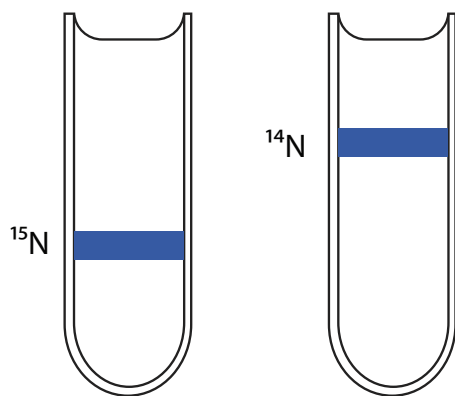
Part II – Nitrogen

Meselson and Stahl had tools like Avery, McCarty, and McLeod: ^{14}N and ^{15}N .

Questions

1. Why is a nitrogen label a good tool for studying DNA?
2. What other molecules in a cell have nitrogen in them?
3. What's the difference between ^{14}N and ^{15}N at the atomic level?
4. What's the term for two atoms of the same element with different molecular masses?
5. Give an example of another element that has atoms of more than one molecular mass.

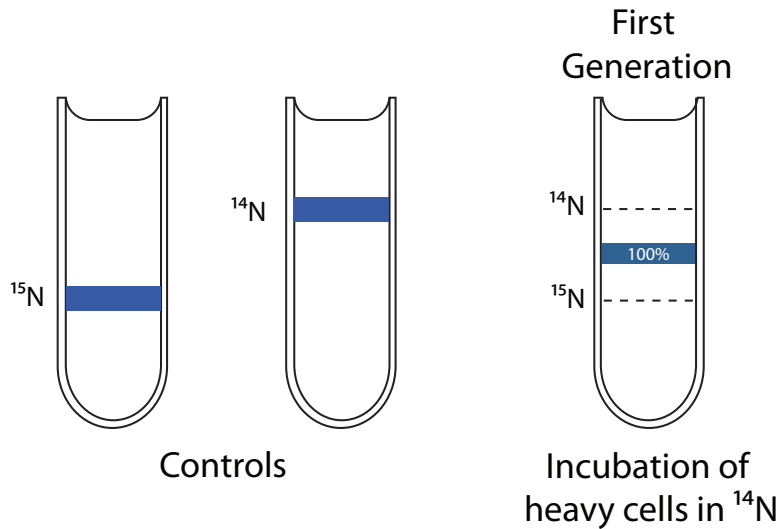
Bacteria in the laboratory can grow on plates or in broth cultures composed of precisely defined mixtures of chemicals. Meselson and Stahl grew bacteria in cultures containing only ^{15}N nitrogen for many generations so that the DNA was almost entirely composed of ^{15}N -containing nucleotides. These chromosomes are more dense than ^{14}N chromosomes, and by spinning chromosomes at very high speeds in a density gradient tube, Meselson & Stahl could tell the difference between the two kinds of chromosomes. Heavy chromosomes sank farther to the bottom of the tube, where the liquid was more dense. Lighter chromosomes floated in the less dense liquid toward the top of the tube. This can be represented by the diagram below. The blue lines represent the location of chromosomes in the tubes after centrifugation.



Controls

Part III – Results

After growing the bacteria in ^{15}N , producing bacteria with “heavy” chromosomes, they shifted the bacteria to growth conditions where only ^{14}N was present—making all the newly synthesized DNA from this less dense form of nitrogen. Here are the results of their density gradients after exactly one generation of bacterial growth:

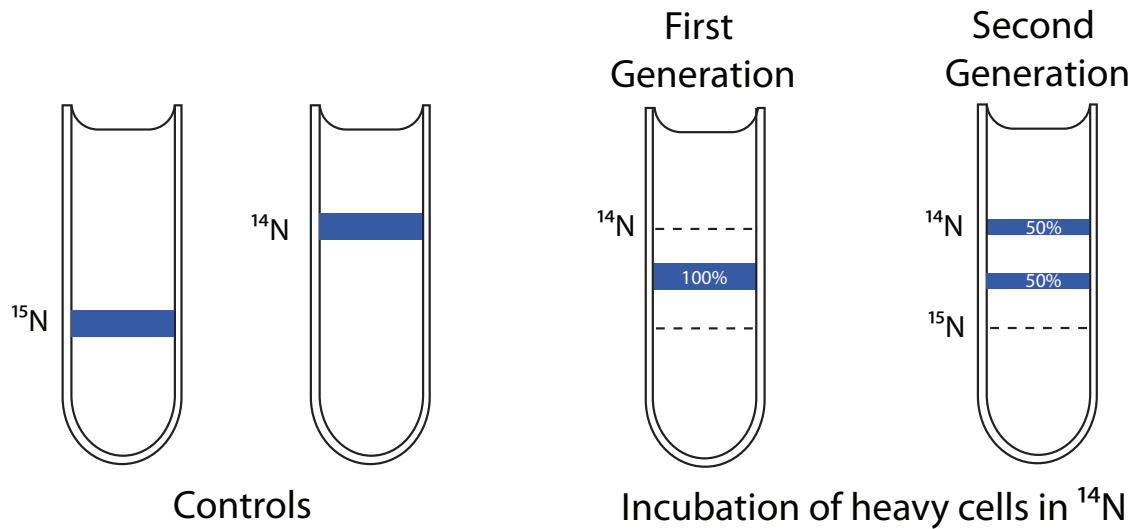


Questions

1. Which of the three models for DNA replication are ruled out by this experiment?
2. What would the data look like if the model you ruled out was what was really happening? Include a diagram of a tube as part of your answer.
3. What could they do to tell which of the two remaining models is actually happening, using the tools that have already been described?

Part IV – Second Generation

The diagram below shows the results from the experiment of the 2nd generation of cells grown in ¹⁴N.



Questions

1. Which model has now been ruled out by these results?
2. What would the data look like if this model was actually happening? Include a diagram of a test tube as part of your answer.

Take-Home Assignment

Address the following question using a well-constructed essay paragraph. If you use diagrams, you must have text to thoroughly explain the diagrams rather than just drawing a picture.

Describe in detail the chemical structure of DNA, how DNA is replicated, and the experiment by Meselson and Stahl that determined the method of DNA replication.



References

Judson, H.F. (1996). *The Eighth Day of Creation: Makers of the Revolution in Biology*, Expanded Edition. New York: Cold Spring Harbor Laboratory Press.

Meselson, M., and F.W. Stahl (1958). The replication of DNA in *Escherichia coli*. *PNAS* 44:671-682.



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