

Meselson & Stahl 1958

Home

Biol 4241

Luria-Delbruck 1943

Hershey-Chase 1952

Meselson-Stahl 1958

Garapin et al. 1978

McClintock 1953

King-Wilson 1975

Sanger et al. 1977

Jeffreys et al. 1985

Rothberg et al. 2011

Hamer et al. 1993

HISTORY

[Matthew Meselson](#) (Born May 24, 1928) and [Franklin Stahl](#) (Born October 6, 1929)

Devised an experiment to test by which model DNA is **replicated** in *Escherichia coli*

Published findings in their 1958 paper titled: [The Replication of DNA in *Escherichia Coli*](#)



Mathew Meselson and Franklin Stahl together

BACKGROUND

Replication **mechanism** not known at this point

DNA Replication

Duplication of a double stranded DNA molecule.

Double stranded molecule created is an **exact copy** of the original DNA molecule.

Nucleotides added simultaneously to both strands.

They can only be added in the 5'→3' direction.

There are [5 Steps](#) to DNA replication.

Semi- Conservative Model

In 1953, [Watson and Crick](#) proposed the molecular structure of DNA as the **Semi-Conservative Model**.

This theory states that two chains separate and expose the hydrogen bonding sites allowing the chains to serve as templates for the synthesis of new DNA strands

Three [models](#) were proposed:

- 1) Conservative Model
- 2) Semi-Conservative Model
- 3) Dispersive Model

METHODS

Experiment done in two separate phases

- 1) First phase used to calibrate [growth curve](#)
Did not know exact generation time
Could not stop bacterial growth at exact generations
- 2) Second phase used to get **exact** generations (1 gen, 2.5 gen, etc...)
Able to stop bacterial growth at exact generations
Done using calibrated growth curve as reference

Bacteria grown through multiple [steps](#):

- 1) First grown in "**heavy**" N^{15} medium for several generations
DNA contained only heavy N^{15}
- 2) Bacteria transferred to "**light**" N^{14} medium
DNA took up light N^{14}

Analytical Centrifugation

Separate sub cellular components based on a [density gradient](#) (CsCl) solvent with **very** high centrifugal force

DNA was extracted and transferred to an **analytical centrifuge**

First used density-gradient ultracentrifugation to determine approximate [density](#) of normal DNA

DNA separated into [separate bands](#) based on N^{14} or N^{15} content

Stopped bacterial growth to determine the amount of N^{14} and N^{15} present in DNA at different generation times

Video description of [Meselson and Stahl Experiment](#)

Heat Denaturation

Density of *E. coli* DNA was measured to be about the same as phage T2 and T4 DNA as well as calf thymus and **salmon sperm DNA**

Isolated DNA from salmon sperm and used heat to denature the two strands of DNA in a CsCl centrifuging medium

Same procedure was carried out with the *E. coli* DNA

RESULTS

Analytical Centrifugation

Explanation of [Figure 4](#):

The findings of Meselson and Stahl lead them to the following 3 conclusions:

- 1) DNA subunits must be **conserved**- nitrogen of the DNA molecule is divided equally between two subunits and remains intact through many generations
- 2) Each new daughter helix receives **one** of the parental strands of DNA.
- 3) DNA replication acts as a form of **doubling**

The results of the experiment are as predicted by the Watson and Crick Model for [Semi- Conservative](#) replication.

Heat Denaturation

Determined the DNA from *Escherichia coli* varies from purified Salmon sperm DNA in an experiment using heat denaturation.

When heat denatured, salmon sperm retains its initial molecular weight while *Escherichia coli* dissociates into two subunits which are conserved during duplication.

Two interpretations can be made from this:

- 1) Salmon and *Escherichia coli* contain analogous subunits, then salmon sperm subunits are more tightly bound than *E. coli* or
- 2) Salmon DNA does not contain these subunits, so *Escherichia coli* DNA must be more complex than the salmon DNA (This would mean the Semi- Conservative Model is not correct)

This experiment did not go as planned as the difference between prokaryotic and eukaryotic DNA was **unknown**.

CONCLUSION

As Watson and Crick had predicted, this study proved that DNA replicates semi-conservatively.

They utilized the density-gradient ultracentrifugation technique and they were able to eliminate the conservative and dispersive replication models.

This study provided a major molecular basis for further in depth discoveries on the DNA molecule.

- 1) "What are the **molecular structures** of the subunits of *Escherichia coli* DNA which are passed on intact to each daughter molecule?"
- 2) "What is the **relationship** of these subunits to each other in a DNA molecule?"
- 3) "What is the **mechanism** of the synthesis and dissociation of the subunits in vivo?"

"THE MOST BEAUTIFUL EXPERIMENT IN BIOLOGY"

Some useful educational videos:

DNA Timeline: Science from Mendel to Today:

<http://www.dnai.org/timeline/index.html?m=4>

Matthew Meselson: The Semi- Conservative Replication of DNA

<http://ibiomagazine.org/issues/september-2011-issue/matthew-meselson.html>