MECP2 gene
methyl-CpG binding protein 2

Normal Function

The MECP2 gene provides instructions for making a protein called MeCP2. This protein helps regulate gene activity (expression) by modifying chromatin, the complex of DNA and protein that packages DNA into chromosomes. The MeCP2 protein is present in cells throughout the body, although it is particularly abundant in brain cells.

In the brain, the MeCP2 protein is important for the function of several types of cells, including nerve cells (neurons). The protein likely plays a role in maintaining connections (synapses) between neurons, where cell-to-cell communication occurs. Many of the genes that are known to be regulated by the MeCP2 protein play a role in normal brain function, particularly the maintenance of synapses.

Researchers believe that the MeCP2 protein may also be involved in processing molecules called messenger RNA (mRNA), which serve as genetic blueprints for making proteins. By cutting and rearranging mRNA molecules in different ways, the MeCP2 protein controls the production of different versions of certain proteins. This process is known as alternative splicing. In the brain, the alternative splicing of proteins is critical for normal communication between neurons and may also be necessary for the function of other types of brain cells.

Health Conditions Related to Genetic Changes

MECP2 duplication syndrome

An extra copy (duplication) of the MECP2 gene in each cell causes MECP2 duplication syndrome, a condition characterized by intellectual disability, delayed development, and seizures. This condition affects males more often than females. When females are affected, they tend to have milder features. The duplication occurs on the long (q) arm of the X chromosome and includes the MECP2 gene; other genes may also be involved, depending on the size of the duplicated segment. The size of the duplication varies from 100,000 to a few million DNA building blocks (base pairs).

Duplication of the MECP2 gene leads to the production of extra MeCP2 protein and an increase in protein function. The resulting changes in gene regulation and protein production in the brain lead to abnormal neuronal function. These neuronal changes disrupt normal brain activity, causing the signs and symptoms of MECP2 duplication syndrome.
MECP2-related severe neonatal encephalopathy

At least 19 mutations in the MECP2 gene cause MECP2-related severe neonatal encephalopathy. This condition almost exclusively affects males and is characterized by small head size (microcephaly), movement disorders, breathing problems, and seizures. Many of the MECP2 gene mutations that cause this condition in males cause a similar disorder called Rett syndrome (described below) in females. Most of these mutations change single base pairs, insert or delete base pairs in the gene, or change how protein is produced from the gene. These changes in DNA alter the structure of the MeCP2 protein or reduce the amount of protein that is produced. As a result, cells do not have enough MeCP2 protein to bind to DNA and regulate other genes. A shortage of MeCP2 alters the activity of genes that are normally controlled by this protein. Mutations in the MECP2 gene may also disrupt alternative splicing of proteins critical for communication between neurons. Although these defects disrupt normal brain development, it remains unclear how MECP2 gene mutations lead to the signs and symptoms of MECP2-related severe neonatal encephalopathy.

PPM-X syndrome

Mutations in the MECP2 gene have been found to cause PPM-X syndrome. This disorder is characterized by mild to severe intellectual disability, bipolar disorder, and a pattern of movement abnormalities known as parkinsonism. This condition affects males more often than females; when females are affected, they tend to have only mild intellectual disability.

Eight particular mutations are responsible for approximately half of all cases of PPM-X syndrome. These mutations either change single protein building blocks (amino acids) in the MeCP2 protein or create a premature stop signal in the instructions for making the protein. Mutations that cause PPM-X syndrome lead to the production of a MeCP2 protein that cannot properly interact with DNA or other proteins and so cannot control the expression of genes. It is unclear how MECP2 gene mutations lead to the signs and symptoms of PPM-X syndrome, but misregulation of genes in the brain likely play a role in the development of intellectual disability and movement and mood disorders in affected individuals.

Rett syndrome

More than 620 mutations in the MECP2 gene have been identified in females with Rett syndrome, a brain disorder that causes problems with communication, learning, and coordination. These mutations include changes in single base pairs, insertions or deletions of DNA in the gene, and changes that affect how the information carried by the gene is used to produce proteins. MECP2 gene mutations alter the structure of the MeCP2 protein or reduce the amount of protein that is produced. The resulting shortage of functional MeCP2 likely impairs the regulation of gene expression in brain cells and may also disrupt alternative splicing of proteins critical for communication between neurons. Studies suggest that these changes may reduce the activity of
certain neurons and impact their ability to communicate with one another. It is unclear how these changes lead to the specific features of Rett syndrome.

Autism spectrum disorder

Other disorders

Mutations in the MECP2 gene have also been identified in people with several other disorders that affect the brain. For example, MECP2 gene mutations are associated with some cases of moderate to severe X-linked intellectual disability without other features of the syndromes described above. In addition, several people with both the features of Rett syndrome and signs and symptoms similar to Angelman syndrome (a condition characterized by intellectual disability, problems with movement, and inappropriate laughter and excitability) have mutations in the MECP2 gene. MECP2 gene mutations or changes in the gene’s activity have been reported in some cases of autism spectrum disorder, which affects communication and social interaction.

Chromosomal Location

Cytogenetic Location: Xq28, which is the long (q) arm of the X chromosome at position 28

Molecular Location: base pairs 154,021,800 to 154,097,731 on the X chromosome (Homo sapiens Annotation Release 109, GRCh38.p12) (NCBI)

Credit: Genome Decoration Page/NCBI

Other Names for This Gene

- MeCP2 protein
- MECP2_HUMAN
- methyl CpG binding protein 2
- methyl CpG binding protein 2 (Rett syndrome)
- MRX16
- MRX79
- PPMX
• RTS
• RTT

Additional Information & Resources

Educational Resources
• Madame Curie Bioscience Database: Chromatin Mechanisms Regulating Gene Expression In Health And Disease
  https://www.ncbi.nlm.nih.gov/books/NBK45032/
• Rare Diseases Clinical Research Network: Rett Consortium
  https://www.rarediseasesnetwork.org/cms/rett/Learn-More/Disorder-Definitions#MECP2

Clinical Information from GeneReviews
• MECP2 Duplication Syndrome
  https://www.ncbi.nlm.nih.gov/books/NBK1284
• MECP2-Related Disorders
  https://www.ncbi.nlm.nih.gov/books/NBK1497

Scientific Articles on PubMed
• PubMed
  https://www.ncbi.nlm.nih.gov/pubmed?term=%28%28MECP2%5BTI%5D%29+OR+%28methyl+CpG+binding+protein+2%5BTI%5D%29%29+AND+%28%28Genes%5BMH%5D%29+OR+%28Genetic+Phenomena%5BMH%5D%29%29+AND+english%5Bla%5D+AND+human%5Bmh%5D+AND+%22last+1080+days%22%5Bdp%5D

Catalog of Genes and Diseases from OMIM
• ANGELMAN SYNDROME
  http://omim.org/entry/105830
• AUTISM
  http://omim.org/entry/209850
• MENTAL RETARDATION, X-LINKED, SYNDROMIC 13
  http://omim.org/entry/300055
• METHYL-CpG-BINDING PROTEIN 2
  http://omim.org/entry/300005
Research Resources

• Atlas of Genetics and Cytogenetics in Oncology and Haematology
  http://atlasgeneticsoncology.org/Genes/GC_MECP2.html

• ClinVar

• HGNC Gene Family: Methyl-CpG binding domain containing
  https://www.genenames.org/cgi-bin/genefamilies/set/1025

• HGNC Gene Family: X-linked mental retardation
  https://www.genenames.org/cgi-bin/genefamilies/set/103

• HGNC Gene Symbol Report

• International Rett Syndrome Foundation: RettBASE: IRSF MECP2 Variation Database
  http://mecp2.chw.edu.au/cgi-bin/mecp2/views/basic.cgi?form=basic

• Monarch Initiative
  https://monarchinitiative.org/gene/NCBIGene:4204

• NCBI Gene

• UniProt
  https://www.uniprot.org/uniprot/P51608

Sources for This Summary

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/21326358

• Amir RE, Van den Veyver IB, Wan M, Tran CQ, Francke U, Zoghbi HY. Rett syndrome is caused by
  185-8.
  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/10508514

• Carney RM, Wolpert CM, Ravan SA, Shahbazian M, Ashley-Koch A, Cuccaro ML, Vance JM,
  Pericak-Vance MA. Identification of MeCP2 mutations in a series of females with autistic disorder.
  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/12770674

• Chahour M, Zoghbi HY. The story of Rett syndrome: from clinic to neurobiology. Neuron. 2007 Nov
  8;56(3):422-37. Review.
  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/17988628

• Gonzales ML, LaSalle JM. The role of MeCP2 in brain development and neurodevelopmental
  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/20425298
  Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2847695/
  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/26237041 
  Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4563741/

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/18985075 
  Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2986218/

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/25732612 

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/21636743 
  Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3150190/

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/15070486 

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/21632916 
  Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3127460/

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/26930212 
  Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4773238/

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/20188665 
  Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4338610/

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/16080119 
  Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1226209/
  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/26148505
  Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4493987/

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/16251272
  Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1266160/

Reprinted from Genetics Home Reference:

Reviewed: March 2017
Published: October 30, 2018

Lister Hill National Center for Biomedical Communications
U.S. National Library of Medicine
National Institutes of Health
Department of Health & Human Services