Timeline of Genomics (1901–1950)*

Year	Event and Theoretical Implication/Extension	Reference
1901	**Hugo de Vries** adopts the term **MUTATION** to describe sudden, spontaneous, drastic alterations in the hereditary material of *Oenothera*.	de Vries, H. 1901. *Die Mutationstheorie.* Veit, Leipzig, Germany.
	Thomas Harrison Montgomery studies spermatogenesis in various species of Hemiptera and finds that maternal chromosomes only pair with paternal chromosomes during meiosis.	1. Montgomery, T.H. 1898. The spermatogenesis in Pentatoma up to the formation of the spermatid. *Zool. Jahrb.* 12: 1-88. 2. Montgomery, T.H. 1901. A study of the chromosomes of the germ cells of the Metazoa. *Trans. Am. Phil. Soc.* 20: 154-236.
	Clarence Ervin McClung postulates that the so-called accessory chromosome (now known as the "X" chromosome) is male determining.	McClung, C.E. 1901. Notes on the accessory chromosome. *Anat. Anz.* 20: 220-226.
	Hermann Emil Fischer(1902 Nobel Prize Laureate for Chemistry) and **Ernest Fourneau** report the synthesis of the first dipeptide, glycylglycine. In 1902 Fischer introduces the term **PEPTIDES**.	1. Fischer, E. and Fourneau, E. 1901. Über einige Derivate des Glykocolls. *Ber. Dtsch. Chem. Ges.* 34: 2868-2877. 2. Fischer, E. 1907. Syntheses of polypeptides. XVII. *Ber. Dtsch. Chem. Ges.* 40: 1754-1767.
1902	**Theodor Boveri** and **Walter Stanborough Sutton** found the chromosome theory of heredity independently.	1. Boveri, T. 1902. Über mehrpolige Mitosen als Mittel zur Analyse des Zellkerns. *Verh. Phys -med. Ges. Würzberg* NF 35: 67-90. 2. Boveri, T. 1903. Über die Konstitution der chromatischen Kernsubstanz. *Verh. Zool. Ges.* 13: 10-33. 3. Boveri, T. 1904. *Ergebnisse über die Konstitution der chromatischen Substanz des Zellkerns.* Gustav Fischer, Jena, Germany. 4. Sutton, W.S. On the morphology of the chromosome group in *Brachystola magna. Biol. Bull.* 4: 24-39. 5. Sutton, W.S. 1903. The chromosomes in heredity. *Biol. Bull.* 4: 231-251.
	William Bateson coins the terms **GENETICS**, **F1**, **F2**, **ALLELOMORPH** (later shortened to **ALLELE**), **HOMOZYGOTE**, **HETEROZYGOTE**, and **EPISTASIS**.	1. Bateson, W. 1902. *Mendel's Principles of Heredity: A Defense.* University Press, Cambridge, United Kingdom. 2. Bateson, W. 1909. *Mendel's Principles of Heredity.* University Press, Cambridge, United Kingdom. 3. Bateson, W. 1916. The mechanism of Mendelian heredity (a review). *Science* 44: 536-543.
	Clarence Ervin McClung proposes that particular chromosomes determine the sex of the individual carrying them, not just in insects, but also perhaps in other species (including man).	McClung, C.E. 1902. The accessory chromosome—sex determinant? *Biol. Bull.* 3: 43-84.

* Edited by the Editorial Office of *Genomics, Proteomics* & *Bioinformatics.*

Year	Event and Theoretical Implication/Extension	Reference
1902	**Carl Correns** discusses the time and place of segregation.	Correns, C. 1902. Über den Modus unde den Zeitpunkt der Spaltung der Anlagen bei den Bastarden vom Erbsen-Typus. *Botan. Zeitg.* 60, II, 5/6: 65-82.
	Archibald Edward Garrod identifies the first human genetic disease, alkaptonuria.	Garrod, A.E. 1902. The incidence of alkaptonuria: a study in chemical individuality. *Lancet* 2: 1616-1620.
	Hermann Emil Fischer and **Franz Hofmeister** demonstrate that proteins are polypeptides.	Hofmeister, E. 1902. Über Bau und Gruppierung der Eiweisskorper. *Ergebnisse der Physiologie* 1: 759.
	William Maddock Bayliss and **Ernest Henry Starling** resurrect the term **HORMONE** when they dicover secretin.	Bayliss, W.M. and Starling, E.H. 1902. The mechanism of pancreatic secretion. *J. Physiol.* 28: 325-353.
1903	**William Castle** recognizes the relationship between allele and genotype frequencies for the first time.	Castle, W.E. 1903. The laws of heredity of Galton and Mendel and some laws governing race improvement by selection. *Proc. Amer. Acad. Arts Sci.* 39: 223-242.
	Wilhelm Ludvig Johannsen introduces and defines the concepts of **PHENOTYPE**, **GENOTYPE**, and **SELECTION**.	Johannsen, W. 1903. *Über Erblichkeit in Populationen und reinen Linien.* Fischer, Jena, Germany.
1905	**Edmund Beecher Wilson** and **Nellie Maria Stevens** independently discover that separate X and Y chromosomes determine sex.	1. Wilson, E.B. 1905. The chromosomes in relation to the determination of sex in insects. *Science* 22: 500-502. 2. Stevens, N.M. 1905. Studies in spermatogenesis with especial reference to the "accessory chromosome". *Carnegie Institution of Washington, Publication* 36: 1-33.
	William Bateson, **Edith Rebecca Saunders**, and **Reginald Crundall Punnett** investigate the exceptions to Mendel's rules, leading to the discovery of two new genetic principles: **LINKAGE** and **GENE INTERACTION**.	1. Bateson, W., Saunders, E.R., and Punnett, R.C. 1905. Experimental studies in the physiology of heredity. *Reports to Evol. Comm. Royal Soc.* 2: 1-131. 2. Bateson, W., Saunders, E.R., and Punnett, R.C. 1906. Experimental studies in the physiology of heredity. *Reports to Evol. Comm. Royal Soc.* 3: 1-53.
	Lucien Claude Jules Cuénot extends Mendel's discoveries to animals and discovers the first lethal allele: the yellow coat color allele in mice (*agouti*).	Cuénot, L. 1905. Les races pures et leurs combinaisons chez les souris. *Arch. Zool. Expér. Gén.* 4th series, 3, notes et revue, pp. cxxiii-cxxxii.
1906	**Craig W. Woodworth** and **William Ernest Castle** introduce *Drosophila melanogaster* as a new experimental material for genetic studies.	
	Robert Heath Lock suggests the relation between linkage and exchange of parts between homologous chromosomes.	Lock, R.H. 1906. *Recent Progress in the Study of Variation, Heredity, and Evolution.* pp. 299. E.P. Dutton & Co., New York, USA.
	Mikhail Semenovitch Tswett (Tsvett), a Russian botanist, creates and baptizes the technique of chromatography.	Tswett, M. 1906. On a new category of adsorption phenomena and their application to biochemical analysis. *Ber. Deut. Botan. Ges.* 24: 316-384.

Year	Event and Theoretical Implication/Extension	Reference
1907	**Anna Mae Lutz** proves that the mutation "*gigas*" in the evening primrose *Oenothera lamarckiana* contains an extra set of the usual chromosomes. This leads to the analysis and artificial production of polyploidy in plants, a much used technique for crop improvement.	1. Lutz, A.M. 1907. A preliminary note on the chromosomes of *Oenothera lamarckiana* and one of its mutants, *O.gigas*. *Science* 26: 151-152. 2. Lutz, A.M. 1909. Notes on the first generation hybrid of *Oenothera lata* and *O.gigas*. *Science* 29: 263-267.
1908	**Godfrey Harold Hardy** and **Wilhelm Weinberg** independently formulate the Hardy-Weinberg law relating mathematically the genotypic frequencies to the frequencies of alleles in randomly mating populations. This theorem forms the mathematical basis for population genetics.	1. Hardy, G.H. 1908. Mendelian proportions in a mixed population. *Science* 28: 49-50. 2. Weinberg, W. 1908. Über den Nachweis der Vererbung beim Menschen. *Jahresh. Wuertt. Ver. Vaterl. Natkd.* 64: 369-382.
	Archibald Edward Garrod discusses the biochemical genetics of man (or any other species).	1. Garrod, A.E. 1908. Inborn errors of metabolism. *Lancet* 2: 1-7, 73-79, 142-148, 214-220. 2. Garrod, A.E. 1909. *Inborn Errors of Metabolism.* Oxford University Press, London, UK.
	Erwin Baur first clearly demonstrates a lethal gene in *Antirrhinum.*	Baur, E. 1908. Untersuchungen über die Erblichkeitsverhältnisse einer nur in Bastardform lebensfähigen Sippe von *Antirrhinum majus. Zeits. ind. Abst. Vererb.* 1: 124.
1909	**Wilhelm Ludwig Johannsen** coins the word **GENE**, instead of the hereditary factor, and introduces the phenotype/genotype distinction.	1. Johannsen, W. 1909. *Elemente der Exakten Erblichkeitslehre.* pp. 123-124. Fischer, Jena, Germany. 2. Johannsen, W. 1911. The genotype conception of heredity. *Am. Nat.* 45: 129-159.
	Herman Nilsson-Ehle proposes the multiple-factor hypothesis to explain the quantitative inheritance of seed-coat color in wheat.	Nilsson-Ehle, H. 1909. Kreuzungsuntersuchungen an Hafer und Weizen. *Lunds Universit. Arsskr.* N.F. 5, 2: 1-122.
	Frans Alfons Janssens proposes the chiasmatype hypothesis.	Janssens, F.A. 1909. La théorie de la chiasmatypie. *La Cellule* 25: 389-411.
	Phoebus Aaron Theodor Levene, assuming that proteins are the support of heredity, studies nucleic acids to understand their role and discovers that the sugar ribose is found in some nucleic acids, which we now call RNA. He subsequently analyzes the compositon of nucleic acids and proposes that they are made of tetranucleotides in constant proportion, making them a monotonous macromolecule. This view delayed the discovery of DNA as the genetic material.	1. Levene, P.A. and Jacobs, W.A. 1909. *Chem. Ber.* 42: 2474. 2. Levene, P.A. 1909. Über die Hefenucleinsaure. *Biochem. Ziet.* 17: 120-131. 3. Levene, P.A. and London, E.S. 1929. The structure of thymus nucleic acid. *J. Biol. Chem.* 83: 793-802.
1910	**Thomas Hunt Morgan** (1933 Noble Prize Laureate for Physiology or Medicine) discovers sex-linked inheritance for the first mutation, white eye, in *Drosophila melanogaster.*	1. Morgan, T.H. 1910. Chromosomes and heredity. *Am. Nat.* 44: 449-496. 2. Morgan, T.H. 1910. Sex-limited inheritance in *Drosophila. Science* 32: 120-122.

Year	Event and Theoretical Implication/Extension	Reference
1910	**Edward Murray East** applies Mendelian inheritance to all inherited characters.	East, E.M. 1910. A Mendelian interpretation of variation that is apparently continuous. *Am. Nat.* 44: 65-82.
1911	**Thomas Hunt Morgan** proposes that the genes for white eyes, yellow body, and miniature wings in *Drosophila* are linked together on the X chromosome.	Morgan, T.H. 1911. An attempt to analyze the constitution of the chromosomes on the basis of sex-limited inheritance in *Drosophila*. *J. Exp. Zool.* 11: 365-413.
	Alexis Carrel (1912 Nobel Prize Laureate for Physiology or Medicine) and **Montrose Thomas Burrows** develop and publish the technique of *in vitro* tissue culture.	Carrel, A. and Burrows, M.T. 1911. Cultivation of tissues *in vitro* and its technique. *J. Exp. Med.* 13: 387-396, 415-421.
1912	**Thomas Hunt Morgan** reports the first sex-linked recessive lethal gene in *Drosophila*.	Morgan, T.H. 1912. The explanation of a new sex ratio in *Drosophila*. *Science* 36: 718-719.
	Thomas Hunt Morgan and **Clara J. Lynch** first publish the case of autosomal linkage in *Drosophila*.	Morgan, T.H. and Lynch, C.J. 1912. The linkage of two factors in *Drosophila* that are not sex-linked. *Biol. Bull.* 23: 174-182.
	George de Hevesy (1943 Nobel Prize Laureate for Chemistry) makes the first practical application of a radioisotope tracer.	
	Sir William Henry Bragg and **Sir William Lawrence Bragg** (both are 1915 Nobel Prize Laureates for Physics) develop the x-ray crystallography technique.	1. Bragg, W.L. 1912. The diffraction of short electromagnetic waves by a crystal. *Proc. Camb. Phil. Soc.* 17: 43-57. 2. Bragg, W.L. 1914. The analysis of crystals by the X-ray spectrometer. *Proc. Roy. Soc. Lond.* A 89: 468-489. 3. Bragg, W.H. and Bragg, W.L. 1915. *X Rays and Crystal Structure.* G. Bell & Sons, London, UK.
1913	**Alfred Henry Sturtevant** completes the first linear gene map.	Sturtevant, A.H. 1913. The linear arrangement of six sex-linked factors in *Drosophila*, as shown by their mode of association. *J. Exp. Zool.* 14: 43-59.
	Rollins Adams Emerson and **Edward Murray East** study multiple genes in maize, bringing the inheritance of quantitative characters into Mendelism.	Emerson, R.A. and East, E.M. 1913. The inheritance of quantitative characters in maize. *Bull. Agric. Exper. Sta. Nebr.* pp.120.
1914	**Calvin Blackman Bridges** reports nondisjunction of sex chromosomes as a proof of the chromosome theory of heredity.	1. Bridges, C.B. 1913. Nondisjunction of the sex chromosomes of *Drosophila*. *J. Exp. Zool.* 15: 587-606. 2. Bridges, C.B. 1914. Direct proof through non-disjunction that the sex-linked genes of *Drosophila* are borne on the X-chromosome. *Science* 40: 107-109. 3. Bridges, C.B. 1916. Nondisjunction as proof of the chromosome theory of heredity. *Genetics* 1: 1-52, 107-163. 4. Bridges, C.B. 1921. Genetical and cytological proof of nondisjunction of the fourth chromosome of *Drosophila melanogaster*. *Proc. Nat. Acad. Sci.* 7: 186-192.

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1915	**Thomas Hunt Morgan, Alfred Henry Sturtevant, Hermann Joseph Muller**, and **Calvin Blackman Bridges** publish *The Mechanism of Mendelian Heredity*.	Morgan, T.H., Sturtevant, A.H., Muller, H.J., and Bridges, C.B. 1915. *The Mechanism of Mendelian Heredity*. Henry Holt and Company, New York, USA.
	Frederick William Twort discovers a virus capable of infecting and destroying bacteria.	Twort, F.W. 1915. An investigation on the nature of ultra-microscopic viruses. *Lancet* 2: 1241-1243.
1917	**Calvin Blackman Bridges** discovers the first chromosome deficiency in *Drosophila*.	Bridges, C.B. 1917. Deficiency. *Genetics* 2: 445-465.
	Felix Hubert d'Herelle, independently of Frederick Twort, discovers the virus infecting and destroying bacteria, which he calls a **BACTERIOPHAGE**.	1. D'Hérelle, F. 1917. Sur un microbe invisible antagoniste des bacilles dysentériques. *C. R. Acad. Sci.* 165: 373-375. 2. D'Hérelle, F. 1921. *Le bactériophage: son comportement dans l'immunité*. Masson & Cie, Paris, France. 3. D'Hérelle, F. 1926. *The Bacteriophage and its Behavior*. Williams & Wilkins, Baltimore, USA.
1919	**Thomas Hunt Morgan** publishes *The Physical Basis of Heredity*, which summarized the rapidly growing findings in genetics.	Morgan, T.H. 1919. *The Physical Basis of Heredity*. J. B. Lippincott Company, Philadelphia, USA.
	Calvin Blackman Bridges discovers the chromosomal duplications in *Drosophila*.	Bridges, C.B. 1919. Duplication. *Anat. Rec.* 15: 357-358.
	Francis William Aston (1922 Nobel Prize Laureate for Physics) invents the first mass spectrograph to demonstrate the existence of isotopes. Rare isotopes have been used as tracers in the study of biological processes since 1923.	1. Aston, F.W. 1919. The constitution of the elements. *Nature* 104: 393. 2. Aston, F.W. 1920. Isotopes and atomic weights. *Nature* 105: 617.
1920	**Hans Winkler** coins **GENOME** as a conjunction between gene and chromosome.	Winkler, H. 1920. *Verbreitung und Ursache der parthenogenesis im pflanzenund Tierreiche*. pp. 165. Verlag Fischer, Jena, Germany.
1921	**Calvin Blackman Bridges** publishes analysis resulted from the study of triploidy, genic balance, and sex determination in *Drosophila*.	Bridges, C.B. 1921. Triploid intersexes in *Drosophila melanogaster*. *Science* 54: 252-254.
1922	**Lilian Vaughan Morgan** discovers attached-X chromosomes in *Drosophila*.	Morgan, L.V. 1922. Non-criss-cross inheritance in *Drosophila melanogaster*. *Biol. Bull.* 42: 267-274.
	Ralph Erskine Cleland reports chromosome rings in *Oenothera*.	1. Cleland, R.E. 1922. The reduction divisions in the pollen mother cells of *Oenothera franciscana*. *Am. J. Bot.* 9: 391-413. 2. Cleland, R.E. 1923. Chromosome arrangements during meiosis in certain Oenotheras. *Amer. Nat.* 57: 562-566.
1923	**Calvin Blackman Bridges** discovers chromosomal translocations in *Drosophila*.	Bridges, C.B. 1923. The translocation of a section of chromosome-II upon chromosome-III in *Drosophila*. *Anat. Rec.* 24: 426-427.

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1923	**A. E. Boycott** and **C. Diver** describe "delayed" Mendelian inheritance controlling the direction of the coiling of the shell in the snail *Limnea peregra*. **Alfred Henry Sturtevant** suggests that the direction of coiling is determined by the character of the ooplasm, which is in turn controlled by the mother's genotype.	1. Boycott, A.E. and Diver, C. 1923. On the inheritance of sinistrality in *Limnaea peregra*. *Proc. Roy. Soc. Lond. B* 95: 207-213. 2. Sturtevant, A.H. 1923. Inheritance of the direction of coiling in *Limnaea*. *Science* 58: 269-270.
	Theodor Svedberg (1926 Nobel Prize Laureate for Chemistry) invents the ultracentrifuge and uses it to determine the sedimentation rates of proteins.	Svedberg, T. and Pedersen, K.O. 1940. *The Ultracentrifuge*. Oxford University Press, New York, USA.
1924	**John Burdon Sanderson Haldane** (1939 Nobel Prize Laureate for Chemistry) presents algebraic analysis of the effects of selection.	Haldane, J.B.S. 1924. A mathematical theory of natural and artificial selection. *Proc. Camb. Philos. Soc.* 23: 19-41, 158-163, 363-372, 607-615, 838-844.
	Robert Joachim Feulgen and **Heinrich Rossenbeck** develop a chemical test for "thymonucleic acid" that is still widely used to test for DNA.	Feulgen, R.J. and Rossenbeck, H. 1924. Mikroskopischchemischer Nachweiss einer Nucleinsäure von Typus der Thymonucleinsäure und die darauf beruhende selektive Farbung von Zellkernen in mikroskopischen Präparaten. *Hoppe-Seyler's Z. Physiol. Chem.* 135: 203-248.
1925	**Alfred Henry Sturtevant** analyzes the Bar-eye phenomenon in *Drosophila* and discovers position effect.	Sturtevant, A.H. 1925. The effects of unequal crossing over at the bar locus in *Drosophila*. *Genetics* 10: 117-147.
	Ernest Gustav Anderson reports the proof of 4-strand crossing over in *Drosophila*.	1. Anderson, E.G. 1925. Crossing over in a case of attached X chromosomes in *Drosophila melanogaster*. *Genetics* 10: 403-417. 2. Bridges, C.B. and Anderson, E.G. 1925. Crossing over in the X chromosomes of triploid females of *Drosophila melanogaster*. *Genetics* 10: 418-441.
	Felix Bernstein proposes multiple allele interpretation of human ABO blood groups.	Bernstein, F. 1925. Zusammenfassende Betrachtungen über die erblichen Blutstrukturen des Menschen. *Zts. Abst. Vererb.* 37: 237-270.
1926	**Alfred Henry Sturtevant** finds the first inversion in *Drosophila*.	Sturtevant, A.H. 1926. A crossover reducer in *Drosophila melanogaster* due to inversion of a section of the third chromosome. *Biol. Zentralbl.* 46: 697-702.
	James Batcheller Sumner (1946 Noble Prize Laureate for Chemistry) first crystallized an enzyme, urease, and proved it to be a protein.	Sumner, J.B. 1926. The isolation and crystallization of the enzyme urease. *J. Biol. Chem.* 69: 435-441.
1927	**Hermann Joseph Muller** (1946 Noble Prize Laureate for Physiology or Medicine) discovers induction of mutations by X-rays in *Drosophila*.	Muller, H.J. 1927. Artificial transmutation of the gene. *Science* 66: 84-87.
	John Belling proposes interpretation of chromosome rings.	Belling, J. 1927. The attachment of chromosomes at the reduction division in flowering plants. *J. Genet.* 18: 177-205.

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1927	**Leo Loeb** and **Sewall Wright** demonstrate genetics of transplant specificity in mammals.	Loeb, L. and Wright, S. 1927. Transplantation and individuality differentials in inbred families of guiena pigs. *Amer. J. Pathol.* 3: 251-283.
	Karl Landsteiner (1930 Noble Prize Laureate for Physiology or Medicine) and **Philip Levine** discover the MN and the P blood groups in human.	1. Landsteiner, K. and Levine, P. 1927. A new agglutinable factor differentiating individual human bloods. *Proc. Soc. Exp. Biol. Med.* 24: 600-602. 2. Landsteiner, K. and Levine, P. 1927. Further observation on individual differences of human blood. *Proc. Soc. Exp. Biol. Med.* 24: 941-942.
1928	**Frederick Griffith** reports the transmission of genetic information between bacterial cells.	Griffith, F. 1928. The significance of Pneumococcal types. *J. Hyg.* 27: 113-159.
	Lewis John Stadler reports the artificial induction of mutations in maize, and demonstrates that the dose-frequency curve is linear.	1. Stadler, L.J. 1928. Mutations in barley induced by X-rays and radium. *Science* 68: 186-187. 2. Stadler, L.J. 1928. The rate of induced mutation in relation to dormancy, temperature and dose. *Anat. Record.* 41: 97.
1930	**Ronald Aylmer Fisher** publishes *Genetical Theory of Natural Selection*, a formal analysis of the mathematics of selection.	Fisher, R.A. 1930. *The Genetical Theory of Natural Selection.* Clarendon Press, Oxford, UK.
1931	**Curt Stern** and independently **Harriet B. Creighton** and **Barbara McClintock**, provide the cytological proof of crossing over.	1. Stern, C. 1931. Zytologisch-genetische Untersuchungen als Beweise für die Morgansche Theorie des Faktorenaustauschs. *Biol. Zentralbl.* 51: 547-587. 2. Creighton, H.B. and McClintock, B. 1931. A correlation of cytological and genetical crossing-over in *Zea mays*. *Proc. Nat. Acad. Sci.* 17: 492-497.
	Phoebus A. T. Levene and **Lawrence Bass** introduce the chemical component and the basic structure of DNA.	Levene, P.A. and Bass, L.W. 1931. *Nucleic Acids.* Chemical Catalog Company, New York, USA.
1932	**Sewall Wright** stresses the importance of "genetic drift" due to chance in small populations during evolution.	Wright, S. 1932. The roles of mutation, inbreeding, crossbreeding, and selection in evolution. *Proc. VI Internat. Congr. Genetics* 1: 356-366.
	Niels Henrik David Bohr (1922 Nobel Prize Laureate for Physics) introduces the idea of complementarity to biology in a lecture at an international congress of light therapy.	Bohr, N. 1933. Light and life. *Nature* 131: 421-423, 457-459.
	Max Knoll and **Ernst Ruska** (1986 Nobel Prize Laureate for Physics) invent the first electron microscope.	Knoll, M. and Ruska, E. Das Elektronenmikroskop. *Z. Physik* 78: 318-339.
1933	**Emil Heitz** and **Hans Bauer**, and independently **Theophilus Shickel Painter** discover the nature of salivary gland chromosomes.	1. Heitz, E. and H. Bauer. 1933. Beweise für die Chromosomennatur der Kernschleifen in den Knäuelkernen von *Bibio hortulanus* L. *Zeits. Zellf. mikr. Anat.* 17: 67-82. 2. Painter, T.S. 1933. A new method for the study of chromosome rearrangements and the plotting of chromosome maps. *Science* 78: 585-586.

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1933	**Ernst Wolfgang Caspari** analyses the eye-pigment phenomenon in the meal moth *Ephestia.*	Caspari, E. 1933. Über die Wirkung eines pleiotropen Gens bei der Mehlmotte Ephestia Kühniella. *Arch. Entw.-mech.* 130: 352-381.
1934	**Dorothy Crowfoot Hodgkin** (1964 Nobel Prize Laureate for Chemistry) uses X-rays crystallography to illuminate the structure of protein.	Crowfoot, D. 1935. X-ray single crystal photographs of insulin. *Nature* 125: 591-592.
	Ladislaus Laszlo Marton first examines biological specimans with the electron microscope, which achieves magnifications of 200–300,000 ×. Later in 1937, he publishes the first electron micrographs of bacteria.	Marton, L. 1934. La microscopie electronique des onjectes biologiques. *Bull. Acad. Belg. Cl. Sci.* 20: 439-466.
	Alice Evans accomplishes the first typing of a strain of bacteria with bacteriophage.	Evans, A. 1934. Streptococcus bacteriophage: A study of four serological types. *Public Health Rep.* 49: 1386-1401.
1935	**Boris Ephrussi** and **George Wells Beadle** in *Drosophila*, **Alfred Kühn** and **Adolf Friedrich Johann Butenandt** (1939 Noble Prize Laureate for Physiology or Medicine) in *Ephestia*, study the biochemical genetics of eye-pigment synthesis, respectively, the first step of the "one gene, one enzyme" hypothesis.	1. Ephrussi, B. and Beadle, G.W. 1935. La transplantation des disques imaginaux chez le Drosophile. *C. R. Acad. Sci.* (Paris) 201: 98. 2. Ephrussi, B. 1942. Chemistry of "eye-color hormones" of *Drosophila. Quart. Rev. Biol.* 17: 327-338. 3. Kühn, A. and Henke, K. 1935. Über einen Fall von geschlechtsgekoppelter Vererbung mit wechselnder Merkmalsausprägung bei der Mehlmotte Epestia kühniella Zeller. In *Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen. Math.-phys. Klasse.* NF 1, 14. S.247-259, Abb. 4. Butenandt, A., Weidel, W. and Becker, E. 1940. Kynurenin als Augenpigmentbildung auslösendes Agens bei Insekten. *Naturwiss* 28: 63-64.
	Calvin Blackman Bridges publishes the salivary gland chromosome maps for *Drosophila melanogaster.*	1. Bridges, C.B. 1935. Salivary chromosome maps. *J. Hered.* 26: 60-64. 2. Bridges, C.B. 1938. A revised map of the salivary gland X-chromosome. *J. Hered.* 29: 11-13.
	John B. S. Haldane first calculates the spontaneous mutation frequency of a human gene.	Haldane, J.B.S. 1925. The rate of spontaneous mutation in a human gene. *J. Genet.* 31: 317-326.
	Wendell Meredith Stanley (1946 Noble Prize Laureate for Chemistry) crystallizes tobacco mosaic virus and shows it remains infectious. However, he does not recognize that the infectious material is nucleic acid and not protein.	Stanley, W.M. 1935. Isolation of a crystalline protein possessing the properties of tobacco mosaic virus. *Science* 81: 644-645.
1935-1936	**Otto Heinrich Warburg** (1931 Nobel Prize Laureate for Physiology or Medicine) and **Hans von Euler-Chelpin** (1929 Nobel Prize Laureate for Chemistry) isolate pyrimidine nucleotides and determine their structure and action.	1. von Euler, H., Adler, E., and Hellström, H. 1936. *Hoppe-Seyler's Z. Physiol. Chem.* 241: 239. 2. Warburg, O. and Christian, W. 1941. Isolierung und Kristallisation des Gärungsferments Enolase. *Biochem. Z.* 310: 384-421.

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1936	**John Desmond Bernal, F. C. Bauden, N. W. Pirie** and **Isadore Fankuchen** demonstrate that isolated preparations of tobacco mosaic virus (TMV) contain phosphorus as a component of a phospho-ribonucleic acid. They also isolate ribonucleic acids. This challenges the claim by Stanley that the TMV is composed only of protein.	1. Bauden, F.C., Pirie, N.W., Bernal, J.D., and Fankuchen, I. 1936. Liquid crystalline substances from virus infected plants. *Nature* 138: 1051-1052. 2. Bernal, J.D. and Fankuchen, I. 1941. X-ray and crystallographic studies of plant virus. *J. Gen. Physiol.* 25: 111-165.
	Milislav Demerec and **Margaret E. Hoover** point out the correspondence between giant salivary gland chromosome bands and gene maps. Demerec begins to think about a nomenclature for the description of genes.	Demerec, M. and Hoover, M.E. 1936. Three related X chromosome deficiencies in Drosophia. *J. Hered.* 27: 206-212.
1937	**Theodosius Dobzhansky** publishes *Genetics and the Origin of Species*—a milestone in evolutionary genetics.	Dobzhansky, T. 1937. *Genetics and the Origin of Species.* Columbia University Press, New York, USA.
	Albert Francis Blakeslee and **Amos G. Avery** use colchicine to produce artificial polyploidy in plant cells.	Blakeslee, A.F., and Avery, A.G. 1937. Methods of inducing doubling of chromosomes in plants. *J. Hered.* 28: 392-411.
	Arne Wilhelm Kaurin Tiselius (1948 Nobel Prize Laureate for Chemistry) develops electrophoresis technique.	1. Tiselius, A. 1937. A new apparatus for electrophoretic analysis of colloidal mixtures. *Trans. Farad. Soc.* 33: 524-531. 2. Tiselius, A. 1937. Electrophoresis of serumglobin. II. Electrophoretic analysis of normal and immune sera. *Biochem. J.* 31: 524-531. 3. Tiselius, A. and Claesson, S. 1942. Adsorption analysis by interferometric observation. *Arkiv. för kemi., mineralogi och geologi 15 B.* 18: 1-6.
1938	**Theodosius Dobzhansky** and **Alfred Henry Sturtevant** publish the first account of the use of inversions in constructing a chromosomal phylogenetic tree.	Dobzhansky, T. and Sturtevant, A.H. 1938. Inversions in the chromosomes of *Drosophila pseudoobscura.* *Genetics* 23: 28-64.
	William Thomas Astbury and **Florence O. Bell** first use X-ray crystallography to analyze the structure of DNA.	Astbury, W.T. and Bell, F.O. 1938. X-ray study of thymonucleic acid. *Nature* 141: 747-748.
	John Desmond Bernal, **Isadore Frankuchen**, and **Max Ferdinand Perutz** (1962 Nobel Prize Laureate for Chemistry) study chymotrypsin and hemoglobin using X-ray crystallography.	Bernal, J.D., Fankuchen, I., and Perutz, M.F. 1938. An X-ray study of chymotrypsin and haemoglobin. *Nature* 141: 523-524.
1939	**Emory L. Ellis** and **Max Delbrück** establish the concept of the one-step viral growth cycle for a bacteriophage active against *E. coli*, marking the beginning of modem phage work.	Ellis, E.L. and Delbrück, M.L. 1939. The growth of bacteriophage. *J. Gen. Physiol.* 22: 365-384.
1940	**Edmund Briscoe Ford** defines **GENETIC POLYMORPHISM**.	Ford, E.B. 1940. Polymorphism and Taxonomy. In *The New Systematics* (ed. Huxley, J.), pp. 493-513. Clarendon Press, Oxford, UK.
	Karl Landsteiner and **Alexander Solomon Wiener** discover the Rh blood factor.	Landsteiner, K. and Wiener, A.S. 1940. An agglutinable factor in human blood recognized by immune sera for rhesus blood. *Proc. Soc. Exp. Biol. Med.* 43: 223-224.

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1941	**George Wells Beadle** and **Edward Lawrie Tatum** (both are 1958 Noble Prize Laureates for Physiology or Medicine) develop the "one-gene, one-enzyme" hypothesis through their experiments on *Neurospora*, a bread mold.	Beadle, G.W. and Tatum, E.L. 1941. Genetic Control of Biochemical Reactions in *Neurospora*. *Proc. Nat. Acad. Sci.* 27: 499-506.
	Kenneth Mather coins the term **POLYGENE** and describes polygenic traits in various organisms.	Mather, K. 1941. Variation and selection of polygenic characters. *J. Genet.* 41: 159-193.
	Archer John Porter Martin and **Richard Laurence Millington Synge** (both are 1952 Noble Prize Laureates for Chemistry) begin the development of partition chromatography and apply it to amino acid analysis.	Martin, A.J.P. and Synge, R.L.M. 1941. A new form of chromatogram involving two liquid phases. *J. Biochem.* 35: 1358-1368.
1942	**Salvador Edward Luria** and **Thomas Foxen Anderson** obtained the first high-quality electron micrograph of a bacteriophage.	Luria, S.E. and Anderson, T.F. 1942. The identification and characterization of bacteriophages with the electron microscope. *Proc. Nat. Acad. Sci.* 28: 127-130.
1943	**Salvador Edward Luria** and **Max Delbrück** (both are 1969 Noble Prize Laureate for Physiology or Medicine) demonstrate that bacterial resistance to virus infection is caused by random mutation and not adaptive change adequate evidence of spontaneous mutation.	1. Luria, S.E. and Delbrück, M. 1943. Mutations of bacteria from virus sensitivity to virus resistance. *Genetics* 28: 491-511. 2. Luria, S.E. 1945. Mutations of bacterial viruses affecting their host range. *Genetics* 30: 84-99.
1944	**Oswald T. Avery**, **Colin M. Macleod**, and **Maclyn McCarty** describe the pneumococcus transforming principle, suggesting that DNA is the hereditary chemical.	Avery, O.T., MacLeod, C.M., and McCarty, M. 1944. Studies on the chemical nature of the substance inducing transformation of pneumococcal types. *J. Exp. Med.* 79: 137-158.
1945	**Edward B. Lewis** (1995 Noble Prize Laureate for Physiology or Medicine) designates that there are two different types of position effects, S-type (stable) and V-type (variegated).	1. Lewis, E.B. 1945. The relation of repeats to position effects in *Drosophila melanogaster*. *Genetics* 30: 137-166. 2. Lewis, E.B. 1950. The phenomenon of position effect. *Adv. Genet.* 3: 73-115.
	Erwin Brand and co-workers reports the first complete amino acid analysis of a protein, beta-lactoglobulin, by chemical and microbiological methods.	Brand, E., Saidel, L.J., Goldwater, W.H., Kassell, B., and Ryan, F.J. 1945. The empirical formula of beta-lactoglobulin. *J. Am. Chem. Soc.* 67: 1524-1532.
1946	**Joshua Lederberg** (1958 Noble Prize Laureate for Physiology or Medicine) and **Edward Lawrie Tatum** demonstrate genetic recombination in bacteria.	1. Lederberg, J. and Tatum, E.L. 1946. Novel genotypes in mixed cultures of biochemical mutants of bacteria. *Cold Spring Harb. Symp. Quant. Biol.* 11: 113-114. 2. Lederberg, J. and Tatum, E.L. 1946. Gene recombination in *E. coli*. *Nature* 158: 558-559.
	Max Delbrück, William T. Bailey, and **Alfred D. Hershey** (1969 Noble Prize Laureate for Physiology or Medicine) demonstrate genetic recombination in bacteriophage.	1. Delbrück, M. and Bailey, W.T. 1946. Induced mutations in bacterial viruses. *Cold Spring Harbor Symp. Quant. Biol.* 11: 33-37. 2. Hershey, A.D. 1946. Spontaneous mutations in bacterial viruses. *Cold Spring Harb. Symp. Quant. Biol.* 11: 67-77.

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1948	**Edward B. Lewis** studies position pseudoalleism in *Drosophila*.	1. Lewis, E.B. 1948. Pseudoallelism in *Drosophila melanogaster. Genetics* 33: 113. 2. Lewis, E.B. 1951. Pseudoallelism and gene evolution. *Cold Spring Harbor Symp. Quant. Biol.* 16: 159-174. 3. Lewis, E.B. 1954. Pseudoallelism and the gene concept. *Proc. IX Int. Congr. Genet.*, Caryol. Suppl. 100-105. 4. Lewis, E.B. 1955. Some aspects of position pseudoallelism. *Am. Nat.* 89: 73-89
1949	**James V. Neel** and **E. A. Beet** independently provide genetic evidence that the sickle-cell disease is inherited as a simple Mendelian autosomal recessive.	1. Neel, J.V. 1949. The inheritance of sickle cell anemia. *Science* 110: 64-66. 2. Beet, E.A. 1949. The genetics of sickle cell trait in a Bantu tribe. *Ann. Eur. Gen.* 14: 279-282. 3. Beet, E.A. 1949. Primary splenic abscess and sickle cell disease. *East African Med. J.* 26: 180-186.
	Linus Carl Pauling finds that sickle cell hemoglobin showed different electrophoretic properties than normal hemoglobin. This demonstrates that genetic mutations lead to specific chemical changes in protein molecules.	Pauling, L., Itano, H.A., Singer, S.J., and Wells, I.C. 1949. Sickle cell anemia, a molecular disease. *Science* 110: 543-548.
1950	**Edwin Chargaff** discovers base equivalencies in DNA: the amounts of adenine (A) and thymine (T) are always equal, as are the amounts of guanine (G) and cytosine (C). Later this is called "Chargaff's Rules", which lays the foundations for nucleic acid structural studies.	1. Chargaff, E. 1950. Chemical specificity of nucleic acids and mechanism of their enzymic degradation. *Experientia* 6: 201-209. 2. Chargaff, E. 1951. Structure and function of nucleic acids as cell constituents. *Fed. Proc.* 10: 654-659.
	Linus Carl Pauling (1954 Noble Prize Laureate for Chemistry and 1962 for Peace), **Robert B. Corey** and co-workers publish their alpha helix model of polypeptide protein structure.	1. Pauling, L. and Corey, R.B. 1950. Two Hydrogen-bonded spiral configurations of the polypeptide chain. *J. Am. Chem. Soc.* 72: 5349. 2. Pauling, L., Corey, R.B. and Branson, H.R. 1951. The structure of proteins, two hydrogen-bonded helical configurations of the polypeptide chain. *Proc. Natl. Acad. Sci. USA.* 37: 205-511. 3. Pauling, L. and Corey, R.B. 1953. Stable configurations of polypeptide chains. *Proc. Roy. Soc. Lond. B* 141: 21-33.
	Barbara McClintock (1983 Noble Prize Laureate for Physiology or Medicine) first reports on "transposable elements" known today as "jumping genes".	1. McClintock, B. 1950. The origin and behavior of mutable loci in Maize. *Proc. Natl. Acad. Sci. USA* 36: 344-355. 2. McClintock, B. 1956. Controlling elements and the gene. *Cold Spring Harb. Symp. Quant. Biol.* 21: 197-216.

(To be continued)