Timeline of Genomics (1865-1900)*

Year	Event and Theoretical Implication/Extension	Reference
1865	**Gregor Mendel** establishes the laws of segregation and independent assortment.	Mendel, G. 1865. Versuche über Pflanzenhybriden. *Verh. Naturforsch. Ver. Brünn* 4: 3-47.
1866	**Ernst Heinrich Häckel** hypotheses that the nucleus of a cell transmits its hereditary information.	Häckel, E. 1866. *Generelle Morphologie der Organismen.* G. Reimer, Berlin, Germany.
1867	**Wilhelm Friedrich Benedict Hofmeister** establishes the regularity of the "dissolution" of the nucleus prior to division of the maternal cell, and the appearance of new nuclei in daughter cells.	Hofmeister, W. 1867. *Die Lehre von der Pfanzenzelle.* Verlag von Wilhelm Engelmann, Leipzig, Germany.
1869	**Francis Galton** claims that intelligence is inherited as a straightforward trait.	Galton, F. 1869. *Hereditary Genius: An Inquiry into Its Laws and Consequences.* The Macmillan Co., London, United Kingdom.
1871	**Johann Friedrich Miescher** discovers and isolates **NUCLEIN** (DNA) in the cells from pus in open wounds. It became known as nucleic acid after 1874, when Miescher separated it into a protein and an acid molecule.	Miescher, F. 1871. Über die chemische Zusammensetzung der Eiterzellen. In *Medicinisch-chemische Untersuchungen aus dem Laboratorium für angewandte Chemie zu Tübingen.* (Hoppe-Seyler, F., ed.) 4: 441-460. A. Hirschwald, Berlin, Germany.
	Charles Darwin describes the role of sexual selection in evolution for the first time.	Darwin, C. 1871. *The Descent of Man and Selection in Relation to Sex.* John Murray, London, United Kingdom.
1873	**Friedrich Anton Schneider** first describes pictures of the nucleus in division (mitosis) in cells of cleaving eggs of the isoturbellarian worm, *Mesostomum ehrenbergii.* He observed prophase, metaphase, and the formation of a spindle.	Schneider, A. 1873. Untersuchungen über Plathelminthen. *Oberhessischen Gesellschaft für Natur und Heilkunde.* 14: 69-140.
1875	**Wilhelm August Oscar Hertwig** establishes the principle of fertilization. By studying the reproduction of the sea urchin he concludes that fertilization in both animals and plants consists of the physical union of the two nuclei contributed by the male and female parents.	Hertwig, O. 1876. Beitrage zur Kenntniss der Bildung, Befruchtung und Theilung des thierischen Eies. *Morphol. Jahr.* 1: 347-452.
	Eduard Adolf Strasburger accurately describes the process of mitotic cell division in a series of experiments.	Strasburger, E. 1875. *Zellbildung und Zellteilung.* Jena, Germany.
1876	**Wilhelm Friedrich Kühne** finds a substance in pancreatic juice that degrades other biological substances (trypsin). He subsequently proposes the term "Enzym" instead of "diastase" and distinguishes enzymes from the micro-organisms that produce them.	1. Kühne, W. 1877. Über das Verhalten verschiedener organisirter und sog ungeformter Fermente. *Verhandlungen des Heidelb. Naturhist. Med. Vereins* (Neue Folge) 1: 190-193. 2. Kühne, W. 1877. Erfahrungen und Bemerkungen über Enzyme und Fermente. *Untersuchungen a.d. physiol. Institut der Universität Heidelberg* 1: 291-324.

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Year	Event and Theoretical Implication/Extension	Reference
1876	**Edouard van Beneden** discovers the cell center. He found an extremely successful subject, eggs of the horse roundworm (*Ascaris megalocephala*), which are large and have few chromosomes (∼4, as few as 2 in some strains).	van Beneden, E. 1876. Contributions à l'histoire de la vésicule germinative et du premier noyau embryonnaire. *Bull. Acad. Roy. Sci. Belg.* 41: 79.
1877	**Hermann Fol** reports watching the spermatozoon of a starfish penetrate the egg. He saw the transfer of the intact nucleus of the sperm into the egg, where it became the male "pronucleus". Later in 1879, he proved that fertilization has to be accomplished by a single spermatozoon.	1. Fol, H. 1877. Sur le commencement de l'hénogénie chez divers animaux. *Arch. Zool. Exper. Gen.* 6: 145-169. 2. Fol, H. 1879. Recherches sur la fécondation et le commencement de l'hénogénie chez divers animaux. *Mem. Soc. Phys. Hist. Nat. Geneve* 26: 92-397.
1878	**W. Schleicher** coins the term **KARYOKINESIS**.	Schleicher, W. 1878. Die Knorpelzellteilung. *Arch. Mikr. Anat.* 16: 248-300.
1879	**Albrecht Kossel** (1910 Nobel Prize Laureate for Physiology or Medicine) isolates nucleoproteins from the heads of fish sperm cells.	
1881	**Edouard-Gérard Balbiani** finds the Dipteran, *Chironomus*, has large banded chromosomes in its salivary gland nuclei. This is later found to be true for Diptera in general.	Balbiani, E.G. 1881. Sur la structure de noyau des cellules salivaires chez les larves de Chironomus. *Zool. Anz.* 4: 637-641, 662-666.
	Wilhelm Olbers Focke coins the term **XENIA** to denote immediate effect of pollen on the endosperm in the maize seed.	Focke, W.O. 1881. *Die Pflanzenmischlinge.* Bornträger, Berlin, Germany.
1882	**Robert Koch** (1905 Nobel Prize Laureate for Physiology or Medicine) develops a technique for staining and identifying bacteria in pure culture by plating them on solid media (first gelatin, later agar).	Koch, R. 1882. Die Åtiologie der Tuberkulose. *Berl. Klin. Wochenschr.* 15: 221-230.
	Walther Flemming discovers lampbrush chromosomes, and coins the terms **CHROMATIN**, **MITOSIS**, and **SPIREME**.	Flemming, W. 1882. *Zellsubstanz, Kern und Zellteilung.* F. C. W. Vogel, Leipzig, Germany.
	Eduard Adolf Strasburger coins the terms **CYTOPLASM** and **NUCLEOPLASM**.	
1883	**Carl de Laval** invents the first centrifuge.	
	Wilhelm Roux proposes a possible explanation for the function of mitosis that mitosis provides correct and uniform division of the nuclear substance into two equal and identical halves.	Roux, W. 1883. *Über die Bedeutung der Kerntheilungsfiguren: Eine hypothetische Eršrterung.* Engelmann, Leipzig, Germany.
	Edouard van Beneden announces the principles of inheritable continuity of chromosomes and reports the occurrence of chromosome reduction at germ cell formation. The sperm and egg are haploid and fertilization restores the diploid chromosome number.	van Beneden, E. 1883. Recherches sur la maturation de l'oeuf et la fécondation. *Arch. Biol.* 4: 610-620.
	August Friedrich Leopold Weismann points out the distinction in animals between the somatic cell line and the germ cells, stressing that only changes in germ cells are transmitted to further generations.	Weismann, A. 1883. *Über die Vererberung.* Ein Vortrag, Jena, Germany.

Year	Event and Theoretical Implication/Extension	Reference
1883-1903	**Albrecht Kossel** discovers that DNA contains the bases, adenine (A), cytosine (C), guanine (G), and thymine (T).	Guanine 1. Kossel, A. 1883. *Chem. Ber.* 17: 537. 2. Kossel, A. 1883-1884. *Z. Physiol. Chem.* 8: 404. Adenine and Thymine 3. Kossel, A. 1885. *Chem. Ber.* 18: 79. 4. Kossel, A. 1886. *Z. Physiol. Chem.* 10: 248. 5. Kossel, A. 1887. *Chem. Ber.* 20: 3356. 6. Kossel, A. 1888. *Z. Physiol. Chem.* 12: 241. 7. Kossel, A. 1888. Über eine neue base auf den pflanzenreich. *Chem. Ber.* 21: 2164. 8. Kossel, A. and Neumann, A. 1893. Über das Thymin, ein Spaltungsproduct der Nucleinsäure. *Chem. Ber.* 26: 2753-2756. 9. Kossel, A. and Neumann, A. 1894. Darstellung und Spaltungsproducte der Nucleinsäure (Adenylsäure). *Chem. Ber.* 27: 2215-2222. 10. Kossel, A. 1896. *Z. Physiol. Chem.* 22: 188. Cytosine 11. Kossel, A. and Steudel, H.Z. 1903. *Physiol. Chem.* 38: 49. Uracil 12. Kossel, A. and Steudel, H.Z. 1902-1903. *Physiol. Chem.* 37: 245.
1884	**Eduard Adolf Strasburger** creats the terms **PROPHASE**, **METAPHASE**, and **ANAPHASE**.	Strasburger, E. 1884. Die Controversen der indirecten Kemtheilung. *Arch. Mikr. Anat.* 23: 301.
1884-1885	**Oscar Hertwig**, **Eduard Strasburger**, **Rudolf Albert von Kölliker**, and **August Weismann**, independently of one another, put forward the hypothesis that the nucleus is the carrier of hereditary properties.	1. Hertwig, O. 1884. *Untersuchungenzur Morphologie und Physiologie der Zelle.* Vlg. G. Fischer, Jena, Germany. 2. Strasburger, E. 1884. *Neue Untersuchungen uber den Befruchtungsvorgang bei den Phanerogamen als Grunglagefur eine Theorie der Zeugung.* Jena, Germany.
1885	**August Weismann** advocates the **GERM-PLASM** theory and establishes the Weismann Barrier. This eventually led to the rediscovery of Gregor Mendel's work.	1. Weismann, A. 1885. The continuity of the germ-plasm as the foundation of a theory of heredity. In *Essays Upon Heredity and Kindred Biological Problems.* 1889. Oxford at the Clarendon Press, United Kingdom. 2. Weismann, A. 1893. *The Germ-Plasm.* Charles Scribner's Sons, New York, United States.
	Carl Rabl theorizes the individuality of chromosomes in all stages of the cell cycle.	Rabl, C. 1885. Über Zellteilung. *Morph. Jahrbuch.* 10: 214-330.

Year	Event and Theoretical Implication/Extension	Reference
1887	**August Weismann** elaborates an all-encompassing theory of chromosome behaviour during cell division and fertilization, and predicts the occurrence of a reduction division (meiosis) in all sexual organisms.	Weismann, A. 1887. On the number of polar bodies and their significance in heredity. In *Essays Upon Heredity and Kindred Biological Problems*. 1889. Oxford at the Clarendon Press, United Kingdom.
	Wilhelm Roux suggests that the linear arrangements of chromosomes are transmitted equally to both daughter cells at meiosis.	
	Edouard van Beneden demonstrates chromosome reduction in gamete maturation and discovers each species has a fixed number of chromosomes, thereby confirming **August Weismann**'s predictions.	van Beneden, E. and Neyt, A. 1887. Nouvelles recherches sur la fécondation et la division mitosique chez l'Ascaride mégalocéphale. *Bull. Acad. Roy. Sci. Belg.*, n.s. 14: 238.
	Richard Julius Petri invents the Petri dish, a new type of microbe culture dish for semi-solid media.	Petri, R.J. 1887. Eine kleine Modification des Koch'schens plattenverfahrens. *Centralblatt für bacteriologie und Parasitenkunde* 1: 279-280.
	Hermann Emil Fischer (1902 Nobel Prize Laureate for Chemistry) elaborates the structural patterns of proteins.	
1888	**Heinrich Wilhelm Gottfried von Waldeyer-Hartz** coins the term **CHROMOSOME**.	Waldeyer, W. 1888. Über Karyokineze und ihre Beziehung zu den Befruchtungsvorgängen. *Arch. Mikr. Anat.* 32: 1.
1889	**Francis Galton** formulates the Law of Ancestral Inheritance, a statistical description of the relative contributions to heredity made by one's ancestors.	Galton, F. 1889. *Natural Inheritance.* The Macmillan Co., London, United Kingdom.
	Richard Altmann renames nuclein as **NUCLEIC ACID**.	
1890	**Theodor Boveri** establishes two main theories of individuality and continuity of chromosome: (1) Chromosomes remain organized and individual structures through the process of cell division; (2) Sperm and egg contribute the same number of chromosomes.	Boveri, T. 1890. Zellenstudien III: über das Verhalten der chromatischen Kemsubstanz bei der Bildung der Richtungskorper und bei der Befruchtung. *Jena. Zeit. Naturwiss.* 24: 374.
	Richard Altmann develops the theory of the protoplasm granular structure: elements of the protoplasm are "bioblasts" (granules), independent microorganisms. Altmann's "bioblasts" were later identified as mitochondria.	Altmann, R. 1890. *Die Elementarorganismen und ihre Beziehungen zu der Zellen.* Veit & Comp, Leipzig, Germany.
1892	**Francis Galton** invents the first system of fingerprinting.	Galton, F. 1892. *Fingerprints.* The Macmillan Co., London, United Kingdom.
1894	**Martin Heidenhain** introduces the term **TELOPHASE**.	Heidenhain, M. 1894. *Arch. Mikr. Anat.* 43: 423.
	Hans Driesch finds that all nuclei of an organism are equipotential but varied in their activity in accordance with the differentiation of tissues.	Driesch, H. 1894. *Analytische Theorie der organschen Entwicklung.* W. Engelmann, Leipzig, Germany.

Year	Event and Theoretical Implication/Extension	Reference
1894	**William Bateson** emphasizes the importance of discontinuous variations, foreshadowing the rediscovery of Mendel's work.	1. Bateson, W. 1894. *Materials for the Study of Variation.* The Macmillan Co., New York, United States. 2. Bateson, W. 1899. Hybridisation and cross-breeding as a method of scientific investigation. *J. Royal Horticult. Soc.* 24: 59-66.
1896	**Edmund Beecher Wilson** establishes a synthesis of cytology, ontogenetics and genetics.	Wilson, E.B. 1896. *The Cell in Development and Heredity.* The Macmillan Co., New York, United States.
1898	**Sergey Gavrilovich Navashin** and **Léon Guignard** discover independently the developmental origin of endosperm from double fertilization in angiosperms.	Guignard, L. Le developpement du pollen et la reduction chromatique dans le Naias major. *Arch. Anat. Micro.* 2: 505.
	Walther Flemming determines the chromosome number as 24 pairs in man.	
1900	**Carl Correns**, **Hugo de Vries**, and **Erik von Tschermak** claim to have independently discovered and verified Gregor Mendel's principles, marking the beginning of modern genetics.	1. Correns, C. 1900. G. Mendels Regel über das Verhalten der Nachkommenschaft der Rassenbastarde. *Ber. Dtsch. Bot. Ges.* 18: 158-168. 2. de Vries, H. 1900. Das Spaltungsgesetz der Bastarde. *Ber. Dtsch. Bot. Ges.* 18: 83-90. 3. de Vries, H. 1900. Sur la loi de disjonction des hybrides. *Compt. Rend. Acad. Sci. (Paris).* 130: 845-847. 4. von Tschermak, E. 1900. Über Künstliche Kreuzung bei Pisum sativum. *Ber. Dtsch. Bot. Ges.* 18: 232-239.
	Walter Stanborough Sutton observes homologous pairs of chromosomes in grasshopper cells, showing that during meiosis the chromosome pairs split, and each chromosome goes to its own cell.	Sutton, W.S. 1900. The spermatagonial divisions in *Brachystola magna. Kansas Univ. Quart.* 9: 135-160.
	Karl Landsteiner (1930 Nobel Prize Laureate for Physiology or Medicine) establishes ABO blood group system.	Landsteiner, K. 1900. Zur Kenntnis der antifermentativen, lytischen und agglutinierenden Wirkungen des Blutserums in der Lymphe. *Zbl. Bakteriol. Orig.* 27: 357-362.

(To be continued)

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