

	Discovery	Practical Consequences	Scientist
1	Symbiogenesis Formation of a new type of organism by fusing one cell into another	Biology moves past "survival of fittest" to cooperation and partnership	Konstantin Mereschkowsky 1910* Boris Kozo-Polyansky 1924* Lynn Margulis 1971 *not acknowledged by Futuyma, Coyne or Dawkins
2	Macroevolution is punctuated evolution by major genome reorganizations that produce new species and is very different from gradual Darwinian "microevolution"	Stage 3 and 4 cancers make evolutionary leaps. It is impossible to comprehend or cure cancer without distinguishing large scale macro-evolutionary jumps from small incremental changes. The two are completely different.	Richard Goldschmidt, "The Material Basis of Evolution" 1940
3	Transposition Cells rearrange mobile DNA elements; discovered Mobile Genetic Elements aka "Controlling Elements" which guide evolutionary changes	McClintock's contribution rivaled Darwin's. She won the Nobel, yet is not well known. First to observe evolution in real time and decipher how it worked. Starting point for how all life manages stress and evolves at the cellular level.	Barbara McClintock 1950-1953
4	Epigenetics Control of DNA sequence expression by the way it is packaged in the nucleus. Parents pass learned adaptations to their offspring.	Our lifestyle choices affect the heredity of our children. Evolution involves much more than just "genes." Holds profound implications for nutrition, exercise, addiction, drug treatment, smoking and family / social environment	Conrad Waddington 1942-1957
5	Horizontal Gene Transfer Even distantly related organisms exchange DNA with one another. Bacterial "Infectious heredity" alters offspring	Bacteria outsmart any antibiotic. This is why we are losing the antibiotic resistance "arms race" and why we are powerless against "superbugs."	Joshua Lederberg et al 1952
6	DNA Repair Ability of cells to repair chemical or physical damage to their DNA. Repaired DNA sometimes has different information than the old.	Contradicts the "meaningless and purposeless" overtones of Neo-Darwinism. Evolution is not random and has goals. Many rare genetic diseases (i.e. Werner syndrome) are caused by failures in DNA repair systems	Jean Weigle 1953 Evelyn Witkin 1966 Amanda Goodman 1998
7	Reverse Transcription Ability to copy RNA into DNA	We are not prisoners of our genes. The genome is a dynamic interactive organ of the cell and our DNA is not a "fixed program."	Howard Temin 1970
8	Generation of Novelty and Gene Regulation Repetitive DNA elements provide raw material for formatting gene regulatory networks to generate complex new traits	Early evidence the "Junk DNA" theory was wrong. The best discoveries are being found there. This DNA is where many evolutionary changes get engineered.	Roy Britten & Eric Davidson 1971
9	Endosymbiogenesis Chloroplasts originated when photosynthetic bacteria merged with eukaryotic cells	Our bodies have cells within cells within cells, underscoring the cooperative interdependent fabric of life	Geoffrey Pigott & Noel Carr 1972 Linda Bonen & Ford Doolittle 1975 Lawrence Zablen, Martin Kissel et al 1975
10	Pervasiveness of Mobile Genetic Elements All forms of life, including the simplest microbes, use transposable genetic elements to alter or reformat their genomes.	All organisms are capable of adapting and self-evolving as a proactive response to external changes	Al Bukhari, James Shapiro & Sankar Adhya 1977
11	Archaea A new category of ancient cell is discovered ("archaea") A symbiogenetic fusion between a bacterium and an archaeon was ancestor to all eukaryotes including ourselves	Symbiogenetic "merger acquisitions" featuring a branch of life discovered in the 1970s were a major foundational step in the evolution of all modern life forms	Carl Woese & George Fox 1977
12	Retroviruses as evolutionary building blocks Retroviruses supply genome networks for new complex characteristics like placenta formation, early embryonic development, and innate immunity.	Transforms our understanding of viruses, which are not always predators. Can be detrimental and beneficial. Viruses are the "open source code repository" of the earth and life finds new uses for them.	Chao-Nan Ting, Susan Rosenberg et al 1992 Mark Boyd, Bridget Bax et al 1993 Patrick Venables, Sharon Brookes et al 1995
13	RNA mediated control of gene expression RNA molecules modify gene expression and complex traits such as embryonic development.	DNA sequences once labeled "Junk" produce RNA strands that in turn regulate DNA.	Andrew Fire, SiQun Xu, et al 1998 Yasushi Okazaki, Masaaki Furuno et al 2002 Marcel Dinger, Paulo Amaral et al 2008
14	Linkage between environment and genome change Comparison of neighbors in distinct ecological conditions to show that differences stimulate specific genome changes.	Our bodies and all living things actively adapt to ecological niches, custom adapting us for where we live and work	Eviatar Nevo 1998
15	Large scale modular genome reorganization Sequencing of the human genome shows large-scale modular reorganisations of DNA, not small random mutations	Human genome project showed that our bodies generated new proteins via large Lego-like combinations of DNA data blocks, not just small increments	Eric Lander, Lauren Linton et al 2001
16	Epigenetic transmission of acquired traits Mice alter the DNA of their own sperm, countering a long-standing dogma that genetic information only flows one way	Diet, exercise and environment impact heredity for our children and grandchildren. Major implications for cancer, Alzheimer's and hundreds of diseases. Recognized by most fields but not evolutionary biology	Antonio Giordano et al 2000 Kevin Smith & Corrado Spadafora 2005 Carmine Pittoggi et al 2006
17	Holobionts Organisms are a mosaic of symbiotic life forms called "holobionts." Humans host symbiotic skin and gut bacteria and more, making "microbiomes." Evolution occurs by adding and subtracting symbiotic partners.	Health is greatly impacted by companion organisms in our bodies like gut bacteria that are "not us"; we have to take proper care of them so they can take care of us	Ricardo Guerrero, Lynn Margulis et al 2013

Even some of Charles Darwin's greatest insights have been sidelined. Watch the 15 minute "Discovering the Real Darwin" filmed at Darwin's Down House by Voices from Oxford: www.voicesfromoxford.org/darwin

Reference: Shapiro, James, and Denis Noble. "What prevents mainstream evolutionists teaching the whole truth about how genomes evolve?" *Progress in Biophysics and Molecular Biology* (2021). <https://tinyurl.com/shapironoble> Table has been updated to include the most recent editions of these books as of June 2021. ©2021 Denis Noble and James Shapiro. This is available under the Creative Commons CC-BY-NC-ND license and permits non-commercial use of the work as published, without adaptation or alteration, provided the work is fully attributed. For commercial permissions, contact Denis Noble through his website www.DenisNoble.com.

¹ Azra Raza *The First Cell: and the Human Costs of Pursuing Cancer to the Last* Basic Books (2019)