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Notes on *Richard Dawkins The Oxford Book of Modern Science Writing*
Oxford Press 2008

Martin Rees *Just Six Numbers*
Our explanations of the universe rely on 6 numbers, the fundamental constants of physics.
Many physicists, including Rees, believe their precise values are crucial to the existence of a universe capable of producing biological evolution of some kind p.5.
Basic idea:
The expanse of cosmic matter and space is not an extravagant superfluidity; without it human life would not have occurred.

One of the 6 numbers is N, the ratio of the electrical force that holds atoms together to the gravitational force which holds the universe together; it is 10 to the 36 power. Gravity is dominant because it is always an attraction, while the electric force is largely balance out by positive and negative charges.

Gravity is the right strength to squeeze the gasses making up the stars enough to make them shine. If it were stronger, say 10 30, galaxies would form more quickly, stunting complex evolutionary development, and be much smaller; insects would need thick legs on any planet, and anything our size would be crushed. A weaker gravity could allow even more elaborate evolution.

Peter Adkins *Creation Revisited*
Adkins shows how the universal downhill degradation towards disorder can be harnessed locally to drive processes uphill and build up order, including life. Argues that all change arises from an underlying collapse into chaos or decay. The quality of energy decays. Harnessing the decay results in civilization. “The tendency of energy to chaos is transformed into love or war through the agency of chemical reactions”, ie a rearrangement of atoms. A reaction tends to occur if n the process energy is degraded into a more disbursed chaotic form p. 15.

Helene *Cronin The Ant and the Peacock*
Darwin and Wallace assumed that living things had evolved. The mechanism for evolution was natural selection. The key to how natural selection is able to produce its wondrous results is many small but cumulative changes. P.18.

R.A. Fisher *The Genetical Theory of Natural Selection*
Fisher is considered by Dawkins to be the successor to Darwin. Considers Fisher a mathematician first, and a biologist second. Fisher was one of the three great founders of population, mathematical, and evolutionary genetics and a founder of the neo Darwinian Modern Synthesis. P.19.
Particulate theory of Inheritance. Similar to Mendelian or factorial inheritance. Particles are Genes. It appears that all the main characteristics of the Mendelian system flow from the assumptions of a simple particulate inheritance model.

Theodosius Dobzhansky *Mankind Evolving*
One of the co-founders of the neo-Darwinian Modern Synthesis. Author of one of the most influential books, Genetics and the Origin of the Species.
ME: a lucid exposition of how genes interact with the environment in the determination of the variation among human individuals.

G.C. Williams *Adaption and Natural Selection*
As Fisher was perhaps the first to realize, evolution, at bottom, consists of the changing frequencies of genes in gene pools.
It was left to Williams to apply the same insight clearly to adaptation, the tendency of living organisms to look as though they were designed for a purpose. Cui bono; who benefits from adaptation? Dawkins says adaptations are for the benefit of the genes responsible for the differences between individuals.
The essence of the genetical
theory of natural selection is a statistical bias in the relative rates of survival of alternatives. P.28.

Francis Crick *Life Itself*
Mendelian genetics is digital. Genes themselves are digital. A gene is a sequence of 4 code letters, and the genetic code is universal throughout all known living systems. Life is the execution of programs written using these code elements, in a single universal machine language. This realization was the hammer blow that knocked the last nail into the coffin of vitalism and by extension, dualism. P. 30.

DNA and RNA provide mechanism for replication.

Matt Ridley *Genome*
23 chapters; one for ach chromosome

JBS Haldane
A giant of the neo-Darwinian synthesis.

Fred Hoyle *Man in the Universe*
"looking back along this chain of evolution …I am overwhelmingly impressed by the way in which chemistry has gradually given wa to electronics… Although electrochemical processes are important in plants, organized electronics, in the sense of data processing, does not enter or operate in the plant world. But primitive electronics begin to assume importance as soon as we have a creature that moves around…"

D'Arcy Thomson
Stood aloof from the neo-Darwinian synthesis. He is a patron of a minority school of biologists who, while not quite denying natural selection, prefer to emphasize physical forces as direct determinants of physical form.
"The many structures which display the logarithmic spiral increase, or accumulate, rather than grow." P.71

Nicholas Humphrey One *Self: A Meditation on the Unity of Consciousness*
Why does each of us feel like a single subjective unit. Dawkins considers the question significant.

Steven Pinker
Linguist and evolutionary psychologist

Sir Arthur Eddington. Expedition to Principe in 1919 to observe total solar eclipse, and made observations of a distant star which confirmed Einstein's General Theory of Relativity.

George Gamow; cosmologist and early champion of the Big Bang. Fred Hoyle and his colleagues favored the Steady State theory of continuous creation of matter. The Steady State theory was decisively refuted by the radio telescope observations of Hoyle's colleague at Cambridge, Martin Ryle.

Erwin Schrodinger *What is Life*
Living matter evades the decay into maximum entropy by the process of metabolism of negative entropy, Or sucking of orderliness from the environment.

Per Bak *How Nature Works*

p. 273 f.
"I will argue that complex behavior in nature reflects the tendency of large systems with many components to evolve into a poised 'critical' state, way out of balance, where minor disturbances lead to events, called avalanches, of all sizes. Most of the changes take place through catastrophic events rather than by following a smooth gradual path. The evolution of this very delicate state occurs without design from any outside agent. The state is established solely because of the dynamical interactions among individual elements of the system; the critical state is self-organized. Self organized criticality is so far the only known general mechanism to generate complexity.' Classic example is a growing sand pile.

Claude Shannon, Warren Weaver *The Mathematical Theory of Communication*

p. 297 f.
Claude Shannon best know as the father of information theory. The logarithmic formula for information content he came up with has the same form as the formula developed by Ludwig Boltzmann and still used by physicists to model entropy.

Albert Einstein essay: *What Is the Theory of Relativity*?

p. 314 f.

"The special theory of relativity, on which the general theory rests, applies to all physical phenomena with the exception of gravitation; the general theory provides the law of gravitation and its relation to the other forces of nature. …
"The …principle, on which the special theory … rests, is the 'principle of the constant velocity of light in vacuo'. This principle asserts that light in vacuo always has a definite velocity of propagation (independent of the state of motion of the observer or of the source of the light). The confidence which physicists place in this principle springs from the successes achieved by the electrodynamics of Maxwell and Lorentz. P.…. The special theory …, which was simply a systematic development of the electrodynamics of Maxwell ad Lorentz, pointed beyond itself however. Should the independence of physical laws of the state of motion of the coordinate system be restricted to the uniform translatory motion of coordinate systems in respect to each other? … the choice of its state of motion ought to be subject to no restriction; the laws ought to be entirely independent of this choice (general principle of relativity).

The establishment of this general principle … is made easier by a fact of experience that has long been known, namely, that the weight and inertia of a body are controlled by the same constant (equality of inertial and gravitational mass). Imagine a coordinate system which is rotating uniformly with respect to an inertial system in the Newtonian manner. The centrifugal forces … must, according to Newton's teaching, e regarded as effects of inertia. But these centrifugal forces are, exactly like the forces of gravity, proportional to the masses of the bodies. Ought it not to be possible in this case to regard the coordinate system as stationary and the centrifugal forces as gravitational forces? …the laws according to which solid bodies may be arranged in space do not …accord with the spatial laws attributed to bodies by Euclidian geometry. This is what we mean when we talk of the 'curvature of space'. … In the general theory of relativity, the doctrine of space and time, or kinematics, no longer figures as a fundamental independent of the rest of physics. The geometrical behavior of bodies and the motion of clocks rather depend on gravitational fields, which in turn are produced by matter. P 315-317. [what about linear acceleration?]

Paul Davies *The Goldilocks Enigma* (*The Cosmic Jackpot* in the US)

p. 323
The Goldilocks Enigma title is derived from the fact that the bed, chair, and porridge that goldilocks enjoyed were 'just right'.
Describes Einstein's idea that the universe is a hypersphere, which is finite but unbounded, there is no edge, just as there is no edge to the spherical earth.

WMAP stands for Wilkinson Microwave Anisotropy Probe, which is a satellite sent up to map the cosmic background radiation left over from the Big Bang. WMAP results indicate that Einstein may have been wrong about the shape of the universe.
"The General Theory was designed to take the place of Newton's theory of gravitation. In cosmology, gravity is the dominant force, because of the great mass of the universe.

In Euclidian geometry, the angles in a triangle add up to 180 deg. If we measure the angles in the triangle made by the Earth, Venus, and Mercury, made by bouncing radar waves off of Mercury and Venus, using triangulation, Einstein's prediction of warped space is validated (the angles would add up to more than 180 degrees) (it is really spacetime that is warped, which has also been invalidated. Earth's time warp is measurable. Clocks tick slightly faster at altitude than at sea level.

One of the difficulties people have in conceptualizing a hyper sphere is 'what lies in the middle' (or what lies on the outside) of the hyper sphere. … this s a bit of a red herring… because we are trapped in the hyper-spherical three dimensional 'surface', it does not make a jot of a difference to us whether the interior or exterior region is there or not, or what it contains. … try to put yourself in the position of a flat creature on the surface of a round balloon…. Whatever is on the inside or outside of the balloon does not affect the flat creature's experience, because it cannot access any information beyond the surface of the balloon.

Three possible shapes of a uniform universe: flat, spherical (positive curvature; triangles contain more than 180 degrees) , or saddle (negative curvature; triangles contain less than 180 degrees). WMAP results indicate the universe is flat, so Einstein appears to have been wrong that it is hyper-spherical.

Brian Greene *The Elegant Universe*

p.336 f

"In a paper he sent to Einstein in 1919, Theodor Kaluza proposed that the spatial fabric of the universe might possess more than the three dimensions of common experience. Kaluza realized that this provided an elegant and compelling framework for weaving together Einstein's general relativity and Maxwell's electromagnetic theory into a single entity.

"How can this proposal be squared with the apparent fact that we see precisely three spatial dimensions? The answer was implicit in Kaluza's work and subsequently make explicit by the Swedish mathematician Oskar Klein in 1926: The spatial fabric may have both extended and curled up dimensions. We may see only the extended three dimensions. Kaluza and Klein proposed that our space was made up of three large extended spatial dimensions, and one small circular spatial dimension. Including time, that gives us five dimensions. Cutting edge equipment can detect structures as small as a billionth of a billionth of a meter. So long as an extra dimension is curled up to a size less than this, it is too small for us to detect. Physicists now call the possibility of extra tiny space dimensions Kazula Klein theory.

Dawkins: "Nobel prize winners sometimes disappoint. Obviously good at research, nevertheless you cant help feeling they ought to sound a bit more intelligent, or wise, or

witty, or well read. There are Nobelists who use the platform of the honor to promote bonkers ideas on psychic paranormalism." . 357

Three equations in Newton's theory of gravitation; 14 equations in Einstein's theory of gravitation (general relativity)

Steven Weinberg: *Dreams of a Final Theory*

A symmetry principle is simply a statement that something looks the same from certain different points of view.

Two sides of the human face; cube see from each side; sphere; symmetries that are really important are not the symmetries of things, but the symmetries of (physical) laws.

Douglas Hofstadter; two books on the nature of consciousness: *Godel Escher Bach*; and *I am a strange loop*

John Archibald Wheeler and Kenneth Ford: *Geons, Black Holes, and Quantum Foam*

p. 378 f.

"In this extract from *Geons, Black Holes, and Quantum Foam*, [Wheeler]… introduces his weird idea of "It from Bit", where "Bit" has the information theoretic sense coined by Shannon. I say 'weird', but it is no weirder than much else in quantum physics. The weirdness reflects limitations in our evolved minds rather than in reality. The beautiful truth, when it comes, is bound to seem weird to most of us."

"many students of chemistry and physics, entering upon their study of quantum mechanics, are told that QM shows its essence in waves, or clouds, of probability. A system such as an atom is described by a wave function. This function satisfies the equation that Erwin Schrodinger published in 1926. The electron, in this description, is no longer a nugget of matter located at a point. It is pictured as a wave spread throughout the volume of the atom…

"This picture is alright as far as it goes. It properly emphasizes the central role of probability in QM. The wave function tells where the electron might be, not what it is. But, to my mind, the Schrodinger wave fails to capture the true essence of QM. That essence, as the delayed-choice experiment shows, is *measurement.* A suitable experiment can, in fact, locate an electron at a particular place within an atom. A different experiment can tell us how fast the [an] electron is moving. The wave function is not central to what we actually know about an electron or an atom. It only tells us the likelihood that a

particular experiment will yield a particular result. It is the experiment that provides actual information.

"Measurement, the act of turning potentiality into actuality, is an act of choice, choice among possible outcomes. After the measurement, there are roads not taken. Before the measurement, all roads are possible- one can even say that all roads are being taken at once.

'Thinking about QM in this way, I have been led to think of analogies between the way a computer works and the way the universe works. The computer is built on yes-no logic. So, perhaps, is the universe. Did an electron pass through slit A or slit B? These are the iron posts of observation.

Yet one enormous difference separates the computer and the universe- chance… [In the computer,] Chance plays no role. In the universe, by contrast, chance plays a dominant role. The laws of physics tell us only what *may* happen. Actual measurement tells us what *is* happening. Despite this difference, it is not unreasonable to imagine that information sits at the core of physics, just as it sits at the core of a computer.

"…The universe and all it contains may arise from the myriad yes-no choices of measurement (the 'bits'). Niels Bohr wrestled for most of his life with the question of how acts of measurement (or 'registration') may affect reality. It is registration-whether by a person or a device or a piece of mica (anything that can preserve a record)-that changes potentiality into actuality. I build only a little on the structure of Bohr's thinking when I suggest that we may never understand this strange thing, the quantum, until we understand how information may underlie reality. Information may not be just what we *learn* about the world. It may be what *makes* the world.

"An example of the idea of it from bit: when a photon is absorbed, and thereby 'measured' – until its absorption, it had no true reality- an un-splitable bit of information is added to what we know about the world, *and,* at the same time, that bit of information determines the structure of one small part of the world. It *creates* the reality of the time and place of that photon's interaction.

Less is more… a good principle of design, even a good principle of physics research.…another phrase that I like, borrowed from my Princeton colleague Philip Anderson: 'More is different.' When you put enough elementary units together, you get something that is more than the sum of these units…"

David Deutsch *The Fabric of Reality*

p. 381 f.

"A deep thinking theoretical physicist, he is todays leading proponent of the (again weird, but possibly slightly less so than the competition) 'Many Worlds' interpretation of quantum theory, and pioneer of the futuristic idea of the quantum computer. "

[Mathematics as a form of virtual reality]

“Imagination is a straightforward form of virtual reality. What may not be so obvious is that our ‘direct’ experience of the world through our senses is virtual reality too. For our external experience is never direct; nor do we even experience the signals in our nerves directly- we would not know what to make of the streams of electrical crackles that they carry. What we experience directly is a virtual-reality rendering, conveniently generated for us by our unconscious minds from sensory data plus complex inborn and acquired theories (ie programs) about how to interpret them. “