Scientific Essays in Honor of
H Pierre Noyes
on the Occasion of His 90th Birthday

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Scientific Essays in Honor of **H Pierre Noyes** on the Occasion of His 90th Birthday

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World Scientific

NEW JERSEY • LONDON • SINGAPORE • BEIJING • SHANGHAI • HONG KONG • TAIPEI • CHENNAI

Published by

World Scientific Publishing Co. Pte. Ltd.

5 Toh Tuck Link, Singapore 596224

USA office: 27 Warren Street, Suite 401-402, Hackensack, NJ 07601

UK office: 57 Shelton Street, Covent Garden, London WC2H 9HE

Library of Congress Cataloging-in-Publication Data

Scientific essays in honor of H. Pierre Noyes on the occasion of his 90th birthday / edited by John C. Amson (University of St. Andrews, UK) & Louis H. Kauffman (University of Illinois at Chicago, USA).

pages cm -- (Series on knots and everything ; vol. 54)

Includes bibliographical references.

ISBN 978-981-4579-36-0 (hardcover : alk. paper)

1. Mathematical physics. 2. Physics. I. Noyes, H. Pierre, honouree. II. Amson, John C., editor of compilation. III. Kauffman, Louis H., 1945-- editor of compilation.

QC20.5.S35 2014

530.15--dc23

2013041168

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

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PREFACE

Those who have known Pierre Noyes, whether as a scholar, colleague, supervisor, teacher or friend, will have witnessed both his deep humanity and his keen excitement in the face of a world of physics that offers so much challenge to our understanding. Some of us have experienced it at close hand, others at a distance, and have all benefited each in our own way and come away the richer. No-one who has known Pierre can be unaware of that immense restless inquisitiveness, that urge to speculate, to explore, to appraise. Being close to Pierre in his most alert moments is like trying to catch a thirsty drink from a waterfall with a teaspoon or to contain the hot plasma of ball lightning in a towel. At worst you get soaked or scorched, at best you become inspired. Few are the scientists that have that knack of sharing and communicating their sense of purpose.

Of those with whom he roomed at Harvard in the early days are two who shared his questioning alertness, Thomas Kuhn and Phillip Anderson. The three of them, following their separate paths, each helped bring about a significant change in the way we are to think about the physical world we inhabit and explore: Kuhn with his paradigm shifts, Anderson with his insights into superconductivity, Pierre Noyes with his recognition of discreteness as an essential feature of observation and deduction.

Pierre has spent more than half a century of his professional life at Stanford Linear Accelerator Center, first as head of the theoretical physics division, then as Professor, and later as Emeritus Professor, much of the time concerned with the problems within and related to continuous quantum electrodynamics.

Much more could be said here about the many different facets of his professional career, but these are best summarised in the following section 'About Pierre'. What is not mentioned there is how much of Pierre's achievements and the benefits that have flowed to others have also been made possible by the sixty-two years he has shared with his 'fair, kind, and true' Mary. That bond we are all happy to recognise and to be thankful for.

How Pierre came to his appreciation of the essence of discreteness in physics may be worth telling here. It arose through the accidental discovery of what became known as the ‘Combinatorial Hierarchy’.

Unlikely as it may sound the context in which the Combinatorial Hierarchy originated was not theoretical physics but machine translation, a subfield of computational linguistics. The place was the CLRU (Cambridge Language Research Unit^[1]), the time was the early 1960s, and the catalyst was the coming together of three distinct ideas : a concept of order^[2], Brouwerian fans and spreads^[3], self-organisation and the notion of levels^[4]. The principal agents of this mingling of ideas were Ted Bastin, Margaret Masterman, Frederick Parker-Rhodes, Clive Kilmister, John Amson. Each of those three distinct ideas had their own relevant roles in their own spheres. Each was perceived to be of help in struggling with the many exciting and innovative on-going investigations into the practical goals of automatic machine translation and artificial intelligence. Each was seen to be ably assisted by some of the earliest commercially and academically available computing machines and novel, dedicated software.

At some stage in this Machine Translation milieu it was noticed by Ted Bastin^[5] the theoretical physicist, and Frederick Parker-Rhodes^[6] the polymath, that the organisational structure of their very tentative binary-based system into successive levels was throwing up the iterated four numbers $3 = 2^2 - 1$, $7 = 2^3 - 1$, $127 = 2^7 - 1$ and $2^{127} - 1$, the number of bit-strings in each of the first four levels. It was also noted that the particular algebraic construction employed ensured that the process could not continue beyond those four Levels. It was further noticed that their accumulated sums $3, 10, 137$ and $(2^{127} - 1) + 137 \approx 1.7 \times 10^{38}$ were surprisingly similar to the inverse dimensionless ratios of the super-strong, strong, electromagnetic, and gravitational coupling constants.

From that point on, ‘theoretical physics’ replaced ‘artificial intelligence’ as the prime motivator for further studies of what was then renamed the Combinatorial Hierarchy.

What was not appreciated at that time was the fact that an infinite hierarchy of sets with identical first four level-cardinalities can be constructed on purely set theoretical principles without reference to the algebraic rules deliberately preferred by the CLRU group at the time, and that related hierarchies^[7] had already been introduced by Gödel in 1945, and by von Neumann in the 1950s. The latter’s system (a ‘cumulative hierarchy’) had already been exploited to provide a logical framework for (ZF) Set Theory which together with assumption of the Axiom of Choice provided^[8] a satisfactory foundation (ZFC) for ‘doing mathematics’.

The Combinatorial Hierarchy differed from the cumulative hierarchies in two crucial aspects. The first was deliberately introduced by Parker-Rhodes : the empty-set (or the ‘zero’) was always excluded after the first level. This simple step produced the radically smaller numbers (every one now a prime number, the last three double-Mersenne primes) that related so directly to those four dimensionless physical constants, and also made possible connections with hierarchies of projective

geometries^[9]. The second was discovered by Parker-Rhodes : the growth of the hierarchy stopped at the fourth level (exponential growth trumps geometric growth). It seemed to suggest a new way for ‘doing physics’.

The explorations by the CLRU group might well have jogged quietly along its own path had it not been for the fortunate accident that Ted Bastin, during visits to Stanford, in 1972 and 1973, had been invited by Patrick Suppes to talk to the Stanford Philosophy Department about the Combinatorial Hierarchy, and that in the audience a perhaps previously skeptical Pierre became persuaded to give discreteness a hearing. Pierre joined forces with the CLRU group and helped present its work at von Weizsäcker’s Tutzing Conferences. With his renowned patience and characteristically energetic persuasion Pierre coerced the four ‘B.A.N.K.’ authors to publish their findings in their joint 1979 paper^[10] *On the Physical Interpretation and the Mathematical Structure of the Combinatorial Hierarchy*, in the International Journal of Theoretical Physics. With this behind them, Pierre’s next step was to suggest that, together with Parker-Rhodes, the appropriate thing to do was to promote the expansion of their ideas by forming a wider, international focus through the founding of an association unconstrained by the all too frequent dismissiveness of conventional establishment-based habits of thought.

Pierre had single-mindedly created ANPA, the Alternative Natural Philosophy Association.

Thirty four years later, many of his surviving colleagues have joined together to wish Pierre well on his 90th Birthday by contributing to this Festschrift.

In this volume twenty three authors contribute twenty-one papers.

1. Amson re-constructs the Generalized Kronecker Tensors in the functional analytic form of Unital Operators of every degree, explores their additional properties, and suggests how they can shed new light on existing and novel aspects of nonlinear physics.
2. Bowden makes first steps in reformulating the Combinatorial Hierarchy in the framework of Objects and Morphisms in an arbitrary Category, with special emphasis on the Level Change Operator.
3. Chew discusses quantum cosmological issues to which the special Mersenne primes may prove relevant; the largest of his quintet underpins a ‘macroscopic’ spacetime scale (the scale of life and consciousness) larger than particle scale by another factor of order 10^{19} .
4. Croll introduces his novel ‘BiEntropy’ algorithm that measures order and disorder in bitstrings, and provides examples that may not only apply to future bitstring physics, but also to number theory in that he shows that the sequence of primes is not periodic.
5. Deakin provides an introduction to his theory of constraints linking quantum and classical mechanics and shows how these constraints lead to new insights into

general relativity.

6. Doughty provides his own approach to the Combinatorial Hierarchy using the number theory of Double Fields, and develops his new concept of a catalogue of cosmic geometries.

7. Etter studies the structure of the Boolean lattice released from its particular top and bottom so that it relates to the geometry of the n -cube and investigates the relationship of this structure with link theory and quantum mechanics.

8. Gidney discusses the structure of consciousness in terms of a concept of relative existence.

9. Horner discusses the structure of the organization and productivity of the Alternative Natural Philosophy Association (ANPA) itself over its 33-year existence and how this relates to the Combinatorial Hierarchy.

10. Karmanov and Carbonell discuss two and three-body interactions, including relativistic effects. They note that the three-body system exists only for a limited range of two-body binding energy values, and that for stronger two-body interaction, the relativistic three-body system still collapses. They are led to the notion of critical stability.

11. Kauffman discusses the analysis of discrete physics using derivatives represented by commutators. This includes a dynamic interpretation of the square root of minus one as a clock, a reformulation of work with Noyes on the Feynman-Dyson derivation of electromagnetism and a generalization of Deakin's constraint algebra.

12. Kilmister's report retrospectively assesses in critical detail some of the history and aims of the ANPA research project.

13. Lindesay reflects on three and a half decades of his work with Noyes and its relationship with quantum effects in general relativity and the late time relationships with dark matter, as well as on Dyson's question as to whether intelligent life can be perpetual.

14. McGoveran discusses his Ordering Operator Calculus (OOC) and its applications to discrete physics, especially the notion that tensor equations can be interpreted as a special case of ordering operator equations.

15. Manthey and Matzke discuss the dynamical properties of geometric algebras and their analogies with particle physics, and conclude that driving the entropic expansion of the cosmos we find the Combinatorial Hierarchy.

16. Ord discusses new viewpoints on quantum mechanics and spacetime that emerge from his study of the discrete Dirac equation and the Feynman Checkerboard, allowing him to show that bit-strings provide a simple mechanism for the encoding of relativistic periodic processes, which he illustrates with simple model clocks.

17. Roscoe shows how fractal structure is intimately tied to cosmology, leading necessarily to his conclusion that a definitive signature of a Leibnizian universe is the perception that large scale structure in our experienced Universe is quasi-fractal of dimension 2.

18. Rowlands shows how naturally evolved algebras produce the Double Quaternions and lead naturally to the Dirac equation and to solutions to the Dirac equation from nilpotent elements in the algebra.

19. Shoup shows how the mathematics of special relativity emerges naturally in a discrete context, one in which the passage of time is derived from the motion itself, so that our clock does not tick when there is no motion.

20. Stein summarizes his notion of an oscillating cosmology in a set of thirty-eight concise, and often challenging principles.

21. Young describes the several decades of his work that led to his innovative approach to a new systems biology emerging from biology's surprising complexity, one in which many of its predictions have been verified.

22. In the unusual and unanticipated role as an 'epiloguer' to his own Festschrift Noyes gives voice to his present point of view and predictions arising from his new synthesis of fundamental processes in physics.

In concluding this preface, we wish to say how much this whole project of producing a book of essays for Pierre on his ninetieth birthday has been made possible by the commitment and enthusiasm of all of our contributors. We wish to acknowledge the earlier help of ANPA's current president Keith Bowden in approaching potential contributors. The idea of putting together this book of essays arose, unknown to Pierre, on his previous birthday. That it has turned so quickly from idea to fact in such a short space of time is entirely due to the the help we have received from our essayists at such short notice, and from the willingness and professionalism of our publishers and their editorial team to become involved with this time-constrained project.

Happy Ninetieth Birthday, Pierre, from all of us !

John C. Amson
St Andrews, Scotland, UK

Louis H. Kauffman
Chicago, Illinois, USA

September 2013

Notes to Preface

- (1) The CLRU (1954–1981) was founded by Margaret Braithwaite Masterman (herself a distant relative of Lord Cavendish, 7th Duke of Devonshire, who funded the foundation of the Cavendish Laboratory in Cambridge in 1874 with James Clerk Maxwell as its first professor). Masterman went on to help found in 1965 the Lucy Cavendish College, Cambridge, of which she was its first President. [See *e.g.* Yorick Wilks, *Margaret Masterman*, in : *Early Years in Machine Translation*, edited by W. John Hutchins, Benjamin (2000) pp.279–297].
 - (2) E. W. Bastin, C. W. Kilmister, ‘The Concept of Order : I The space-time structure; II Measurements; III General relativity as a technique for extrapolating over great distances’; *Math. Proc. Camb. Philo. Soc.* Vol.50(02) April, 278–286 (1954); Vol.51(03) July, 454–468 (1955); Vol.53(02) April, 462–472 (1957)
 - (3) (1) L. E. J. Brouwer. ‘Points and Spaces’, *Canadian J. of Mathematics*, vol.6, pp.26–34 (1954);
 (2) L. E. J. Brouwer. *Brouwer’s Cambridge Lectures on Intuitionism*, Ed. D. van Dalen, CUP (1981), re-issued (2011)
 (3) Yorick Wilks, *Language, Cohesion and Form : Margaret Masterman* (Eleven of her papers as a posthumous tribute), C.U.P., Cambridge (2005). See: Paper No.2, ‘Fans and Heads’, fn.1.
 - (4) (1) Ted Bastin, Mary Hesse, Margaret Masterman, ‘Self-Organization and the Notion of Level : A Summary of Discussion held in The Tower Mill, Overy Staithe, Norfolk, and in Cambridge, September – October 1960’. A Working Paper of the Information Structures Unit, 1960. Cambridge Language Research Unit, 20 Millington Road, Cambridge, UK. Recreated with permission, and edited by John Amson, ANPA Proceedings No.32, pp.3–23. (2012)
 (2) E. W. Bastin, A. Woodside. ‘A Theory of the Origin of Mass within a Control Model of the Elementary Particles’, Information Structures Unit, February 20, 1962, Cambridge Language Research Unit. Recreated with permission, and edited, with a Commentary, by John Amson (unpublished, available as PDF) (2012)
 - (5) Ted Bastin, ‘Mathematics of a Hierarchy of Brouwerian Operations’, Information Structures Unit, September 01, 1964, Cambridge Language Research Unit. Recreated with permission, and edited by John Amson, ANPA Proceedings No.19, pp.5–22 (1998)
 - (6) A. F. Parker-Rhodes, J. C. Amson, ‘Hierarchies of Descriptive Levels in Physical Theory’, (original Parker-Rhodes unpublished paper dated 1964, posthumous version edited and annotated by Amson) *Intern. J. of General Systems*, Vol.27, Nos.1,2,3, 57–80 (1998)
 - (7) Wikipedia has helpful information relating to:
 (a) hereditarily finite sets, (b) von Neumann universes.
 - (8) (1) Keith J. Devlin. *The Axiom of Constructibility : a Guide for the Mathematician*, Lecture Notes in Mathematics, No.617 Springer. (1977)
 (2) Keith J. Devlin. *The Joy of Sets : Fundamentals of Contemporary Set Theory*, Second Edition, Undergraduate Texts in Mathematics, Springer-Verlag, Heidelberg (1993)
 (3) Thomas Jech. *Set Theory : 3rd Millennium Edition, revised and expanded*, Springer-Verlag, Berlin (2003)
 - (9) John Amson. ‘Discrimination Systems and Projective Geometries’, in *Discrete and Combinatorial Physics*, Proceedings of ANPA No.9, 158–189 (1988)
 - (10) Ted Bastin, H. Pierre Noyes, John Amson, Clive W. Kilmister, ‘On the Physical Interpretation and the Mathematical Structure of the Combinatorial Hierarchy’, (PITCH) *Intern. J. of Theor. Phys.*, vol 18, No.7, pp.445–488 (1979)
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ABOUT PIERRE

H. Pierre Noyes was born in 1923 in Paris, France, to the American chemist William Albert Noyes, Sr. and Katherine Macy, daughter of Jesse Macy. He grew up in a scientific environment. His father made pioneering determinations of atomic weights, chaired the Chemistry Department at the University of Illinois at Urbana-Champaign from 1907 to 1926, founded and edited several important chemical journals, and received the American Chemical Society's highest award, the Priestley Medal, in 1935. His older half-brothers, W. Albert Noyes, Jr. and Richard Macy Noyes, both became chemists.

Pierre received his baccalaureate degree in physics (*magna cum laude*) in 1943 from Harvard University. One of his room-mates during this time was Thomas Kuhn, author of *The Structure of Scientific Revolutions*; another was Phillip Anderson, author of *More and Different*, who later received the Nobel Prize in Physics for theoretical research into the electronic structure of magnetic and disordered systems. Before moving on to doctoral studies, Pierre spent a year at the Antenna Group at the MIT Radiation Laboratory and served in the US Navy for two years as an Aviation Electronics Technician Mate. Pierre earned his Ph.D. in theoretical physics from the University of California at Berkeley in 1950 doing research under the direction of Robert Serber with Geoffrey Chew as his advisor. Pierre's first doctoral problem was pion-pion scattering, followed by a second problem: meson production from proton-deuteron decay. His work under Chew was among the early applications of S-matrix theory. After earning his Ph.D., Pierre spent a postdoctoral year on a Fulbright scholarship at the University of Birmingham, UK, under the direction of Rudolf Peierls.

Pierre's career included several academic and research positions. He first worked as a post-doctoral fellow and then as assistant professor of Physics at the University of Rochester (1952–5). During that time, he compiled and edited the Proceedings of the 2nd, 3rd, 4th, and 5th Rochester Conferences on High Energy Physics. During the summers of those years, he worked at Project Matterhorn at Princeton, researching thermonuclear weapons (1952) and at the Brookhaven National Laboratory (1953). In the summer of 1954 he worked on calculating the binding energy of the triton using a particular non-relativistic, quantum mechanical potential model fitted to the low energy nucleon-nucleon parameters at the Lawrence Berkeley National Laboratory in Berkeley, California.

In 1955 Pierre joined the Theoretical Division of what was to become the

Lawrence Livermore National Laboratory. From 1956 to 1962 he served there as group leader of the General Research Group, under co-founder and director Edward Teller. During that time, he also served as co-chair of the design-review pre-mortem committee for the devices tested on Christmas Island in 1962 during Operation Dominic I, including the UGM-27 Polaris submarine-launched ballistic missile and Minuteman II intercontinental ballistic missile (ICBM) warhead prototypes.

During a sabbatical from his work at Lawrence Livermore in 1957 and 1958 Pierre was Leverhulme Trust Lecturer in the Experimental Physics Department of the University of Liverpool. He also worked as a consultant to General Atomics under Freeman Dyson and Ted Taylor for Project Orion (a nuclear explosion propelled space ship) from 1958 to 1961 at the invitation of Professor Dyson.

In 1961 Pierre served as AVCO visiting professor at Cornell University. Starting in 1962 he worked at SLAC as head of theoretical physics until he was replaced by Sidney Drell (who combined that responsibility with being Deputy Director of SLAC). He progressed from associate professor from 1962 through 1967 to professor (at SLAC, 1967–2002) and was awarded emeritus status in that rank on May 1, 2000. He collaborated with Richard Shoup at the Boundary Institute.

Pierre served as the Associate Editor of the Annual Reviews of Nuclear Science from 1962 until 1977. In 1979 he received an Alexander von Humboldt U.S. Senior Scientist Award, primarily to continue his theoretical work on the quantum mechanical three body problem for strongly interacting particles. In that same year he joined with John Amson, Ted Bastin, Clive W. Kilmister and A. Fredrick Parker-Rhodes, with whom he been collaborating on approaches to discrete physics *via* the ‘Combinatorial Hierarchy’ since 1973, to found the Alternative Natural Philosophy Association (ANPA), and was president of that organization until 1987.

In his early career Pierre primarily focused on nuclear forces from an elementary particle point of view. In *Inward Bound*, Abraham Pais had commented, correctly, that no one’s work along this line lead to any fundamental new insights into elementary particle theory. Pierre’s research into this area confirmed that the phenomenological analysis of nucleon-nucleon and pion-nucleon scattering, supplemented by an S-matrix based dispersion theory, shows that quantum field theory is roughly correct for two-particle scattering, and in some cases can be connected to the non-relativistic models used in nuclear physics. The research did not, however, lead to any unique, quantitative model of the strong interactions.

After leaving Lawrence Livermore Laboratory he started working on the quantum mechanical three body problem developed by Ludvig Faddeev, Alt, Grassberger, and Sandhas by reformulating it in the relativistic domain. In 1969 he concluded that any nonrelativistic quantum mechanical three body problem using strictly finite range forces between the pairs necessarily implies a non-local interaction in any three body system, which would extend to indefinitely large distances. A specific example of this is the fact that three identical particles with scattering lengths between the pairs that tend toward infinity will support an indefinitely large

number of three body bound states with their radii increasing as the square of that number, as was shown independently by Vitaly Efimov in a specific model.

Driven by this success, an interest in John Stewart Bell's work, and Thomas Phipps' construction of a covering theory for both classical and quantum mechanics, Pierre was inspired to return his attention to the foundations of quantum mechanics. Around this time (1972-3) he heard a report from Ted Bastin on his combinatorial hierarchy work and met with Bastin and his collaborators (as noted above). The research conducted during this interaction resulted in the development of many papers on finite and discrete physics and cosmology, an area that became known as 'bit-string physics'. This work became Pierre's focus for much of the rest of the 20th century and into the present one. It continues to this day. His contributions to the new field include the following:

- Pierre showed, thanks to a 1952 paper by Freeman Dyson, that the integer value of $\hbar c e^2 = 137$ given by the first three levels of the combinatorial hierarchy could be given physical interpretation as the maximum number of electron-positron pairs which could be distributed within a radius of $\hbar / 2 m e$, using renormalized quantum electrodynamics. Further, the rest energy of this system, $(137 \times (2 m e c^2)) \approx m \pi$, could then suggest that the breakdown of quantum electrodynamics found by Dyson might be due to the strong interactions mediated by pions. The same argument extended to the fourth level suggested that the closure of the scheme at the fourth level, characterized by 2^{127} , could be understood as the formation of a black hole with the Planck mass by that number of baryons of protonic mass concentrated within a radius of $\hbar m p c$. Pierre, however, remained profoundly skeptical of these results until a decade later when David McGoveran showed that the scheme not only allowed one to derive the Sommerfeld-Dirac formula for the fine structure spectrum of hydrogen and then to correct the 137 approximation by correctly calculating the next four significant figures in the inverse fine-structure constant in agreement with experiment, but also to correct the value for Newton's gravitational constant and to compute several other elementary particle coupling constants and mass ratios.

- In a joint paper with Louis Kauffman in 1996, published in the Proceedings of the Royal Society, London (A, Vol.452, 81-95), Pierre and Louis showed that the Feynman-Dyson derivation of electromagnetism from the formalism of quantum mechanics can be given a clear interpretation in terms of discrete physics. They also showed (Physics Letters A, No. 218 (1996), pp.139-146) how the Feynman Checkerboard model for the Dirac equation in 1+1 dimensions could be perfectly formulated in discrete physics with the correct continuum limit.

- Work with Michael Manthey led to a cosmological model which long ago predicted that there was not enough matter to close the universe and that the ratio of dark matter to baryonic matter is 12.7. A consistent scheme developed by Ed Jones (Lawrence Livermore National Laboratories) also predicted a positive cosmological constant of the magnitude that was only observed in 2011.

- Pierre compiled a selection of his papers into the volume *Bit-String Physics : A Finite and Discrete Approach to Natural Philosophy* (World Scientific, 2001) to serve as an introduction to this new field.
- Some of Pierre's letters to Gregory Breit (1989–1981) are in the collection of the Yale University Library.

Pierre's honors include:

- Fullbright Scholarship (University of Birmingham, UK) (1950-1)
- Leverhulme Lecturer in the Experimental Physics Department of the University of Liverpool, UK (1957-8)
- AVCO visiting professor at Cornell University (1961)
- Alexander von Humboldt Senior Scientist Award (1979)
- First Annual Alternative Natural Philosopher Award (1989)
- 50-year Service Award, SLAC National Accelerator Laboratory (2013)

Pierre receives the First ANPA Award, Palo Alto, 1989

back row, l-r

front row, l-r

* The Five Founder Members

○ Treasurer × Secretary

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Arranged in order of age seniority.

Brief biographies are appended to some Contributors' essays.

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