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Reflections on Key Books and Papers (Selections from 40+ books and 1000+ papers)
by Francisco J. Ayala

- ***Darwin's Gift to Science and Religion*.** Joseph Henry Press, 2007

This book's message is that science and religious beliefs need not be in contradiction. If they are properly understood, they cannot be in contradiction because science and religion concern different matters. They are like two windows through which we look at the world—the same world but we see different aspects. Science concerns the processes that account for the natural world: how the planets move, the composition of matter and space, the origin and function of organisms. Religion concerns the meaning and purpose of the world and of human life, the proper relation of people to their Creator and to each other, the moral values that inspire and govern people's lives.

- ***Darwin and Intelligent Design*.** Fortress Press, 2006

A similar message to *Darwin's Gift*, but shorter and intended primarily for a religious audience, rather than for the general public.

- ***Human Evolution. Trails from the Past.* (with C.J. Cela-Conde).** Oxford University Press, 2007

The discovery of fossil remains of human ancestors has increased tremendously in recent years. Scientific discoveries in genetics, genomics, and evolution theory have considerably advanced our knowledge of human biology. *Human Evolution* integrates recent fossil and biological discoveries seeking a more complete understanding of human evolution and human biological nature. Moreover, the book goes beyond biology and explores the origins of language, art, morality, and religion.

- **What the Biological Sciences Can and Cannot Contribute to Ethics.** In *Contemporary Debates in Philosophy of Biology*, Wiley-Blackwell, 2010
- **Biology Precedes, Culture Transcends: An Evolutionist's View of Human Nature.** *Zygon* Vol.33, December 1998
- **The Biological Roots of Morality.** *Biology and Philosophy* Vol. 2, July 1987

Philosophers and theologians advanced over the centuries a variety of accounts of the origins of ethics and morality. After Darwin, numerous philosophers, theologians and evolutionists argued that morality needs to be explained biologically, as an outcome of the evolutionary process, while others hold on to religious and other traditional explanations. I argue that a proper account of the origin of morality needs to distinguish between (1) moral judgments and (2) the norms or codes by which we judge what

is good and what is evil. Our disposition to judge actions as either good or evil is, I argue, determined by our biological make-up, by the exalted intelligence that we acquired from our evolution. Moral codes, however, are the outcome of cultural evolution including social and religious traditions—this is why norms of morality vary among human groups and change through time.

- ***Studies in the Philosophy of Biology*** **(editor, with Th. Dobzhansky).** Macmillan/University of California, 1974

Up until the mid-twentieth century, philosophy of science was philosophy of physics. However, new philosophical issues and new insights were emerging from the rapidly advancing biological sciences. The great twentieth-century evolutionist Theodosius Dobzhansky and I convened twenty eminent scholars, philosophers and biologists, including several Nobel laureates, to write essays and to discuss them during ten days of "isolation" in the magnificent Villa Serbelloni by Lake Como, in northern Italy. *Studies in the Philosophy of Biology* is often considered one of the foundation documents of the – by now very prolific – philosophy of biology.

- **The Nature of Science: A Primer for the Legal Consumer of Scientific Information.** *Science and Courts* Vol. 1, 1993
- **Science and the Courts (with B. Black).** *American Scientist* Vol. 81, 1993

In the early 1990s, I was invited to several conferences and conventions of the legal profession, judges and/or trial lawyers, concerned with scientific and technical matters. I had published a number of papers on the "scientific method." My assignment was the proper and effective use of scientific evidence in the courts. These two are among several essays I published. Among my proposals, two points elicited considerable controversy because they were contrary to prevailing court practice. One is that the court should assess the credentials of expert witnesses. (It was not unusual, and perhaps it is still not, to have charlatans arguing technical matters, as if they held relevant knowledge.) The second point is more difficult to deal with in practice, namely that when the evidence weighs overwhelmingly on one side of the issue at hand (so that, say, 99 percent of experts are on one side, as in the case concerning the human impact on climate change), it may not be appropriate to allow for equal number of experts and equal court time to both sides.

- **The clonal theory of parasitic protozoa: 12 years on (with M. Tibayrenc).** *TRENDS in Parasitology* Vol. 18, 2002
- **A clonal theory of parasitic protozoa: The population structure of *Entamoeba, Giardia, Leishmania, Naegleria, Plasmodium, Trichomonas,* and *Trypanosoma*. Medical and taxonomical consequences (with colleagues).** *Proceedings of the National Academy of Sciences USA* Vol. 87(7), April 1990
- **Isozyme Variability in *Trypanosoma cruzi*, the Agent of Chagas' Disease: Genetical, Taxonomical, and Epidemiological Significance (with M. Tibayrenc).** *Evolution* 42(2), 1988
- **Natural populations of *Trypanosoma cruzi*, the agent of Chagas' disease, have a complex multiclonal structure (with M. Tibayrenc and colleagues).** *Proc. Natl. Acad. Sci. USA* 83(1), January 1986

Parasitic protozoa are obnoxious infectious agents. They are "eukaryotic" organisms, that is, their cells are very similar to ours and, thus, more difficult to fight with drugs or vaccines than bacteria or viruses.

Agents that damage parasitic protozoa are likely to be harmful to us. Chagas disease, caused by *Trypanosoma cruzi*, causes thirty million cases of disease per year and considerable mortality in South America. Some peculiarities of Chagas disease made me suspect that *T. cruzi* was not just one species but several under the same name. The molecular biology methods that had become available made it possible to investigate the matter. My guess was wrong, but what we discovered was much more important. Although *T. cruzi* is a "sexual" organism, it reproduces clonally, that is, asexually, which is of considerable consequence for fighting the disease. Some years later, we extended this discovery to other parasitic protozoa that cause severe diseases: amaebiosis, leishmaniasis, giardia, and malaria.

- **African great apes are natural hosts of multiple related malaria species, including *Plasmodium falciparum* (with colleagues).** *Proc. Natl. Acad. Sci. USA* Vol. 107(4), January 2010
- **The Origin of Malignant Malaria (with colleagues).** *Proc. Natl. Acad. Sci. USA* Vol. 106(35), September 2009
- **Population structure and recent evolution of *Plasmodium falciparum* (with S.M. Rich).** *Proc. Natl. Acad. Sci.* USA Vol. 97(13), June 2000
- **Phylogeny of the malarial genus *Plasmodium*, derived from rRNA gene sequences (with A.A. Escalante).** *Proc. Natl. Acad. Sci. USA* 91(24), November 1994

Malaria may be the greatest scourge of mankind. In sub-Saharan Africa alone, there are 400-500 million cases a year (bouts of very high fever for days at a time, several times a year – why is this factor not taken into account by politicians and economists when they seek to explain why most countries in the region remain underdeveloped?) and one-to-two million child deaths. We soon discovered that (1) *Plasmodium falciparum*, the agent of malignant malaria was most closely related to *Plasmodium reichenowi*, which causes chimpanzee malaria, and (2) that the spread of malignant malaria had occurred very recently, 5-10 thousand years ago. Within the last two years, we have made some additional discoveries: (1) *P. falciparum* was acquired by a single transmission of *P. reichenowi* to humans from a chimpanzee; (2) chimpanzees and gorillas carry *P. falciparum* (although without being sick) – if malaria is eradicated from human populations, chimps and gorillas would remain as reservoirs for the disease.

- **Dating the Tree of Life (with M.J. Benton).** *Science* Vol. 300, June 2003
- **Molecular clocks: whence and whither?** In *Telling the Evolutionary Time: Molecular Clocks and the Fossil Record*, CRC Press, 2003
- **Vagaries of the molecular clock.** *Proc. Natl. Acad. Sci. USA* Vol. 94(15), July 1997
- **On the virtues and pitfalls of the molecular evolutionary clock.** *J. Heredity* Vol. 77(4), 1986

Certain components of DNA and proteins evolve in a more-or-less regular manner, so that they can be used as molecular clocks of evolution. It was first thought that molecular clocks would behave similarly as radioactive clocks: they would tick not like metronomic clocks but with a constant probability (so that their likely error can be measured by the so-called Poisson distribution). I discovered that molecular clocks vary much more than radioactive decay. Yet, because all genes of an organism reflect the same evolutionary history, by using several clocks (genes) we can achieve as much precision as wanted for determining past evolutionary events, even those that happened hundreds of millions or billions of years ago.

- **The myth of Eve: molecular biology and human origins.** *Science* Vol. 270, December 1995
- **Is a New Evolutionary Synthesis Necessary? (with G. Ledyard Stebbins).** *Science* Vol. 213, August 1981
- **Genetic differentiation during the speciation process in *Drosophila* (with colleagues).** *Evolution* Vol. 28, December 1974

- **Allozymes as diagnostic characters of sibling species in *Drosophila* (with J.R. Powell).** *Proc. Natl. Acad. Sci. USA Vol.* 69 (5), May 1972
- **Genotype, environment, and population numbers.** *Science* Vol. 162, December 1968

These papers embrace genetic studies that use molecular biology to investigate important biological problems, such as rate of population growth, genetic changes associated with speciation, how to distinguish species that are morphologically identical, and the minimum number of individuals from which the human species derives.

- **Competition between species: frequency dependence.** *Science* Vol. 171, February 1971
- **Experimental invalidation of the principle of competitive exclusion.** *Nature* Vol. 224, December 1969
- **Evolution of fitness in experimental populations of *Drosophila serrata*.** *Science* Vol. 150, November 1965
- **Relative fitness of populations of *Drosophila serrata* and *Drosophila birchii*.** *Genetics* Vol. 51, April 1965

These papers investigate the contribution that genes make to the ecology of a species, including population dynamics and competition with other species. The "principle of competitive exclusion" was generally accepted by ecologists in the 1960s. I demonstrate experimentally that it is not correct.

- ***Genetics and the Origin of Species: From Darwin to Molecular Biology 60 Years after Dobzhansky*** **(editor, with W.M. Fitch).** National Academy Press, 1995

One of the founding works of the modern ("synthetic") theory of evolution was Th. Dobzhansky's *Genetics and the Origin of Species*. This multi-authored book records some major developments in evolutionary biology over the past sixty years.

- ***Modern Genetics*** **(with J.A.Kiger).** Benjamin/Cummings, 2nd edition, 1984; 1st edition, 1980

This textbook introduces a new way of organizing the teaching of genetics around the three properties of genes: reproduction, mutation, and evolution.

- ***Population and Evolutionary Genetics: A Primer*****.** Benjamin/Cummings, 1982

This textbook incorporates the major advances that had occurred in the genetic study of populations and the evolution of species.

- ***Evolution*** **(with Th. Dobzhansky, G.L. Stebbins, and J.W. Valentine).** W.H. Freeman, 1977
An effort to synthesize the science of evolution by leading experts: Dobzhansky in population genetics, Stebbins in plant evolution, Valentine in paleontology, and Ayala in molecular evolution. No major treatise or textbook existed at the time that integrated the diversity of evolutionary disciplines.

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