

Perspectives

Anecdotal, Historical and Critical Commentaries on Genetics

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Just and Unjust: E. E. Just (1883–1941)

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Natur hat weder Kern

Noch Schale

Alles ist sie mit einem Male²

THIS year marks the 125th anniversary of the birth of Ernest Everett Just. He was one of the greatest biologists of the early 20th century, but being Afro-American, he never had a position that permitted full development of his research talent. The latter part of his life was a time of great frustration, for both professional and social reasons. Despite insufficient time for research and poor financial support, he published more than 70 articles and two books.

I first heard of Just during my graduate student days. J. T. Patterson, my major professor at the University of Texas, had mentioned his work in a lecture. Later, in the fall of 1941, I joined the faculty at Dartmouth College and learned of Just's death, which was on October 27. He had been a student there and my elderly colleague, John Gerould, remembered him well. I have been interested in him ever since, but I knew very little until the 1980s when I read Kenneth Manning's magnificent biography (MANNING 1983). That is the source of most of the material in this essay.

EARLY DAYS

Ernest Just was born on August 14, 1883, in Charleston, South Carolina. His grandfather had been a slave, who inherited the Just name from his master and very likely a haploid genome as well, for he was the light-skinned favorite. Ernest's father loved alcohol and

women. In addition to his wife he kept a mistress although he did not earn enough to support even one household. He died when Ernest was 4 years old.

Ernest's mother was a remarkable woman. After her husband's death she sold their home in Charleston and moved to James Island, off the coast of South Carolina, where she did manual work at a phosphate factory. This was an unusual job for a woman, but it paid better than any women's work. She managed to earn enough to invest in real estate. In addition, she quickly became a community leader and later founded the first school on the island. And she had great ambitions for her gifted son.

At age 13 Ernest enrolled at South Carolina State College, also known as The Colored Normal, Industrial, Agricultural, and Mechanical College, where he completed the regular 4-year course in 3 years. But instead of the expected teaching career, he and his mother decided he should get more education. Seeing an ad in the *Christian Endeavor World* for a private secondary school, Kimball Union Academy in Meriden, New Hampshire, they decided that he should apply for entrance.

Without knowing whether he would be admitted, Ernest took a ship to New York, working on board to pay his passage. He then did various jobs in the city for a few weeks, earning enough for the trip to New Hampshire. Surprisingly, he was admitted and in fact received a scholarship reserved for "deserving" students. He also worked part time, usually in the kitchen.

Just was determined to be a classical scholar and took courses in Latin and Greek. He also excelled in oratory and journalism. Having acquired his mother's administrative and organizational talents, he edited the student newspaper, won an oratory contest, and was chosen to

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²Nature has neither core nor shell; she is everything at the same time. This quotation, from Goethe, was used on the title page of Just's definitive book (JUST 1939b). It epitomizes his holistic view of the cell.

deliver a commencement address. Clearly, he was the outstanding student in his class.

Dartmouth College was only a dozen miles away, so naturally he moved to that campus for his college education. He entered in the fall of 1903 at age 20. He remained interested in classics and continued his studies of Latin and Greek. As he had done at Kimball, he got involved in numerous activities. Among other things he wrote poetry and short stories, something he continued for the rest of his life. Some of these were printed in Dartmouth College publications. More important for his future life, his interests gravitated toward biology. He was especially attracted to William Patten, a distinguished paleontologist who was an influential faculty member and had a strong effect on Dartmouth's curriculum. Patten later organized a course in evolution, required of all freshmen. This must have required both leadership and courage, especially at a time when the Scopes Trial had made evolution highly controversial. Just did research projects for Patten and was duly acknowledged in his text. Another Dartmouth influence was J. H. Gerould, who was astonished at Just's brilliance and scientific skill. Gerould later became known for his genetic studies of butterflies. With more logic than social awareness, he wondered why a person who very likely had more than 50% white ancestry should be classified as Negro.³ Gerould retained admiration and affection for his brilliant student throughout Just's career.

Again, Just was a top student. In both his junior and senior years he was a Rufus Choate Scholar, Dartmouth's highest honor, particularly unusual for a junior, and he won the Grimes award for scholastic improvement during his 4 years. He graduated in 1907, *magna cum laude*.

HOWARD, CHICAGO, AND WOODS HOLE

With such an outstanding record Just might have been expected to have a number of employment opportunities. Actually, there were only two—at two Negro colleges, Morehouse and Howard. He chose Howard and his initial appointment was in the English Department. He taught various humanities subjects and was quickly recognized for his teaching skills. He was popular with students and active on committees and in various organizations. For example, he organized a drama club and produced Goldsmith's "She Stoops to Conquer." He continued his interest in oratory and wrote poetry, as he had done at Dartmouth. By 1912 his reputation had spread well beyond Howard and in 1915 he received the Spingarn Medal of the NAACP, on the recommendation of Jacques Loeb.

In 1909 he began teaching biology courses and again his interest shifted away from classics and toward science, as had happened at Dartmouth. Thinking of graduate work in zoology, he sought Patten's advice. He

was told that medicine was a better direction for an Afro-American; nevertheless, Patten recommended him to Frank R. Lillie, head of the Zoology Department at the University of Chicago. Lillie accepted him as his assistant at the Marine Biological Laboratory at Woods Hole, Massachusetts. So, in the summer of 1909, at age 26, Just began what was to be a highly successful association with that biologist's Mecca.

In the next few summers he earned a reputation as an excellent scientist. He worked closely with Lillie in the lab and they developed enormous mutual respect. Just quickly became known as particularly knowledgeable in the ways of doing research at this ocean laboratory. He was hard working and regularly went to sea on collecting expeditions. He became an expert collector of the various sea invertebrates, knowledgeable about where to find them. He was also a skilled microscopist. And he began to publish. His first article reported that, in the developing egg of the sea worm, *Nereis*, the first cleavage plane is determined by the point of entry of the sperm (JUST 1912). This article attracted considerable favorable attention, for example, from T. H. Morgan, and marks the beginning of his rapidly growing reputation as a scientist. (I learned about this in an embryology course.) In the next 3 years he published four more articles. Later, his advice came to be sought so much as to become a serious encroachment on his research time.

Just had several close friends at Woods Hole. He enjoyed the company of A. H. Sturtevant and the two regularly ate together. He also spent time with geneticists Donald and Rebecca Lancefield and with cytologists Franz Schrader and Sally Hughes (Schrader) (Figure 1). With Sally he could indulge his passion for discussing poetry, literature, and music. In particular they shared an interest in D. H. Lawrence, whose writings were at that time considered quite scandalous. There were other friends. Just was handsome, intelligent, and personable and had a wide variety of interests, all of which made him very popular.

The exciting science at Woods Hole and the happy association with Lillie led to his desire to do graduate work and Lillie was happy to accept him as a student. He applied for leave from Howard, but was turned down, so his graduate work had to be postponed. A year later he was successful and entered the University of Chicago in 1915. Several of the courses he had taken at Woods Hole were counted toward his graduate degree and he received his Ph.D. on June 6, 1916. He hoped that this might lead to a position with more research opportunities, but this was not to be. He stayed at Howard.

Just was a superb technician and extremely careful worker. He set rigorous standards for experimentation and was openly critical of experiments that did not meet his standards. Furthermore, he trusted his observations and did not hesitate to point out disagreements with others. The most notable of these was a difference with Jacques Loeb. Despite earlier happy associations with Loeb—he

³I am using the vocabulary of the time.



FIGURE 1.—Ernest E. Just pitching horseshoes at Woods Hole, ca. 1912. The person to the left is Donald Lancefield, who began the study of the *Drosophila pseudoobscura* group, later exploited by Sturtevant and Dobzhansky. Reprinted with permission from *Black Apollo of Science. The Life of Ernest Everett Just* by MANNING (1983).

had recommended Just for the Spingard Award—Just thought that Loeb's work was flawed and said so (JUST 1922). Loeb had argued that the development of the egg was initiated by two steps, a cytolysis, induced in the laboratory by butyric acid, followed by a quenching produced by hypertonic sea water. Just showed that, with careful attention to concentrations, sea water alone was sufficient. He thought that Loeb had missed this because of being inattentive to details. And Just had other criticisms. This led to quite a dustup and various embryologists took sides, some supporting Loeb and others supporting Just.⁴ Loeb and Just also differed philosophically. Loeb was a reductionist, searching for chemical and physical explanations, and his papers were often mathematical. Just was a holist and did not like math.

Earlier, Loeb had been a close friend of Just and admired him. Loeb's social views were liberal and he was a strong supporter of social causes. Negro colleges, Howard University in particular, were a special interest. Unfortunately for Just, Loeb's earlier friendship changed to enmity. One of the few opportunities that Just had for a position in a research environment

occurred in 1923. Just was being considered for a position at the Rockefeller Institute for Medical Research. Naturally Loeb's advice was sought and his reply left no uncertainty: "... the man is limited in intelligence, ignorant, incompetent, and conceited; in fact his research work is not only bad but a nuisance" (MANNING 1983, p. 90). I do not know the extent to which Loeb's letter was influenced by personal disagreement, but I am sure that this ruined whatever chance Just had to get into a research environment. He had no choice but to remain at Howard with its time-consuming and intellectually draining teaching and committee responsibilities.⁵

Just continued to spend summers at Woods Hole. He obtained a grant from the National Research Council that let him spend half days at Howard on research. But often his other obligations spilled over into his research time, and he got less done than he had hoped. Nevertheless, he remained productive, especially in the summers at Woods Hole. By 1930 he had published some 50 articles, all substantial and showing his careful work and attention to details.

Meanwhile, things were not going well at Howard. The university was having administrative problems, and Just was caught up in them. His relationship with the university president deteriorated. His grant for research time ran out and his faculty duties seemed ever more oppressive. At the same time his relationships at the Marine Biology Lab were also souring. He found that too much of his time went to helping others. He feared that he would be regarded as only a follower of Frank Lillie. But above all, and surprising for this enlightened community, there were racist incidents. Just was used to having problems getting served in hotels and restaurants, but he was not prepared to find a problem at Woods Hole. He decided one summer to bring his wife and children with him. They encountered remarks that they regarded as offensive and immediately left. The brief encounters he had had in Europe, especially the biological station at the Bay of Naples, led him more and more to desire a move. He found European views of science to his liking and ready acceptance at restaurants and hotels made his life much more pleasant.

A man as intelligent and personable as Just would be expected to attract female companionship. The first of his affairs was with Margret Boveri, the daughter of none other than Theodor Boveri. Later, in 1931, Just met Hedwig Schnetzler, who became his companion and eventually his wife. An affair with a white woman, especially if the Afro-American man was married, would place his whole career at Howard in jeopardy. In Europe,

⁴One enthusiastic Just supporter was Libbie Hyman, a student at the University of Chicago. She later wrote *A Laboratory Manual for Comparative Vertebrate Anatomy*, memorized dutifully if not enthusiastically by virtually every zoology student of my vintage. It was a best seller and she enjoyed pointing out that the royalties permitted her the leisure to work on her beloved invertebrates.

⁵Later Loeb moved into more chemical subjects and became a founding father of protein chemistry, greatly respected for his innovation and his research standards (LOEB 1922; COHEN 1985). He was Sinclair Lewis's model for the character Gottlieb in *Arrowsmith*.

although this was hardly encouraged, it was condoned. Hedwig had a large influence on him, both emotionally and intellectually. From his Dartmouth days, Just had an interest in philosophy. She shared this with him and I think she played a substantial part in his subsequent writing, which became more philosophical. His American colleagues were more interested in experimentation, whereas the Europeans were more accepting of theorizing. For all these reasons, his writing changed from strictly observational and experimental to more philosophical. This is reflected in his book, *The Biology of the Cell Surface* (JUST 1939b).

SELF-IMPOSED EXILE IN EUROPE

After all his discouragements, Just decided to live in Europe. He had been in Naples, Berlin, and Paris. He and Hedwig planned to spend the rest of their lives together in Europe. Earlier he had heard live opera in Paris, something that he had never experienced in America. In Italy he heard high-quality chamber music for the first time, the Busch String Quartet being one example. He and Hedwig both enjoyed music, art, and reading. The only problem was how to find enough money to live in Europe.

His earlier trips had always involved financial problems. His Howard salary went mainly to his family. He had some success with foundations, but it was nip and tuck. Nevertheless, he made a number of trips to Europe, fitting these into times when he could get away from Howard.

He enjoyed the company of Reinhard Dohrn, director of the *Stazione Zoologica* in Naples. He felt completely at home, scientifically and socially, with European scientists and, as already mentioned, he spent a great deal of time with Margret Boveri, who was secretary to Dohrn. It was a period of intense research activity, involving long hours in the laboratory, which he loved. Dohrn was also a lover of art and music. There were concerts in the main lobby of the *Stazione*. He also encouraged Just in his philosophical interests.

Later Just spent time at the *Kaiser-Wilhelm-Gesellschaft* in Dahlem. There he worked in the laboratory of Max Hartmann. It was an intellectually rich experience, for he associated regularly with Richard Goldschmidt, Otto Mangold, and Johannes Holtfreter. He had earlier become convinced that the outer layer of the cytoplasm, the ectoplasm, was of great importance and here he was able to extend his studies to *Amoeba*, taking advantage of its giant cell size.

After his decision to move to Europe, Just tried all sorts of ways to gain financial support. There was only limited opportunity for paid leave from Howard. He applied to one foundation after another, usually getting turned down. He even tried some well-known millionaires. His relations with the Rockefeller Foundation were typical. Although Warren Weaver, head of the Division of Nat-

ural Science, was sympathetic and respected Just's work, he thought, as others had, that the place where Just would do the greatest good for the African-American population was to stay at Howard. But this was precisely what Just did not want. He was desperate to get to Europe. He got a little help from the Carnegie Corporation, but it was hard going. For another facet of Weaver's career, see CROW (1995).

For a while Just had a desk at the Sorbonne, but no money. By 1939 he had got a European divorce and married Hedwig. They settled in a small biological station in Roscoff on the French coast overlooking the English Channel. The facilities were primitive, but there was an abundance of marine fauna. He and Hedwig were isolated, but this suited them. He continued experiments and, with Hedwig's help and encouragement, did more writing. He got no more money from Howard, but Hedwig's brother supplied some badly needed funds.

By 1940 the German armies had invaded Czechoslovakia and the siege of Paris had begun. Despite his love for German culture, Just hated Hitler. In contrast, America did not seem so bad, after all. His zoological colleagues, especially at Woods Hole, were worried about him and hoped for his return. Finally he and Hedwig decided that they must leave Europe. There were passport difficulties and Just was actually interned by the Nazis, but somehow his release was negotiated. Eventually they were able to book passage from Spain and sailed to New York. In the confusion of leaving, all of the Roscoff research records were lost. Furthermore, his health was deteriorating. He found himself getting weaker and he was in considerable pain. He tried to continue work at Howard, but it became increasingly difficult. Finally, after several false clues, the pain was diagnosed as pancreatic cancer. He died October 27, 1941. In 1996 he was commemorated by a postage stamp.

Lillie must have known Just better than any other American scientist. He wrote an obituary for *Science* (LILLIE 1942). In his characteristic restrained way, he said

An element of tragedy ran through all Just's scientific career due to the limitations imposed by being a Negro in America, to which he could make no lasting psychological adjustment in spite of earnest efforts on his part. The numerous grants for research did not compensate for failure to receive an appointment in one of the large universities or research institutes. He felt this as a social stigma, and hence unjust to a scientist of his recognized standing. In Europe he was received with universal kindness, and made to feel at home in every way; he did not experience social discrimination on account of his race, and this contributed greatly to his happiness there. Hence, in part at least, his prolonged self-imposed exile on many occasions. That a man of his ability, scientific devotion, and of such strong personal loyalties as he gave and received, should have been warped in the land of his birth must remain a matter for regret.

(LILLIE 1942, p. 10-11)

SCIENTIFIC WORK

Just's first article (JUST 1912) showed the characteristics for which he was soon to become greatly respected. He was thoroughly familiar with the organism, in this case the polychaete sea worm *Nereis*. He took great pains to find ways to keep the animals healthy, he tried many experimental conditions to find the best, and he reported in detail what he had done. He cleverly used fine particles of India ink to mark the sperm entrance point. In this article, in addition to supplying details about the fertilization process, he showed that the plane of the first cleavage division passes through the entry point of the sperm. This was reviewed in detail by WILSON (1925) in his classic textbook, where he said (p. 1104) "The most decisive evidence seems to be offered by Just's observations . . ."

His next article was done jointly with his teacher, Frank Lillie (LILLIE and JUST 1913). This tells you all you want to know about the life history and especially the breeding habits of *Nereis*. As was typical of the time, individual collections and experiments are described in full. This became the standard reference for others wanting to work on this species.

The next few years brought half a dozen more papers, giving more details of the fertilization process and the many experiments performed, not only on *Nereis*, but also on *Platynereis*, *Echinarachnius*, and *Arbacia*. Several of these followed up on Lillie's idea of "fertilizin," a colloidal substance thought to form the bridge between egg and sperm. All these articles show the Just touch: careful observations, care in providing optimum living conditions, and meticulous attention to experimental details. By this time Just's reputation as the person who knew all the techniques for studying embryology of sea invertebrates was well established. Lillie's idea was controversial; WILSON (1925, p. 422) said "These conclusions should, perhaps, not be taken too literally; but they have the great merit of opening the way to exact experimental studies of the problems on the physiological side." Just did not hesitate to interpret his data; sometimes the interpretations were dubious, but no one questioned his observations.

In a study of *Echinarachnius*, JUST (1919) verified that an egg, as soon as a sperm enters, becomes impermeable to other sperms. His idea was that there are two events in the egg. The first is the liberation from the nucleus of a substance making the egg fertilizable; the second is the entrance of the sperm, which blocks any further sperm entry.

In addition to these experimental articles, Just also wrote a number of articles on the techniques of collecting material from the sea and detailed methods of performing experiments. This culminated in the publication of a book, based on his Woods Hole work (JUST 1939a).

Just had long had an interest in philosophy. He also was willing to speculate. Neither of these was encour-

aged by his Woods Hole associates; they respected him for his careful experimental work. But in Europe, things were different; speculation and philosophy were encouraged. As a result, Just's later work moved in this direction.

For many years Just was concerned that the ectoplasm, the outer layer of the cytoplasm and membrane, was key to many cell activities. This was the part of the cell that is most directly in contact with external agents and other cells and therefore of special importance. From our present viewpoint, he clearly underestimated the importance of the chromosomes in development.

His later work covered several topics, embryology, evolution, and philosophy. Just was impressed by the genetics of the Morgan school. He said that the chromosome theory of heredity along with chromosome mapping was one of the great accomplishments of modern biology. But he held a view, not uncommon at the time, that although genetics had elegantly solved the problem of transmission from generation to generation, it fell short in explaining how the genetic information is translated into development and phenotype. For this he turned to the cytoplasm.

His article on mutation is interesting (JUST 1932). He was much impressed by Muller's discovery of radiation-induced mutagenesis. He also noted that mutation was temperature dependent. From this he reasoned that the specificity of the mutation process lies in the chromosome, since the response to different treatments is characteristic of the particular gene, not the nature of the treatment. So far so good, but then he was off on his holistic cytoplasmic ideas again. "The gene theory is a conception too ultra-mechanistic to yield further profitable results" (JUST 1932, p. 73). But he was candid and admitted that this was speculative. "To many readers this discussion doubtless will appear wholly illusory and fantastic. I own that it is speculative. But I offer it as a suggestion" (JUST 1932, p. 74).

Just's views of the relationship between genetics and embryology were set forth at great length (46 pages) in an article entitled "A single theory for the physiology of development and genetics" (JUST 1936). Here he rejected the view, put forth by some, that genetics and embryology are "nonoverlapping magisteria" (to employ Steve Gould's pomposity). He attempted a synthesis. This article reflects not only his wide erudition, but also his strong desire to emphasize the cytoplasm. His theory, briefly, is this. The egg starts out with a pluripotent cytoplasm. The process of chromosome synthesis that occurs in each cell division takes material from the cytoplasm to make copies of itself. This leaves the cytoplasm changed, and in particular changed so as to have a more restricted set of potencies. As development proceeds, somatic cells would have more restricted functions. To me, this represents a thoughtful approach to the problem, in many ways with a modern

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touch. But when he started to explain mutations, for example *Drosophila* eye colors, he was less convincing. But he was always careful to label his ideas as speculative.⁶

Just's view of a pluripotent cytoplasm that continually loses potencies because of material taken from it to copy chromosomes does not jibe with current ideas of gene regulation. Yet, at a time when there was essentially no understanding of developmental mechanisms and many treated embryology and genetics as entirely separate subjects, his attempt at a synthesis was at least a step in the direction of unification. And, typical of Just, it brought to bear observations from extensive and widely varied sources.

Just never abandoned his view of the primacy of the cytoplasm. Yet, in a later article (JUST 1940), he speculated that genes are nucleic acid. Toward the end of his life he realized that the chemical study of nucleoproteins would be increasingly important. In outlining his plans for future research, he said he hoped to do "... a more exact study of nucleo-protein synthesis to embrace as many different types of eggs as possible" (COHEN 1985, p. 135). Alas, he did not live long enough to do this.

Just summarized his life work in his magnum opus, *The Biology of the Cell Surface*. It is a combination of beautiful and beautifully described experiments interspersed throughout with broad theories and speculation. The writing is at once graceful and forceful. The book was very well received. Yet, his American colleagues wanted him to do more experiments and tried to bring him back to Woods Hole to do them. At the same time, his European friends were much more tolerant of his imaginative, but often not fully supported theories.

In recent years, as more has been written about holistic interpretations, Just has received more attention. Also he has been recognized as a pioneer in the new field, eco-devo, in which the emphasis is on the organism as a whole, studied as far as possible in its natural state (BYRNES and ECKBERG 2006).

In reading Just's writing I was increasingly impressed by the fact that, despite clever ideas and meticulous work, workers in the field of development did not seem to be getting much closer to understanding basic mechanisms. I remember Jim Watson's once saying that until recently he had advised students to stay away from development; the tools were not ready. Now that the tools are here, the subject is taking off in a stampede. Just was too early.

⁶It is easy to see in this article why Just was regarded in some circles as hypercritical and arrogant. He did not hesitate to criticize Morgan, Jennings, Conklin, Demerec, and even his close friend Lillie, sometimes with sarcasm. Here is an example: "In passing, I may point out that Plough and Ives's statement of their method can not be called lucid" (JUST 1936, p. 307).

How I wish Ernest Just had been born a century later. He would now be 25 years old, perhaps with a new Ph.D. He would have a totally different life. Racial inequities still have not disappeared, alas, but things are much better than in his time. A person with his talent, ambition, and work habits would surely find a place in a research environment.

When Just did his work, the most basic mechanisms of development could not be fruitfully attacked for lack of suitable techniques. Were he starting a career now, very likely he would be deeply involved in evo-devo, for evolution was always of great interest to him. And he would be taking advantage of all the powerful tools that the field of molecular genetics has made available. Alternatively, with his philosophical bent he might prefer systems biology, but he would have to learn some math. With his intelligence, hard work, and research drive he would surely thrive. And he would also experience that modern frustration—writing grant applications.

For a complete list of Just's publications, see MANNING (1983). His scientific publications are listed in JUST (1939b). For more details of his scientific accomplishments, see BYRNES and ECKBERG (2006).

My greatest debt is to Kenneth Manning, whose biography of Just is thorough, scholarly, and sympathetic. It is based on an enormous amount of work—countless interviews and exhaustive library research.

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