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CARLOS J. FINLAY AND THE CONCEPTION OF CONTAGION*

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The Finlay doctrine has for a long time been the object of study and controversies, and in the end it may be affirmed that this doctrine was more than many others exposed to a large number of vicissitudes in the History of Medicine. The reason for this being the erroneous interpretation of the doctrine considering it as a more or less excellent application of the theory according to which the mosquito is the causal agent of the disease. Certainly this doctrine involves a new theoretical formulation of the conception of contagion and identification of the biological conveying vector of the Yellow Fever with the mosquito, a practical result which on its part serves as confirmation of the theory.

It also refutes in this article why the affirmation about Finlay's Conception had to be verified and expound the reasons why Reed's Commission, at that time failed in their purpose to find out the origin of the disease, and their medium of propagation. They reached success only when they applied the genial theoretical conception enunciated by Carlos J. Finlay in 1881.

It explains that Finlay's Theory should be qualified as one of the best milestone in the History of Biology because his application is generalized for all living beings and therefore offers the possibilities to eradicate infecto-contagious diseases and create better social conditions. All these justify Finlay being selected as one of the Great Benefactors of Humanity.

One of the reasons that compels one to insist on the same subject again and again is, when one is convinced that the subject has not been understood in all its dimensions. This persistence becomes all the more urgent when the protagonist is surrounded by dramatic events showing historical injustice. Such is the case of the discovery by Carlos J. Finlay.

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In several International Conferences on History of Medicine, starting with the 14th, Finlay, and Finlay alone, has been recognised as the discoverer of the carrier of Yellow Fever. But as Sarton has said, "In the history of science, there are often cases in which the author of a discovery is known not for the real essence of his findings, but for what was considered the most spectacular at his time." That is what has happened in the case of Finlay and his discovery.

There has been an effort to reduce the far-reaching historical significance of his original contribution to Science to an intuitive or casual incident : the discovery of mosquites as biological vectors that spread Yellow Fever. But it is equally true that, as one goes deeper into his work with a scientific-historical spirit, it becomes clear that his formulation with regard to a new type of contagion, announced by him in 1881, brought about an abrupt discontinuation in the scientific thinking of his age. It was so, mainly because his announcement meant an anticipation, a sudden spring up from the existing levels of knowledge about how diseases are caused and how they are disseminated.

That is why, it is justifiable to return to a historical analysis of Finlay's discovery. We think his work has not been explored fully and, as has been said, "the interest raised by such works never diminishes, and it is always possible to discover aspects that have not been understood or correctly valued at their time."

The problem of contagious diseases has been amply discussed in its theoretical aspects. But it still goes on weighing on human minds because of the atavistic fear of death. Not very long ago, infectious diseases were listed among the major causes of death. At the same time, inequality in economic and social development of different countries has not disappeared from the face of the earth. As a result, we are faced with the sad spectacle that millions of people, especially in the underdeveloped countries of the tropical zone, fall prey to these diseases.

The suffering caused by these diseases is infinitely more than the one caused by cardio-vascular and neoplastic ones. And imagine they can be eradicated just by introducing a civilized way of life in these communities.

The black trail of death left behind by the infecto-contagious diseases forces us constantly to reconsider ways of eliminating them, to develop techniques for discovering their causing agents, to immunise the population against them or to interrupt the cycle of their propagation. Perhaps it is the fever to discover new methods that makes us forget the pleiades of scholars who dedicated their best efforts for this purpose. The most

distinguished among these scholars are Pasteur and Finlay because of their eponymous conceptions.

Although they worked along different lines, they made a common contribution: they gave us the modern concept about the origin, ways of propagation and methods of avoiding infectious diseases, thus spelling the end of telluricmiasmatic irrationalism. They enriched the theoretical-conceptual thought that has given medicine a structural socio-biological base, and paved the way for advancement through experimentation and scientific investigation, so that medicine can formulate its own laws about health and disease, about life and death.

The history of the discovery of how yellow fever is transmitted, is a good test for a critical appraisal of medical historians. It is not easy to pinpoint the marrow of Finlay's doctrine if his scientific-experimental works are not studied in depth. So far, a majority of historians have focussed their attention on the most spectacular aspect of his discovery, namely, the identification of mosquito as carrier of yellow fever. But if we take the trouble of methodically following the mental process that resulted in the formulation of his hypothesis and eventually raising it to the category of scientific doctrine, we can find a more rational explanation for the theoretical statement and practical solution put forth by him.

Influenced by the contemporary theories that explained the causes of diseases, Finlay initiated his experiments trying to test the relation between outbreaks of yellow fever and disturbances in the environment around man. He thought he had found this relationship because he noticed that due to chemical reactions of different components of the air, the atmosphere of Havana would become excessively alkaline and that would bring about the disease. This experiment shows that his way of thinking was still governed by the climatic-miasmatic theory, although he thought that the disease was produced by material causes.

This work, however, attracted the attention of the American Commission for the study of Yellow Fever, presided over by G. E. Chaille, in 1879. The Commission considered and accepted Finlay's report, approved of the method adopted by him, and recommended to Dr. Guiteras to continue this kind of experiments at other places on the island.

Once this commission's work was finalized, Dr. Sternberg handed over the collection of microphotographs of histo-pathological sections taken from the necropsies of patients who had died of yellow fever. It was then that Finlay found out that seeing from an anatomo-clinical angle, this disease is

characterised by vascular lesions and physico-chemical alterations of blood. This observation, together with the inefficiency practised in sanitary measures suggested for avoiding the spread of this disease, led him to believe that the prevailing viewpoint about yellow fever was at variance with several observed facts, especially the ones related to contagion.

The historic battle between contagionists and anti-contagionists was becoming bitter and critical over this case of yellow fever. Finlay tried to solve this controversy by declaring, in his own words that "a large number of proofs put forth by two contradictory opinions must be accepted as perfectly authentic, which leaves us, of necessity, to this other conclusion, that it is necessary to admit the intervention of a third independent condition in order to explain these two categories of facts." This is the fundamental premise, the gist, of Finlay's doctrine, and he came upon it without knowing it, through dialectical reasoning, uniting the contradictory opinions into the new conceptual definition of contagion.

With these elements in mind, Finlay formulated what doubtlessly was a qualitative jump in the development of his scientific thinking—the notion of the cycle : patient-agent-apt subject. He reached this knowledge through analogical reasoning which has always played an important part in scientific investigations. Finlay is just another example among many known to history where this type of reasoning is very valuable in scientific activity, and it has served as a fruitful basis for building up of hypotheses which have later developed into really fundamental scientific theories.

Dr. Juan Guiteras has stated how Finlay told him confidentially how he had conceived of the yellow fever propagation cycle. This statement is already well known but we will take the liberty of mentioning it once again. Dr. Guiteras says : "In 1878, Finlay read in *Traite de Botanique* of Van Thiegen, a description about the vital evolutionary cycle of *Puccinia graminis* and this gave him the idea that a similar phenomenon might exist in the spread of yellow fever also."

In order to understand how this analogy came to his mind, it seems ussful to briefly go over what happens in the case of this fungus, popularly known as red blight.

Puccinia graminis is a heteroic species and its development cycle takes place partly on leaves of *Burbaris vulgarics* and also, but only in part, the bares of wheat or other plants of the gramineous family, over like barley, rye, etc It is a parasite that lives and grows on these plants during summer. When autumn comes, it developes spores which remain stuck to the plant during winter, but in spring they start flying around, to end

up on the back-side of barberry leaves where they form minute pustules. In the old times it was believed that this infection of barberry was produced by an autonomous species of fungus, or as it is stated in the *Botany* of Van Thiegen, "the spores transformed into a fungus which was particular to barberry, different from the previous one." But in fact it was only a metagenetic form and these spores are now called ecidiospores. They germinate only when they are in contact with wheat leaves. Although the present-day knowledge about the reproductive mechanism of fungus is much different from that of Van Thiegen's time, what inspired Finlay to formulate his hypothesis about an intermediate guest is still true. The analogy is that if a disease is spread from an affected plant to a same one of the same species through a completely different plant that serves only as a host, the same could happen in the case of yellow fever—it could spread from man to man through an in-between.

This observation was also in keeping with the principal aim of Finlay's investigation. He was not looking for what caused the disease but how to suppress it. He said that if we could finish with red blight of wheat by eradicating barberry, in the same way, once we found out agent of intermediate host of yellow fever, we could root out this disease by simply destroying that agent, whatever it was.

In his hypothetical formula : patient-agent-apt subject, the only missing link was the identification of the nature of this agent, separately from the disease and the patient. He was already clear in his mind that the disease was produced by a "material cause transportable from a person suffering from yellow fever to a susceptible person," i.e. a person who had not yet acquired immunity. Finlay did not solve this problem through deductive or syllogistical reasoning, nor through intuition or assimillation of unrelated or popular type of experiments. He solved it through one of the highest forms of knowledge : through abstraction.

The transmitting agent had to have a direct relation with anatomo-clinical peculiarities of the disease. In this case, the disease affected the circulatory system, so the agent had to be one that could take blood from a patient and inject it into another person. This was a logical conclusion but this alone did not hold a key to the solution, because epidemiologically speaking, yellow fever had a definite curve closely related to climatic changes. This is where abstract thought stepped in, because before determining the agent to be mosquito, Finlay had to mentally reject other agents, and he came to this conclusion only when he realized that the mosquito's life-habits included the necessity of sucking blood, travelling

relatively long distances and the coincidence of its abundance and biological activity with the months when yellow fever cases were more numerous as well as frequent. Thus Finlay's conception of contagion led him finally to the mosquito. The next phase was to determine the particular kind of mosquito that fulfilled the conditions. It might be added here that statistics showed that yellow fever was mostly an urban disease.

The admirable dissertation entitled "The Mosquito, Hypothetically Considered the Carrier of Yellow Fever" that Finlay presented before the Royal Academy of Medical, Physical and Natural Sciences at Havana on August 4, 1881, offers a rational explanation of how he selected the culex mosquito, now known as *Aedes aegypti.*

A simple reading of this paper is enough to show that its author was an able and zealous observer, an experimenter of premeditated ideas, a researcher of a methodical and persevering nature,—in short, a man blessed with a serious scientific background. He was a man of great imagination and experience, and he did not take up this project just out of simple curiosity to see what came out of it, but because of a practical necessity born out of his sense of responsibility as a doctor.

Between the years 1879 and 1881, Finlay thought out his doctrine in all its details. By the end of 1880, he had already identified the mosquito, and the fact that he did not announce it at the Washington Conference, was because he wanted to hold some more experiments to confirm the truth. Finally he did so in his paper before the Academy of Sciences. In its last paragraph he says: "Although these proofs certainly support my theory, I do not want to be guilty of exaggeration by saying that everything has been proved—because that is not the case." He concludes, "I understand that an irrefutable demonstration is necessary so that this theory, which differs basically from ideas held so far about yellow fever, may be accepted." This is the language of a modest sage who, while knowing to be in possession of a scientific truth, makes an effort to convince others, so that his discovery should be understood and admitted by everybody, and should be put into practical use.

Finlay conceived of only one experimental method that could scientifically prove his theory. In science, it is not sufficient to formulate a theory, it is necessary to verify it by reproducing the phenomenon *practically*, under experimental conditions so that results equal or similar to the expected ones may be obtained. Scientific truth has to be proved, and so Finlay decided to hold his own experiments. He had to reproduce the disease in a healthy

person, and the right method to do so was to inject this person with a mosquito which had sucked blood from someone suffering from yellow fever.

At that time, experimental medicine had progressed sufficiently enough to offer solutions to numerous physiological-pathogenical problems that a researcher was faced with. Medical history had already recorded numerous cases in which the investigators had risked their own lives by testing their ideas or theories on themselves. But none of these methods served to solve this particular case. It was not possible to experimentally produce this disease in animals because according to the knowledge available, yellow fever was considered to be an exclusively human disease, and moreover, the vector—*Aedes aegypti*—was believed to be a *hematophagus dipteran* of the domestic type. So, there was only one experimental method available, and that was to produce the disease in a human being. The test was original and daring, and the investigator was expected to have not only profound knowledge of the disease but also a sagacious spirit of observation, because at stake was the life of a person who had volunteered to contract such a serious disease, for which no specific cure was known at that time.

Finlay carried out his inoculations under strict clinical control for many years. He carefully protocolized all his cases, drawing out conclusions which fully confirmed his theory. He had proved that his conception about contagion of yellow fever was correct and that his experimental method was competent.

From the theoretical point of view, Finlay had solved an important scientific-medical problem. What was needed was that social practice should confirm this discovery, and he prepared rules for its application. These consisted in a simple system of measures to eradicate the disease by destroying the carrier. He affirmed that if culex mosquito was the only carrier it was enough to organize a campaign to exterminate this insect so that it should be possible to control the epidemic and eventually to eradicate the disease totally.

The campaigns against the vector mosquito that were organized in Havana, Veracruz, Itsmo de Panamá, Rio de Janeiro and New Orleans were surprisingly successful in suppressing yellow fever and the last cases of this disease were reported on the U. S. territory in 1905. Since then the many campaigns organized all over America have proved effective in eradicating or at least restricting yellow fever, especially in the urban areas. Ever since this disease was identified, it remained one of the worst afflictions for more than 250 years. Although its principal victims were tropical and subtropical

areas of the American continent, this 'yellow plague" as it has been called, reached epidemic proportions even in countries like Spain, France, Portugal, England and Italy. Its appearance terrorised the people because nobody knew how to get protection against it. Measures such as quarantine, isolation, cleaning of houses with the help of bonfires etc. which were known to prevent other diseases were useless before yellow fever. The whole city would get paralised and the people would give themselves up to languidness and drinking while they waited for their fatal destiny. Many breakouts were seen in Cuba since 1649 and they caused many deaths ; but it was in the U. S. A. where the cruel devastation reached serious proportions. Just to mention one or two cases, the epidemic of 1878 was responsible for as many as 13,000 deaths, while the last one in New Orleans claimed 5,000 victims, out of which 1,000 died. This signifies that it was precisely the U.S.A. that benefited most from practical applications of Finlay's doctrine.

It was one of those rare cases where the complete cycle of a well-conceived hypothesis had been produced, and it was possible to test it experimentally, and not only that, its practical applications gave it definitive sanction. If Finlay had started studying this disease looking for its ethiological agent, he would not have gone very far because at that time the conditions were not ripe for understanding the role of the viruses and, moreover, this way, control and eradication of the disease could not have been achieved. Finlay knew that if he discovered how yellow fever propagated, he would solve a theoretical problem on which a practical solution depended.

According to Gordon, the epidemiology of an infectious disease rests on a triad : infectious agent, the guest, and the environment ; the first two being essential. When the diseasc gets transferred from one man to another, through the mosquito as in the case of yellow fever, the vector itself assumes the same category as the infectious agent. This view supports Finlays assertion and his decision is not to look for the cause of the disease but for its means of transmission. He did not depart from the so called mosquito theory, and paid no attention to many suggestions on the subject, that could be found in medical literature. He did not even know them nor did he take any interest in them although he was very fond of history, as is revealed in his works about the origin of yellow fever, a historical problem which has raised many controversies.

The history of natural sciences has recorded several cases in which mosquitos have been held responsible for being the cause of, or being related to, the appearance of diseases. Finlay himself has dedicated a paragraph

of his Dissertation to mention some quotations about the subject. Dr. Tro has said in his article "Ideas about Contagion of Diseases Through Mosquitos" that "before Finlay, the theories about the transmission of diseases through mosquitos are just conjectures and have no experimental basis nor the necessary correlations". In support of this true and just assertion, he critically examines the so-called precursors of the mosquito theory. If one gleans through ancient writings one can always find annotations which can supply a fanciful mind with the forgotten precursor of any scientific theory. If we reason in a simplistic way, we can admit that all present discoveries have their forerunners, because scientific knowledge, in order to develop and progress, has to be dased on previous knowledge. But this would amount to vulgarising historical thought. In natural science, as in social science, the qualitative jump is a distinct product of each one of the quantitative elements that comprise a process. Therefore we can say that there are many theories that do not have any precedence. Finlay's doctrine on contagion is one of them.

There is another aspect also. Finlay was working under extremely unfavourable conditions. The first public expositions of his hypothesis were made at a time when the country was living in an atmosphere of general depression that followed the defeat of the first armed revolutionary movement led by the Cuban bourgeoisie fighting for definitive separation from the Spanish Crown. The country was still ignored in the international field, and that was partly the reason why his theory was not received with interest in foreign scientific circles. The other very important reason for this was that, as the civilized nations were quite advanced in medical sciences, the researchers in those countries did not pay much attention to this subject, especially because it dealt with a disease not found in their own template climates. But the United States were behind Western Europe as far as science was concerned. Moreover, they had prompted the Americans to attend to this problem.

When in 1895, armed struggle for national independence was re-started, Finlay had finished his scientific work. But naturally, the representative of the new revolutionary thought in Cuba were more preoccupied with political and military action. Under these conditions, development material well-being seemed much more important than questions related to public health. Finlay's scientific work was lying hidden as a valuable but untapped source in the middle of big social conflicts that Cuba was faced with.

The Government of the United States sent a Military Medical Commission to study yellow fever headed by Dr. Walter Reed. This Commission started

their research on a pre-planned programme based on contagion, and tried to find the causing agent of yellow fever. But it failed. However, the Commission was pressed in order to arrive at some practical solution. Faced with this dilemma, the commission decided to test Finlay's doctrine, thinking that if they were not successful, they could justify their inability by saying that they had tried all possibilities. At that moment this was the only alternative available in Cuba because the "mosquito theory" had been making its way to the most scientifically advanced doctors who respected this theory because of its experimental and practical proofs. So, without any great hopes, and full of many doubts because, among other things, they did not fully know the natural history of yellow fever, the American Medical Commission accepted the idea as also the experimental methods put forth by Finlay. They arrived at the same conclusions as Finlay, with only minor differences. They had worked under many advantages including a more sophisticated technique of inoculation and the help of a team of specialists. The Commission improved upon the Cuban doctor's findings only in one point : they affirmed the viral nature of this disease.

The enthusiasm raised by the happy discovery of a solution to this problem immediately prompted General E. Wood, the Governor General, to publicly recognise Finlay, rightly giving all the credit for the same to this Cuban doctor.

This attitude on the part of the military administrator was at variance with the posture adopted by Walter Reed who had never admitted for a moment that if Finlay's theory was proved, he (Finlay) would be given credit for it. How can we explain this discrepancy among American authorities ? Reed had been sent by the Washington government to specifically study yellow fever and had received special instructions about his work from the Army Surgeon General. Wood, on the other hand, as governor of the island, along with his Chief of Public Health, Gorgas, showed much interest in Cuban medical specialists. Reed knew the role he was playing in the plans of the U. S. government, and therefore, was not prepared to make any concessions, not even when scientific integrity demanded it. The U. S. had to show to the world that their occupation of Cuba was not a military campaign but a "civilizing job." And what can be more charitable than improving the health conditions in the country : But for that they had to solve the yellow fever problem. In spite of the meticulous and well organized plan of Gorgas, the epidemic had not been controlled. When the U. S. government came to know that it had been experimentally proved that yellow fever was transmitted through the mosquito, and it was possible to eradicate the disease, they announced through their spokesmen that it was an American

triumph in the field of medical science, but many scientific institutions, amongst them the Academy of Medicine of Paris, defended the scientific truth and recognised only Finlay as the first to prove the scientific theory of the contagion.

Finlay reacted strongly against the American usurpation. He was personally responsible for directing the sanitation projects—not only for eradication of yellow fever, but also for organising public health. Similar protests were raised not only by the feeble medical institutions in the country but also by the most prominent doctors, including Diaz Albertini, Claudio Delgado, Juan Guiteras, Francisco Dominguez Roldan, Jorge Le Roy, Enrique Barnet and Enrique Nunez, etc. But in spite of these efforts and the sympathy and support of notable foreign scientific personalities, this discovery has been a matter of controversy.

For half a century, a strong polemic has raged over this notable medical discovery, and it is becoming more and more clear every day that this is an achievement of Cuban medicine, and of its greatest and the most original investigator, Carlos J. Finlay.

Finlay's doctrine, as we have proved, is not just the exposition of the so-called mosquito theory. This is one practical application. It is, in fact, the preparation of a new theoretical formulation in the conceptual apparatus of contagion. It is the product of a profound dialectical reasoning, and represents a synthesis of the contradictions between the contagionist and anticontagionist view-points which contained true and false elements.

Finlay's concepts represent a theoretical wealth for medical science, and were expressed in a language worthy of scientific literature of the time.

There is no doubt that the vicissitudes of this doctrine are the product of its significance in biological history. That is why many people have tried to get the credit for this discovery—thus proving a moral postulate prophetically put forth by Jose Marti when he said. "He who discovers something new always finds emulators who dispute his claim."

Finlay's unquestionable merit consisted in the elaboration of a new concept of contagion, capable of explaining the transmission of numerous diseases where there is neither direct or indirect, nor bad hygienic conditions, nor telluric emanations and nor still any role played by sins of punishment from the gods.

The consequences of Finlay's brilliant theoretical concept were that not only the medium of transmission of yellow fever was discovered but it really

became possible to eradicate this disease. It also resulted in the creation of a direct method of experiments on human beings, gave some new ideas about acquired immunity, replaced the miasmatic concept of diseases by the biological one and, finally, gave birth to a new branch of natural sciences, namely Medical Entomology, giving the Hygiene a rational and scientific foundation. His conception about the contagion helped to make in advance the Theory of Medicine, as well as setting up in solid support the Experimental Medicine and Biological Science.

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