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Biometry and Anthropometry: from Galton to Constitutional Medicine

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Summary - *In this paper I review the significant events in the history of the emergence of quantitative inquires in the anthropological field, with a focus on their application to clinical practice. The roots of Biometry - the meeting between life sciences, instruments and numbers - lie in the adventure which began with the overtaking of the Cartesian mechanicism and the Linnean classification of man among the natural objects. When an "histoire naturelle de l'homme" (Broca) became possible, it began "the season of measurers", who were convinced of the practical utility of numbers. In the second half of the 19th century, Galton played a noteworthy part in the systematic introduction of quantitative methods to investigate biological phenomena. What Galton liked to measure most were human traits and qualities. Even if in literature he is often credited as the "pioneer of biometry", in practice his privileged 'instrument' was Anthropometry. The art of measuring the human body was practiced since ancient times, but its use was mostly restricted to the realm of the figurative arts. In the strictly naturalistic field, the employment of anthropometry does not have a long history. A short manual entitled "Anthropometria", probably the first appearance of the term, was published by the naturalist Johann Sigismund Elsholtz in the 17th century. It was only from the second half of the 18th century that anthropometry was adopted more widely, first by naturalists and then by anthropologists, in order to investigate man and his main morphological characteristics. During the 19th century, the relevance of the research of Adolphe Quetelet popularized the anthropometrical method which was extensively employed in several fields. With the rise of Constitutional medicine at the end of 19th century, anthropometry became a new 'instrument' of the clinical practice. However, the aim of constitutional physicians was different from that of anthropological program - the identification of common traits in human beings to study and determine population groups – and from the descriptive aim of the figurative arts. Constitutional medicine was interested in the question of Individuality and, by employing quantitative inquiries, its ambition was that of finding the differences between individuals for diagnostic, preventive and therapeutic aims.*

Keywords - *Anthropometry, Biometry, Constitutional medicine.*

Introduction

The history of Biometry is an immense chapter of the history of science. In 1935, Ronald Aylmer Fisher (1890-1962), who two years before had been appointed to the prestigious Galton chair, gave a series of Lectures on the History of Biometry at the University College of London. Fisher's first three lectures concerned the *Principles of Geology* of Charles Lyell (1797-1875) and his collected data on mollusk fossils. Then he moved to a different topic, Gregor Mendel (1822-1884), his experimental method, the data he had reported and the rediscovery of this work in 1900. The following lectures were devoted to Adolphe Quetelet (1796-1874), his book *Sur l'homme* (1835) and to Carl Friedrich Gauss (1777-1855). Finally, the lectures series considered the part played by Karl Pearson (1857-1936) in the implementation of the biometric program (Stigler, 2007). Fisher defined biometry as "the active pursuit of biological knowledge by quantitative methods" (Fisher, 1948, p. 218).

This meaning had not essentially changed from its first formal definition by Francis Galton (1822-1911) as "the application to biology of the modern methods of statistics" which appeared in the first number of the *Biometrika* (1901), the *Journal for the Statistical Study of Biological Problems* edited, in consultation with Galton, by W. F. R. Weldon (1860-1906), C. B. Davenport (1866-1944) and Karl Pearson (Gayon, 1996 and 2007). The new Journal promised to "rescue physical anthropology" from the "stagnant condition in which it has remained since the time of Blumenbach and Retzius", and it would have included not only studies on anthropological topics, "but the whole field of biology" (Gray, 1902, p. 29). Although during the 20th century, the numerous works produced, the publication of dedicated Journals and the organization of congresses on the matter, showed the development of biometry as a coherent institutional context, it appeared more as a corpus of methods employed by many biological disciplines than a discipline itself (Gayon, 1996a). So, what is biometry?

> *"A variety of definition is possible. We should all agree however that it is something to do with life and something to do with measurement. […] The term measurement […] includes physical measurement in the strictest possible sense; it includes the recording of qualities, and also the region intermediate between the two. Perhaps most important of all, it includes counting. One of the tasks of biometrical method is to find the appropriate techniques for dealing with each kind of measurement"* (Irwin, 1959, p. 363).

Biometry is hence the history of the meeting between life sciences and measurement. It embraces quantitative inquiries on man, animals and plants. It employs measurement, instruments, mathematical and statistical methods. An explanation of the rise and development of biometry should include therefore an historical reconstruction of many elements. The intent of this paper is to point out some of them, restricting the investigation to the anthropological field and the medical practice (see Table 1 for the historical sequence). The structure of the work is the following:

1) *The man: a natural object*
    - i) *The rise of measurement: instruments and statistical applications in life sciences*
2) *The origin of the term "Biometry" and its fortune before acquiring its current meaning*
    - ii) *Biometry and Heredity: the Biometrics and Mendelians debate*
3) *The matter of Galton's statistical analysis: Anthropometry*
    - iii) *The art of measuring the human body: from descriptive to scientific purpose*
4) *Anthropometry in clinical practice: the case of Constitutional medicine*
    - iv) *Constitution: an ancient question*
    - v) *French and German constitutional schools*
    - vi) *The* "clinica col metro" o*f Achille De Giovanni*
    - vii) *Italian constitutional school: Biotipology and the neglect object*

The man: a natural object

Even if in the 18th century, anthropology was not yet established as an independent science, the increase of naturalistic inquiries on human body attested the beginning of a new scientific approach. First of all, the "bravery" of the naturalists indicated that they were "ripe" in going beyond the Cartesian mechanicism that had for a long time established a qualitative difference between man and other species. The result of this discrimination was the inhibition of the naturalistic investigations on man. At last, he returned to nature: this finally allow to submit man to quantitative inquiries. The fulfilment of this process was the naturalization of man, ratified by Carl von Linné (1707-1778): in the tenth edition of the *Systema naturae* (1758-1759), he removed the demarcation line which still survived between man and monkey (Barsanti, 1986).

The effects of this process became concretely observable during the 19th century. In 1809, the French naturalist Jean-Baptiste Lamarck (1744-1829) published the *Philosophie zoologique* and proposed an early concept of evolution proceeding in accordance with natural laws. He suggested the possibility that man could also descend from animals. In 1859, Charles Robert Darwin (1809-1882) published *On the Origin of Species* where he formalised the theory of evolution by common ancestries for a scientific explanation of diversification in nature. In 1863, the English biologist Thomas Huxley (1825-1895) published *Evidence as to Man's Place in Nature,* the first discussion on human evolution, and eight years later Darwin published *The descent of man*. All these works encouraged the research of the "missing links" between man and monkey in order to confirm human evolution.

Tab. 1 - Historical sequence: from **Anthropometria** ***to*** **Biometrika.**

Years	Events
1654	Johann Sigismund Elsholtz publishes the manual "*Anthropometria*"
1750	Jean-Joseph Sue presents at the *Académie des Sciences* of Paris "*Sur les proportions du squelette de l'homme*"
1835	Adolphe Quetelet publishes "*Sur l'homme et le développement de ses facultés*"
1859	Paul Broca found in Paris the *Societé d'Anthropologie*
1870	Adolphe Quetelet publishes "*Anthropométrie*"
1881	Paul Topinard publishes "*Eléments d'Anthropologie générale*"
1884	Galton set up an Anthropometric Laboratory in London
1891	De Giovanni publishes "*La Morfologia del Corpo Umano*"
1893	Giuseppe Sergi found the *Società Romana di Antropologia* (the present *Istituto Italiano di Antropologia*)
1897	An Anthropometric Laboratory is set up at the *Museo nazionale d'Antropologia* of Florence
1901	First number of "*Biometrika*", the *Journal for the Statistical Study of Biological Problems*

In the second half of the 19th century, the French anatomist and physician Paul Broca (1824-1880) was one of the principal protagonists of the anthropological movement. In 1859, he founded in Paris the *Societé d'Anthropologie*, with the intent of giving a new institutional status to anthropology, conceived as "*histoire naturelle de l'homme*". Broca also set up an Anthropological Laboratory and established a *Revue d'Anthropologie*. He made clear that the object of the anthropological program was "*l'étude du groupe humain considéré dans son emsemble, dans ses details et dans ses rapports avec le reste de la nature*" (Broca, 1866, p. 276).

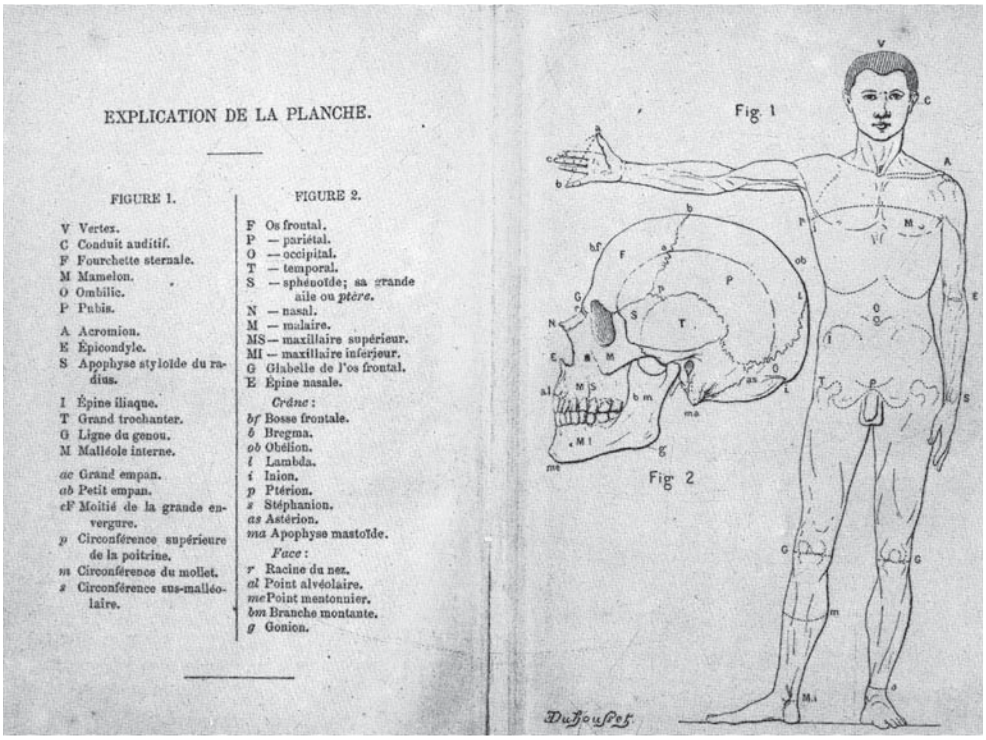
The aim of Broca's anthropological project was to obtain, with the use of measurements and statistical calculations, medium values able to describe numerically the typical and common traits of a group of individuals. Discussing the instruments employed to measure the skull, he clarified this purpose:

> *"le but de ces instruments est de substituer à des évaluations en quelque sorte artistiques, qui dépendent de la sagacité de l'observateur, de la justesse de son coup d'oeil, - […] – des procédés mécaniques et uniformes, qui permettent d'exprimer en chiffres les résultats de chaque observation, d'établir des comparaisons rigoureuses, de réduire autant que possible les chances d'erreur […] d'échapper ainsi à l'influence trompeuse des variétés individuelles"* (Broca, 1860-1863, p. 42-43).

In Broca's program, even qualitative characteristics, as eye and hair colour, had to be translated into quantitative expressions. This choice responded to the metric demand emerging in the second half of the 19th century, and to the ambition of finding rigorous methods enabling the conversion of the human characteristics into numerical entities. He published the *Instructions* for the standardisation of the measures of the skull (Broca, 1875; Fig. 1). The anthropological initiative of Broca was an incentive for the development of the entire discipline. Some years later, between 1863 and 1879, numerous new Anthropological Societies were founded in London, Madrid, Moscow, Berlin and Vienna.

In Italy, the first academic chair of anthropology was established at the University of Florence in 1869 and assigned to Paolo Mantegazza (1831-1910). In 1871, he also gave birth to the *Società Italiana per l'Antropologia e l'Etnologia*. In 1893, Giuseppe Sergi (1841-1936) founded in Rome the *Società Romana di Antropologia*, which later became the present *Istituto Italiano di Antropologia*.

In 1897, it was established in Livorno the *Istituto antropologico italiano*, a sort of walk-in laboratory, which had some resemblances with Galton's Anthropometric Laboratory of London (Pogliano, 1986). The aim was to extend the anthropological investigation from cadaver to living (Marina, 1897). In 1899, Costantino Melzi established in Arona the *Gabinetto italiano di Antropologia* and proposed the employment of anthropometry in schools (Melzi, 1899; Mochi, 1903), for he was convinced that educators had to become "anthropologist of childhood" (Pogliano, 1986, p. 69). An anthropometric laboratory was set up at the *Museo nazionale d'Antropologia* of Florence in 1901 (Mainardi, 1901; Mochi, 1901), and offered to Mantegazza for the celebration of his fortieth academic anniversary, and then was led by Aldobrandino Mochi (1874-1931).



EXPLICATION DE LA PLANCHE.

FIGURE 1.

V Vertex.
C Conduit auditif.
F Fourchette sternale.
M Mamelon.
O Ombilic.
P Pubis.

A Acromion.
E Épicondyle.
S Apophyse styloïde du radius.

I Épine iliaque.
T Grand trochanter.
G Ligne du genou.
M Malléole interne.

ac Grand empan.
ab Petit empan.
cF Moitié de la grande envergure.
p Circonférence supérieure de la poitrine.
m Circonférence du mollet.
s Circonférence sus-malléolaire.

FIGURE 2.

F Os frontal.
P — pariétal.
O — occipital.
T — temporal.
S — sphénoïde; sa grande aile ou *ptère*.
N — nasal.
M — malaire.
MS — maxillaire supérieur.
MI — maxillaire inferieur.
G Glabelle de l'os frontal.
E Épine nasale.

Crâne :
bf Bosse frontale.
b Bregma.
ob Obélion.
l Lambda.
i Inion.
p Ptérion.
s Stéphanion.
as Astérion.
ma Apophyse mastoïde.

Face :
r Racine du nez.
al Point alvéolaire.
me Point mentonnier.
bm Branche montante.
g Gonion.

Fig.1 - "Explication de la Plance" (From: Broca P. 1875. Instructions craniologiques et craniometriques de la Scoieté d'Anthropologie de Paris. Masson, Paris.)

The rise of measurement: instruments and statistical application in life sciences

The British statistician Joseph Oscar Irwin (1898-1982), debating on the origin of biometry, directed attention to two main sources which have characterized its development. The first one goes back to the beginning of the 17th century and the rise of the idea of "making numerical measurement, recording qualities and then aggregating the results" (Irwin, 1959, p. 364). The second one refers to the main contributions in the field of applied mathematics in the beginning of 18th century – Joseph-Louis Lagrange (1736-1813), Pierre Simone Laplace (1749-1827) – and the development of the theory of errors codified by Gauss at the beginning of the 19th century. But the biological field, as Irwin recalled, "was hardly explored at all" (Irwin, 1959, p. 366). He distinguished three different categories of biometric application:

1. Measurements made in relation to a single individual,
2. Measurements or numerical statements relating to small groups of individuals,
3. Measurements or numerical statements relating to large groups of individuals or even to populations as a whole.

He clarified that biometry was "not concerned with the first as such", but he admitted the necessity to know "how to measure a single individual" before dealing with groups (Irwin, 1959, p. 365).

At the beginning of the 17th century, the introduction of the first instruments into clinical practice became the principal factor of the new quantitative approach, which invaded the medical field. For counting and measuring instruments were needed. One of the first instruments was the '*pulsilogium*'. It was invented by a Venetian named Santorio Santorio (1561-1636) or Sanctorius, appointed to the chair of Medicine at the University of Padua. In his clinical practice he employed this devise to evaluate the rate of the pulse. He also used a thermometer to measure body-temperature. In a book on Galenic medicine, he described many other instruments (Sanctorius, 1612). Measuring became essential in every branch of medical practice. In the following years, several instruments proliferated for quantifying everything susceptible to be measured: manometer and sphygmograph for measuring blood-pressure, haemocytometer for counting blood-cells, haemoglobinometer for haemogoblin estimation, spirometer for testing vital capacity.

Instruments therefore, and numbers. In 1825, the French physician Pierre Charles Alexandre Louis (1787-1872) applied "the numerical method" to his research on phthisis. His work was based on the observation of 123 cases of which he noted meticulously the recurrence and the frequency of symptoms. Then, by employing his numerical method, he deduced diagnostic, prognostic and therapeutic inferences. Louis, though often forgotten by medical literature, is credited for having introduced probability calculus in clinical practice and for his pioneeristic studies of medical statistics (Sournia, 1992).

The other main source of the development of the biometric approach was the growing introduction of mathematical and statistical methods in the analysis of biological phenomena and clinical practice. If "all science is measurement" – with the well-known Helmholtz's dictum (Darrigol, 2003) – it is also true that every measurement can enlarge its implications in a comparative model. Statistical methods offered the possibility to control the significance of the medical evidence (Porter, 1986; Stigler, 1986).

The fundamental work on probability was mainly developed by Carl Friedrich Gauss (1809) and Laplace (1812) at the beginning of the 19th century. The theory was employed especially by mathematicians to manage the errors in astronomic measurements.

The introduction of the new science of probability and statistics into the field of social science is owed to Adolphe Quetelet. He was keenly aware of the overwhelming complexity of social phenomena and the many variables that needed measurement. In his work published in 1835, *Sur l'homme et le développement de ses facultés*, he developed the new science of "social physics" and especially applied to it the notion of "average" and the Gaussian curve.

The origin of the term "Biometry" and its fortune before acquiring its current meaning

The name "biometry", as well as the term "biometrics", became expressions of common use only after the foundation in 1901 of the journal *Biometrika* and were strictly linked to Francis Galton and Karl Pearson. Therefore, "there are at least two known earlier independent inventions in English and several in other languages" (Stigler, 2000, p. 653). The philosopher and historian of science William Whewell (1794-1866) employed in 1831 the term biometry - "if you choose to call your calculations on lives by a Greek name"-, talking about demography (Todhunter, 1876, p. 134).

It seems that the term biometry was "a natural choice for anyone reaching for a way to combine measurement and biology in one name" (Stigler, 2000, p. 654). So, it is not surprising that it occured frequently and with various and very different meanings. There are at least three earlier uses of the term "*biométrie*" in France: the first, in relation to the indices of growth of animals and plants (Virey, 1833); the second, in a dictionary of the 19th century as "*art de calculer l'emploi de la vie, de manière à en tirer le parti le plus avantageux*" (Barré, 1842, p. 129); the last refers to the description of a "*biométre*", an instrument invented by a Doctor Collongues and employed to measure health numerically through the patient's ability to detect vibrations produced by the device (Larousse, 1867).

One of the first references to "biometry" in English medical literature appeared in an article published in 1875, where it was designated as the study of the length of life and its correlates (Morris, 1875). The biometry taught in Italian statistics courses about that time had the same meaning (Wright, 1890).

Biometry and Evolution: the Biometrics and Mendelians debate

Ronald A. Fisher, speaking on the rise and development of biometry during the Inaugural meeting of the British Region of Biometric Society, acknowledged that "the man who in the nineteenth century did more than any other to prepare the way was, I think, undoubtedly Francis Galton" (Fisher, 1948, p. 218). Scientific literature agrees that Galton played a noteworthy part in the systematic introduction of quantitative methods to investigate biological phenomena. He is designated as the "pioneer of biometry" (Bulmer, 2003).

In 1901, in the first number of *Biometrika* (the "K" for the initial of Karl, the first name of Pearson; Gayon, 2007), Galton pointed out the importance of the birth of the Journal for "no periodical exists in which space could be allowed for the many biometric memoirs that call for publication" (Galton, 1901, p. 8). And he clarified that:

> *"The primary object of Biometry is to afford material that shall be exact enough for the discovery of incipient changes in evolution which too small to be otherwise apparent. […] The organic world as a whole is a perpetual flux of changing types. It is business of Biometry to catch partial and momentary glimpses of it […]. For instance, it may not require many investigations to establish statistical laws of heredity on a secure basis […]. Biology could soon be raised to the status of a more exact science than it can as yet claim to be, if each of many biometricians would thoroughly work out his own particular plot […]"* (Galton, 1901, pp. 9-10).

Galton was interested in heredity (Galton, 1889). In this context, the emergence of biometry was related to the evolutionary heritage and it represented a "crucial historical episode in the history of the theoretical Darwinism" (Gayon, 1996a, p. 320). Galton had founded a Committee on the Measurement of Plants and Animals, and he demanded the aid of the Council of the Royal Society to establish and maintain a Biological Farm in the Darwin House at Down for experimental evolution. The project was aborted and in 1897 the Committee was changed into the Evolution Committee of the Royal Society. The admission of William Bateson (1861-1926) and others adherents to the discontinuist theory of variation determined the legendary controversy between "Biometricians" and "Mendelians" about the mendelian's theory of heredity (Lyndsay, 1975; Rushton, 2000). In the following years, the employment of the expression "Biometry" progressively lost the reference to its original context, Darwinism and evolutionism.

The matter of the Galton's statistical analysis: Anthropometry

Quantification was an actual fascination in Galton's life (Pearson, 1914, 1924, 1930; Fig.2).

Fig. 2 - Francis Galton aged 87, with Karl Pearson, his biographer and collaborator (from: http://galton.org/).

"Whenever you can, count" was his motto (Pearson, 1924, p. 340). What Galton liked to measure most were human traits and qualities. His main interest was in the anthropological area and his privileged instrument of investigation was anthropometry. With the introduction of a specific method employing measurement and numbers, Galton played a relevant role in the progress of anthropology and "gave it the status and dignity of a real science" (Pearson, 1924, p. 333). Karl Pearson, his collaborator and disciple, pointed out clearly that the quantitative methods in Galton's inquiries were considered "in the service of anthropology" and that there was "certainly no field of research which owes more to Galton than that of anthropometry " (Pearson, 1924, p. 333).

Even if his most sustained inquiries were in biometry, in practice Galton's biometry was anthropometry (Confort, 2006). The following list shows the number of Galton's papers in the different fields he was interested (From: http://galton.org/):

Heredity	83
Anthropometry	43
Statistics	29
Anthropology	23
Eugenics	22
Biometry	2

Since his first interest on the question of heredity (Galton, 1877) Galton was aware of "the pressing necessity of obtaining a multitude of exact measurements relating to every measurable faculty of body or mind for two generations at least, on which to theorise" (Galton, 1909, p. 244). Galton was constructing his own theory of inheritance so he "was anxious to obtain quantitative anthropometric measurements that he could analyze statistically" (Gillham, 2001, p. 92). What he needed so was anthropometric data.

Galton's idea of anthropometry - "the art of measuring the physical and mental faculties of human beings" (Galton, 1906, p. 93) - was different from the meaning it had at the end of the 19th century. For Paul Topinard (1830-1911), Broca's pupil who had published his *Eléments* *d'Anthropologie générale*, "Anthropometry, since the time of Quételet, means the measurement of the entire human body (living or upon the dissecting-room table) with the view to determine the respective proportions of its parts […]" (Topinard, 1881, p. 212). Galton appreciated the methods employed by "M. Topinard, professor of anthropology in Paris, whose experience of the art of measuring the linear dimensions of the living human body, and those of the skull and other bones, is unsurpassed". In particular, he considered "very ingeniously made and packed into a portable box" the instruments recommended by Topinard for the use of travellers (Galton, 1887, p.4), but he was interested in measuring not only linear dimensions but faculties too.

He did not want to confine the anthropometric inquiries to the external physical characteristics, but he intended to widen the investigation to include mental characteristics. He considered it was finally possible "to pursue an inquiry into certain fundamental qualities of the mind by the aid of exact measurements" (Galton, 1877, p. 345). The successive inclusion of other measurable characteristics, as dynamic workings of the body and its physiological and medical fitness, showed the extensiveness of the project in collecting anthropometric data and also the width of the Galton's concept of anthropometry:

> *"[…] the word « anthropometry » is frequently used in a very restricted sense; but that the sense in which I myself understand it, and in which I propose to employ it now, is equivalent to the « Measurement of the Human Faculty » generally, and includes that of the effects of fatigue"* (Galton, 1892, p. 11).

At first, Galton had suggested the establishment of anthropometric laboratories in schools for the richness of the sources available (Galton, 1874). Then, he decided to extend his anthropometric database. In 1884, he set up an Anthropometric Laboratory for the occasion of the International Health Exhibition which was established in the Gardens of the Royal Horticultural Institution in South Kensington (Fig. 3). The charges of the equipment and the maintenance of the Laboratory were totally financed by Galton himself. Most of the instruments in use at the Laboratory were "wholly or in large part" designed by Galton himself (Galton, 1884, p. 12). "On payment of 3d. at the door, the applicant" was admitted to the Laboratory and submitted to numerous measurements. By the time the International Health closed in 1885, "9,337 persons were measured, of whom 4,726 adult males, and 1,657 adult females" (Galton, 1885, p. 275). When the exhibition was over, he transfered the Laboratory to the Science Galleries of the South Kensington Museum (Fig. 4).

Galton received many letters demanding consultancies on the instruments and the

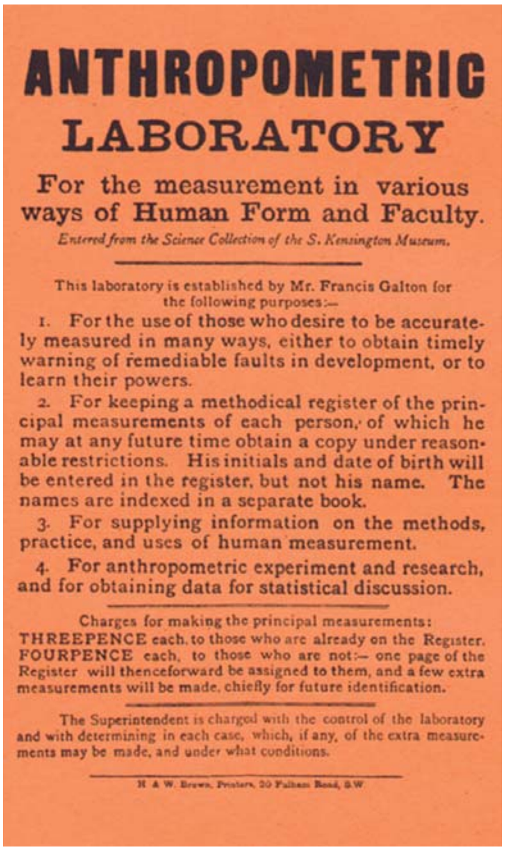


Fig. 3 - ***Galton's Anthropometric Laboratory poster (from: http://galton.org/).***

methods he employed. Among them, there was the Italian anthropologist Giuseppe Sergi:

"Professor Giuseppe Sergi, of the University of Rome, writes to say that he desires to add to his anthropological cabinet a specimen set of instruments for use in schools. He enclosed a pamphlet in which his views on their utility are set forth, and desired me to select a list for him". (Galton, 1887, p. 4).

Galton proposed a double use of the periodical measurements, *personal use* and *statistical use*: the first one, to appreciate in children and youth if the physical development was proceeding normally; the second one, to "discover the efficiency of the nation as a whole and in its several parts, and the direction in which it is changing, whether for better of worse" (Galton, 1884, p. 3-4).

Anthropometric data was the matter of Galton's work. The primary interest in Galton's studies was heredity. He needed statistical methods, as frequency distributions and normal variation, to force the quantitative richness of his collected anthropometric data to prove his theory of heredity. He was convinced of the existence of a law governing the data he had collected. The statistical methods recently introduced by Quetelet gave him a new opportunity and represented a significant innovation in the study of heredity (Olby, 1993).

Fig. 4 - Sir Francis Galton's Anthropometric Laboratory (From: http://galton.org/).

Anthropometry: from descriptive to scientific purpose

Anthropometry (Quetelet, 1870; Robert, 1878; Taruffi, 1881; Fletcher, 1883; Duhousset, 1889) as a means of measuring the human body was practiced since ancient times, but its use was mostly restricted to the realm of the figurative arts. In his *Anthropométrie* Quetelet admited that "*les anciens avaient des notions plus exactes que les modernes sur la théorie des proportions humaines*" but he regreted that it was not known how they attained "*une perfection aussi grande*" (Quetelet, 1870, p. 33).

One of the first works known on human proportions is an ancient Sanskrit book, the *Silpi Sastri* (Quetelet, 1870). Literature traditionally refers also to the Greek sculptor Polykleitos (5^{th} century B.C.) and his canons of the human proportions (Shadow, 1834). Also during the Renaissance the aim of anthropometry remained principally related to the artistic field. In this period even anatomy was indifferently employed for medical and for artistic purposes and its development could not have existed without the empirical investigations of the Renaissance regarding anthropometry (Röhrl, 2000).

With Leon Battista Alberti (1404-1472) and his *De pictura* (1436), "the final break with the tradition of the medieval canons" was ratified. In the *De statua*, he "outlined for the first time in history individual measurements based on mathematical-empirical studies" and his scientific anthropometry enabled him to describe "the real dimensions of a great number of individuals" (Röhrl, 2000, p. 57 ; Alberti, 1972). Leonardo da Vinci (1452-1519) derived from his long experience in anatomical studies the famous "anthropometric canons" presented in his *Trattato della pittura* (Belt, 1969; Keele, 1964). Another transformation was accomplished with Albrecht Dürer (1471-1528), considered a "pioneer of anthropometry" for his work on the human proportions, the *Vier Bücher von menschlicher Proportion* (1528), regarded as the first illustrated treatise on human proportions (Röhrl, 2000). He is also considered a pioneer of biometry of growth for he had perfectly understood that proportions were not the same in children and adults (Gysel, 1997). Dürer, who wanted to establish an ideal canon, produced also numerous representations of male and female constitutional types.

In the strictly naturalistic field, the employment of anthropometry does not have a long history. Probably, the first that employed the term anthropometry was the naturalist Johann Sigismund Elsholtz (1623-1688) in a short manual *De mutua membrorum proportione* published in Padua (1654; Fig. 5 and Fig. 6). In his *Anthropometria,* he proposed the use of some devices to determine the external measures of the human body. Amongst the instruments he presented, there was the illustration of an *anthropometron* (Fig. 7), ancestor of the typical devices employed in the 19th century.

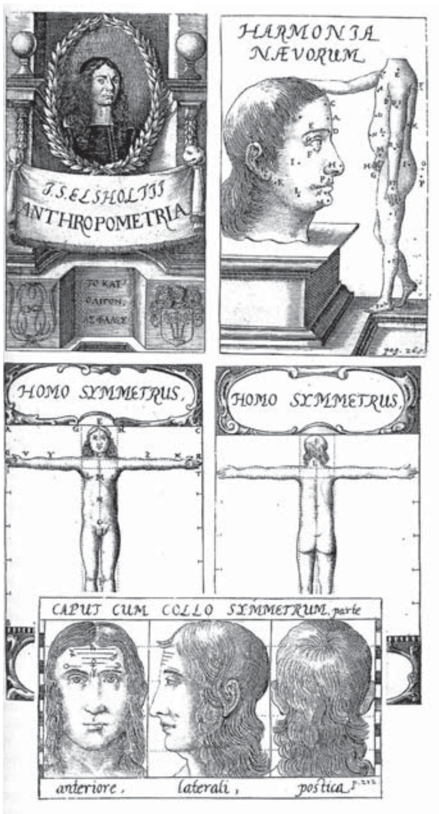


Fig. 5 – Illustrations of Elsholtz's Anthropometria (From: Gysel C. 1997. Histoire de l'orthodontie. Societé Belge d'Orthodontie, Bruxelles).

Elsholtz's use of anthropometry has been probably the earliest recorded attempt to investigate the human form for medical or scientific purposes. He proposed a new quantitative approach to enquiry into the relationship between body proportions and the incidence of disease. He conceived the anthropometric measurements as useful for medical practice, for physiognomy, for the arts and for ethics (Barsanti, 1986; Pogliano, 1986; Gysel, 1997).

It was only from the second half of the 18th century that anthropometry was adopted more widely, first by naturalists and then by anthropologists, in order to investigate man and his main morphological characteristics. In 1750, one of the most famous anatomist of the 18th century, the French Jean-Joseph Sue (1710-1792), presented at the *Académie des Sciences* of Paris a work *Sur les propostions du squelette de l'homme*. In the second half of the 18th century, the naturalistic investigation was displaced from the somatic version of Physiognomy - interested in determining the correspondences between the psychological characteristics and the mobile parts of the face - to a first kind of comparative craniology, interested in determining the fixed structures of skull. The main protagonists of this switching of direction were the Swiss physiognomist Johann Kaspar Lavater (1741-1801) and the German naturalist Johann Friedrich Blumenbach (1752-1840). It began, hence, "the season of measurers", who were convinced of the practical utility of numbers. They introduced in human investigation methodologies coming from mathematics, geometry and statistics. Therefore, they became "anthropometers" (Canestrini, 1998, pag. 291). The skull, designated by anthropologists as the most significant component of body, became their 'privileged object' of investigation. They began to take meticulous measurements and invented several 'geometrical instruments'. One of the first 'devices' was illustrated in the *Mémoire sur les differences de la situation du grand trou occipital dans l'homme et dans les animaux*, published in 1767 by the French anatomist Louis-Jean-Marie Daubenton (1716-1800).

The man who mostly contributed to the introduction of quantitative investigations into the anthropological field and the development of anthropometry was Quetelet. The publication of his *Anthropométrie ou mesure des différentes facultés de l'homme* (1870), was celebrated as a real "triumph of mathematics" (Pogliano, 1986, p. 64). The notion of *homme moyen*, his "binominal law" and their graphical representations entered the common scientific language. Famous was his graphic *Echelle de la croissance de l'homme* (Figure 8).

Between the end of the 19th century and the first decades of the 20th century, anthropometry was extensively employed in several fields (Landogna Cassone, 1950; Drusini, 1986):

1. Forensics and criminal anthropology and the idea that science had to make its voice heard in court (Guarnieri, 1986). In Italy Cesare Lombroso (1835-1909), by employing the new anthropometrical instruments, wanted to prove that the aberrations of the moral sense and mind were related to body anomalies and especially of the skull (Lombroso, 1878; Bulferetti, 1975; Villa, 1985).
2. The *Signalement anthropométrique* of Alphonse Bertillon (1853-1914) who set up an identification system based on physical measurements (Bertillon, 1891). This method was employed by several police to identify criminals. In *La photographie judiciaire* (1890) he suggested a new method to photographic detection.
3. The anthropometric auxology (the study of human physical growth) began in 1912 with the research of Paul Godin at the Jean-Jacques Rousseau Institute in Geneva.
4. The *Antropometria militare* and the studies of Ridolfo Livi (1856-1920) to determine the propensity to military service (Livi, 1896-1905).
5. The clinical anthropometry employed by constitutional medicine and especially in the Italian school of Achille De Giovanni (1838-1916).

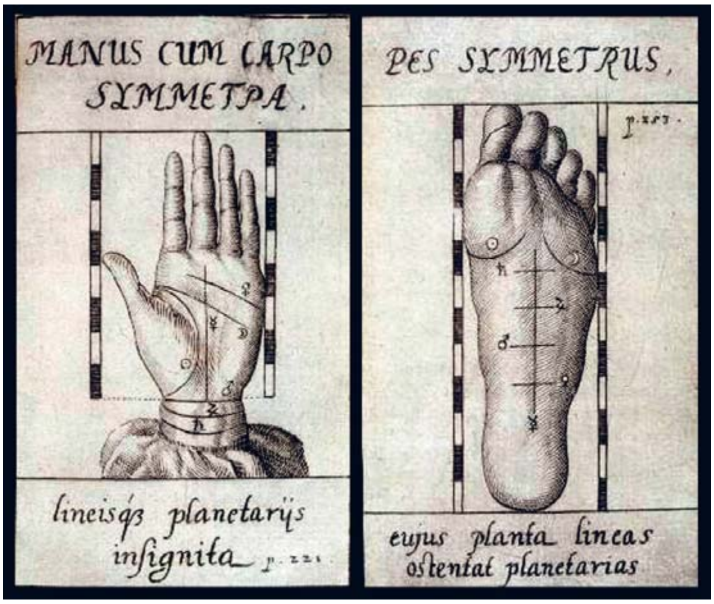


Fig. 6 - Illustrations of* Anthropometria *(From: Elsholtz J. S. 1654.* Anthropometria, accessit doctrina naevorum. Typis Matthaei Cadorini, Patavii*).

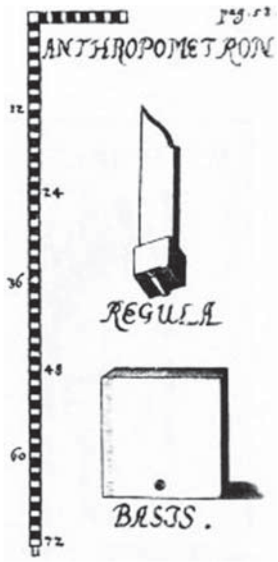


Fig. 7 - Elsholtz's Anthropometron (From: Elsholtz J. S. 1654. **Anthropometria, accessit doctrina naevorum. Typis Matthaei Cadorini, Patavii).**

Anthropometry in clinical practice: the case of Constitutional medicine

The use of measure in clinical practice acquired a substantially different meaning vis a vis the purpose of the anthropological program. Topinard had defined the study of anthropometry as the systematic measurement of the different parts of the human body in order to determine their respective proportions not only at different ages, but also in the human races, so as to distinguish them and establish their relations to each other (Spencer 1997). Therefore, while anthropologists were interested in the identification of common traits in human beings to study and determine population groups, the ambition of quantitative inquiries of clinical activities was that of finding the differences between individuals. The employment of numbers and instruments became essential for some physicians, mostly clinicians, who animated Constitutional medicine between the end of the 19th century and the first decades of the 20th century. Since its beginning, Constitutional medicine took the nature of a 'research program', which intended to explain the complete human pathology, and which was based upon three orders of fundamental concepts.

Firstly, the acknowledgment of the different individual human *habitus*, of the variability of shapes and psychological characters; in other words, everything which was defined as temperament and constitution. Secondly, the empirical evidence of the physiological variability of individual expression, the different reactivity and susceptibility versus the pathogen agents action. Thirdly, the idea that there were some particular dispositions of the human body predisposing it to some specific diseases.

Constitution: an ancient question

The definition of individual constitution was a very ancient question (Ciocco, 1936). Theories on the nature of human temperament were already formed in the Ionic philosophy. Supporting his medical activity by several pointed observations, Hippocrates systematized the first theories and proposed a version that remained a reference paradigm during many centuries. The different human temperaments were the consequence of the different proportion between the four elements composing the individual's constitution. They were identified as black bile, blood, yellow bile, and phlegm, all of which had to be in correct proportion to one another. Hippocrates was among the first supporters of intrinsic pathogenesis of diseases: they originated inside the human organism. During the 2nd century A.C., the humoral doctrine was developed by Galen. By employing the term *krasis* or temperament he remained substantially faithful to the Hippocratic tradition and "for more than 1500 years", these expressions played "the role in pathology that *diathesis* or constitutions played later on" (Ackerknecht, 1982, p. 319).

In the 19th century, medicine was still dominated by the humoral doctrine. Temperament was considered as the ensemble of the vital resistances against diseases. A healthy temperament was "*la meilleure défence contre le mal extérieur*", while a temperament provided by a poor vitality was considered as "*une porte ouverte au parasitisme et à la destruction*" (Luton, 1872, p. 138). Even if the notion of temperament was still strongly present in the medical language, the development of physiology and pathology brought into question its scientific value. In order to give a new solid fundament to the matter, the term constitution began to take its place in medical discussions. It was defined as "*la matière du tempérament*" (Luton, 1872, p. 139) and temperament as "*un mode spécial de la constitution*" (Adelon, 1844, p. 360).

In the second half of the 19th century, with the advent of microbiology and bacteriological researches, many diseases, such as tuberculosis and cholera, found a new explication in relation to the "germ theory" (Brock, 1988; Gerald, 1995; Fantini, 1998). However, the problem of the internal or constitutional factors remained a central point in medical debates. In 1872, a French dictionary pointed out the question clearly: the existence of an "*agent extérieur, tel qu'un virus*", could not be considered as the only cause of disease:

"[…] il sollicite, par une sorte de fécondation, une aptitude pathologique qui, sans doute ne serait pas éclose sans lui, mais qu'il n'a pas le pouvoir de créer. […] Doit-on admettre alors, avec Claude Bernard, une modification primitive dans ce qu'il appelle le milieu intérieur? […] les choses se passent comme si l'organisme avait en lui même la puissance de concevoir les maladies" (Raynaud, 1872, p. 410).

Historical literature agrees that constitutional program rose in competition with the microbiological paradigm, which found its formal expression in the germ theory of specific and necessary

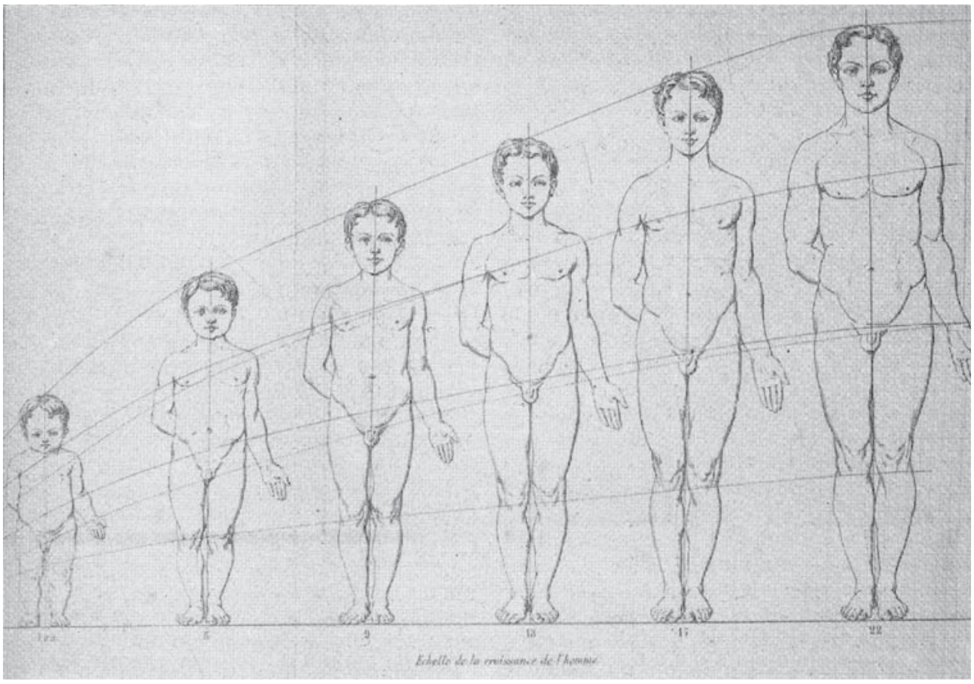


Fig. 8 - "Echelle de la croissance de l'homme" (From: Quetelet A. 1870. Anthropométrie ou mesure des différentes facultés de l'homme. C. Muquardt, Bruxelles).

causality (Fantini, 1998; 2004), conceptually introduced by Louis Pasteur (1822-1895). The new theory was formalized, in a first moment, by Friedrich Henle (1809-1885) and Edwin Klebs (1834-1913), and then it was definitively codified into the Koch's *Postulate* (Carter, 1985). The transit from a multi-causal explicative model of diseases to a model where the cause is one, specific and necessary, represents the most important conceptual innovation produced by the new discipline in medicine.

The advent of the new microbiological paradigm simplified the etiological explication of the principal infectious diseases of the 19th century, cholera and tuberculosis above all. However, the empirical evidence of "familial tendency" to disease and the different susceptibility of individuals versus the same pathological agent showed that this etiological explication was not exhaustive, and "invoke constitutional and hereditary factors" (Olby, 1993, p. 416). All those concepts, strictly connected with the hereditary question of diseases, were the main arguments mentioned by the physicians that supported the hypothesis of endogen determinism of diseases. The establishment of the germ theory of disease, therefore, did not banish the question of constitutional factors from the medical debate.

While in the new microbiological research project, the experimental method confined the research to the laboratory dimension and was based on the identification of the universal laws of causal determinism of diseases, for constitutional clinicians, the problem of Individuality of the patient remained absolutely fundamen tal. The "laboratory" outcomes, dressed with the new scientific protocols, forced many clinicians, conscious of the centrality of Individuality, to give to the concepts of constitution and predisposition a new scientific fundament. And the way they tried to put this ambition into practice, was the implementation of quantitative analysis on the Individuality.

The need to study individual constitution became a crucial question in clinical practice; but how could constitution be evaluated at the end of the 19th century? The scientific context, the medical knowledge and the technological know-how enabled a quantitative appraisal of human morphology. For this reason, medical constitutionalism rose and was put into practice through anthropometry (Federspil, 1989). Even if many physicians interested in constitution availed their researches of several measures coming from anthropological books, the anthropometric techniques employed were very different. They elaborated a specific system of measures in relation to their clinical aim and with a specific physiological meaning. The aim of Clinical anthropometry, very different from that of the anthropological project, was directed "to solve a problem of functional evaluation of individuals" (Landogna Cassone, 1955, p. 269).

French and German constitutional schools

Constitutional medicine rose and developed in the entire European continent and gave the most significant results above all in Germany, Italy and France. The main protagonists of the German movement were Friedrich Wilhelm Beneke (1824-1882), Friedrich Kraus (1858-1936), the Austrian Friedrich von Martius (1850-1923) and Ernst Kretschmer (1888-1964) in the field of psychiatry (Kretschmer, 1942). In particular, Beneke, at the same time as Achille De Giovanni in Italy, began a series of visceral investigations on cadavers by employing anthropometry (Beneke, 1878; 1881) and contributed to the understanding of the concept of constitution (Premuda, 1975). However, his method did not enable the physician to estimate the anatomical basis of constitution and the functional anomalies in livings. Hence, it was considered useless for clinical practice (Viola, 1904).

In France, constitutionalism took a strictly morphological form. Even if Jean-Noel Hallé (1754-1822) was considered "*l'initiateur véritable de la morphologie humaine*" (Mac-Auliffe, 1925, p. 161), systematic studies on constitution began with Claude Sigaud (1862-1921). He focused his attention on the morphological components of individuals (Sigaud, 1914) and described four human types in relation with the four principal systems: respiratory, digestive, muscular and cerebral (Jacquin & Chatellier, 1923).

The morphological investigation maintained a fundamental place even with Auguste Chaillou (1866-1915) and Léon Mac-Auliffe (1876-1937), and took the name of *Morphologie médicale* (Chaillou & Mac-Auliffe, 1912). In 1925, they founded in Paris the *Société d'Etudes des Formes Humaines* and began to publish a *Bulletin*. But the question of predisposition to diseases was not exhaustively considered in their studies. Besides, they did not avail their investigation of the systematic use of anthropometry. Therefore, their medical morphology and typology remained at a "prescientific empirical state" (Landogna Cassone, 1955, p. 248).

The French constitutional studies were strongly innovated in the 30's, by integrating the investigations with the support of anthropometry and statistics. A *Société de Biotypologie* was established in Paris and equipped by a new journal, *Biotypologie*. One of the main protagonists of the new course of French constitutionalism was certainly Marcel Martiny (1897-1982) who, by employing his *biotypométrie,* elaborated a new system of measures to classify the different human types (Martiny, 1948).

The " clinica col metro" of Achille De Giovanni

In historiography, De Giovanni (Galdi, 1926; Premuda & Monsagrati, 1960; Cosmacini, 1981; Pogliano, 1983; Drusini, 1986; Albrizio, 2006) has been portrayed as the father of constitutional medicine in Italy. He played a fundamental role in the systematic introduction of anthropometry in the clinical field, not only for descriptive but, above all, for diagnostic, preventive and therapeutic purposes. In fact, even if the anthropometrical studies increased during the second half of the 19th century under the encouragement of the Quetelt's works, "the field of pathology remained entirely extraneous in his researches" (Viola, 1902, p. 2). For this reason he has been also considered the founder of medical anthropometry (Landogna Cassone, 1955) and a pioneer of anthropological clinic (Martiny *et al.*, 1982). The relevance and the originality of De Giovanni's anthropometrical studies was credited by the physician George Draper in the *Journal of the American Medical Association*:

> *"But the complete anthropometric technic of physical anthropology has, with the exception of the Italian school, led by di Giovanni, been neglected by students of clinical medicine"* (Draper *et al.*, 1924, p. 431).

De Giovanni's anthropometrical method and the measurements he used, differed - as he himself observed - from "those systematically taken by anatomists and anthropologists", and the reason was the different aim of his researches that "required a special method" according to the "fundamental laws of modern morphology". This method was the result of "long and repeated proofs" in his clinical practice and, for this reason, – he argued – "so far as I know, there are no precedents" (De Giovanni, 1891, p. 125). He proposed his anthropometrical method for the appraisal of the individual constitution since 1879. In his "*Prelezione*" to the series of lessons on clinical medicine at the University of Padua, he recommended anthropometry - "this part of anthropology became scientific with the work of Quetelet on ethnological researches" (De Giovanni, 1879, p. 13) - as a new instrument useful in clinical pathology as well.

Using a series of anthropometric instruments, which De Giovanni himself invented or adapted specifically in that aim, he elaborated a method to determine individual morphologic worth. His *Antropometro orizzontale* (Fig.9) was a very complex apparatus derived by the traditional anthropometric tables employed in the 19th century but adapted for his clinical requirements. His ambition was to change clinical medicine, with the help of numbers and measurements, from an empirical into an exact science (Premuda, 1960):

"The old body of medical doctrine *renewed lends itself to the demonstration of the* individuality *in its concrete morphological value, and, evoking from history the philosophico-mathematical principle of the Italian school which was called after Pythagoras, become science, acquires the instinct of exactness, and proceeds with the escort of numbers and measurements"* (De Giovanni, 1891, p. vi).

In the second half of the 19th century, when the analytic tendency of modern medicine (solidistic and localistic pathology) and the introduction in medicine of the experimental method by Claude Bernard (1813-1878) were 'decomposing' the human body, De Giovanni focused his attention on the problem of Individuality. In conflict with the new emergent medical paradigm, microbiology, which insisted upon identifying the external agents considered the cause of the infectious diseases, he, by referring explicitly to the ancient Hippocratic and Galenic doctrine of temperaments and constitutions, upheld the importance of constitutional factors in the causal process of many diseases. He condemned the excesses of microbiology and its

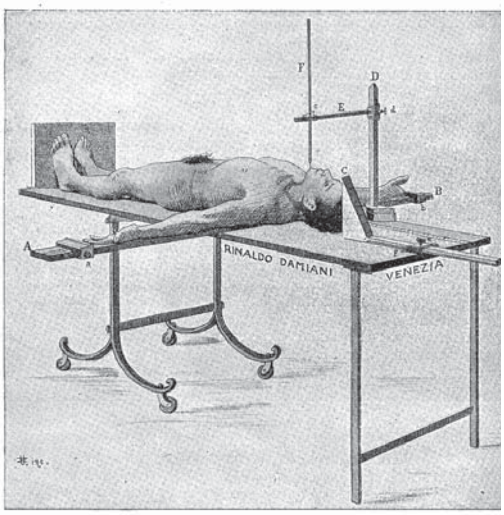


Fig. 9 - Anthropometric horizontal table of Achille De Giovanni (From: De Giovanni A. 1891. La morfologia del corpo umano. Hoepli, Milano).

belief to explain everything "just with the knowledge of microbe" (De Giovanni, 1887, p. 12). In 1891, he published the *Morfologia del corpo umano* where he exposed completely his medico-anthropological theory and his morphological method based on anthropometry. As a clinician, he never forgot the fundamental principle that medicine must treat not diseases, but ill individuals. He was persuaded that the anthropological problem was essential in medicine and clinical practice (Bonuzzi, 1999) and that the study of man had to be related to his natural context:

"[…] I became convinced that medicine must be considered as a branch of zoology, or – to use an expression of Topinard – of zoological anthropology, which is the study of the human group considered in its relations with the rest of organized nature (Eléments d'Anthropologie générale, p. 185, Paris, 1885). […] I found myself confronted by the same unknown: the most subtle analysis, though they were suitable for enabling me to conceive the concrete idea of morbid states, were not sufficient to enable me to understand precisely diseased man. Very frequently, after having pondered over my work, […], I had to content myself with concentrating my thoughts in words which expressed the unknown much more than the known – in the words constitution, temperament, individuality, predisposition. *And my mind after long meditations became more and more convinced that medicine, as part of zoology applied to man, required a method for arriving at the scientific knowledge of the Individuality without which constitution, temperament, predisposition, would always remain vain expressions, very obscure problems"* (De Giovanni, 1891, p. 1-2).

The clinical practice showed De Giovanni "a fact of very common observation known to all physicians – namely, *that the same disease in different patients may present different clinical appearances*" (De Giovanni, 1891, p. 10). This empirical evidence led him to consider predominant that reasons linked to the individual in human pathology. Certain that there was a dependence relationship between form and function, he put forward the hypothesis that to morphological imbalances corresponded physiological dysfunctions. He promoted a strict relationship between morphology and pathology. From his meaning of individual constitution as "the state of morphological harmony or discord" (De Giovanni, 1891, p. 16) he deduced all his pathological conception. If the functional value of the organism was determined by its morphological specificity, everything determining a disharmony in the individual, hereditary or acquired, was or could be cause of disease. De Giovanni was convinced of the existence of certain specific morphological 'predispositions' to certain specific diseases. Therefore, with the aid of anthropometry, he wanted to obtain a classification of morphological types. At first, he thought that he had to find "a pure physiological type and distinct pathological types" (De Giovanni, 1891, p. 126), but then he realized that the *ideal type* was just an abstraction:

> *"But the natural fact of the organization corrected me, recalled me to the principles of morphology which I had unconsciously deserted, and I became aware that the morphological type in the ordinary sense – that which would represent the normal in all, and would represent itself in the majority of individuals – does not exist. The human morphological type, like the morphological types of the races, is a conception, while the morphological type of the individual is a reality"* (De Giovanni, 1891, p. 126).

De Giovanni distinguished and described three fundamental 'morphological combinations' predisposing to three different groups of specific diseases. Every man was, therefore, a variety of its specific type, the result of peculiar modalities of ontogenetic development. De Giovanni drew on anthropometry as an auxiliary science of fundamental importance for his clinical and scientific activity. For this reason, he was strongly criticized and his clinic was pejoratively indicated as the "clinica col metro" (Albrizio, 2005). His therapeutic approach was based upon the idea that it was possible to change the individual constitution in order to rid the body, when and where possible, of its predisposition to disease. His conception of medicine was hence mostly preventive.

Italian constitutional school: Biotipology and the neglect object

Several physicians contributed to sustain the De Giovanni's constitutional theory. Giacinto Viola (1870-1943), whilst remained substantially faithful to his master's doctrine, introduced some modifications concerning the description of the fundamental constitutional types (Viola, 1926). He reserved particular attention to the functional components in the constitutional evaluation. Besides, he improved the anthropometrical method by integrating it with modern statistics and the Quetelet-Gauss law of errors (Landogna Cassone, 1955). His quantitative-statistical method was considered one of the most accurate in defining the morphological types:

> *"La classification de Viola constitue l'une des contribution les plus solides à la science de types humains. Sans hesitation, peut-on dire qu'au point de vue de l'anthropométrie externe elle constitue un chef-d'oeuvre qui jusqu'à present n'a pas été égalé"* (Schreider, 1937, p. 82).

The others main adherents to the Italian constitutional school were Pietro Castellino (1864-1933), Nicola Pende (1880-1970) and Mario Barbàra.

Pende developed the constitutional doctrine on the field of endocrinology, and extended the investigation to psychological sphere. He founded constitutional endocrinology and constitutional psychology (Landogna Cassone, 1955). He described the different endocrinologic temperaments and delineated a new science, the *Biotipologia umana* (Pende, 1924; 1939). The clinical appraisal of individual – he used the expression "*biotipo individuale*" – was structured in four characteristics, *habitus*, temperament, character and intelligence. The diagnosis was described by a "*biotipogramma individuale*".

With the exception of the French school, who had defined a *"type cerebral"*, constitutionalism had neglected and sometimes intentionally excluded, the morphological investigation of skull in the individual appraisal. De Giovanni had never considered the question, Viola had explicitly removed it, Pende had superficially touched the matter. Barbàra gave voice to this negligence:

> *"Strange constitutional school, that was not able, by employing its methods, its measures, its laws, to dominate the most visible and expressive segment of human body!"* (in Landogna Cassone, 1955, p. 206).

By extending the anthropometrical investigation to the skull, Barbàra drew the constitutional school to the anthropological program (Barbàra, 1933). The intent of Biotipology, he claimed, was not the same of clinical medicine. De Giovanni, the father of Italian constitutionalism, availed his research of anthropometry to determine the differences between individuals. Barbàra's investigation had an opposite intent: "not the study of individual or single cases, but the study of human groups" (in Landogna Cassone, 1955, p. 210).

Info on the web

http://galton.org/

Francis Galton web site; several papers are available for free downloading (PDF).

http://biometrics.tibs.org/Interior.aspx

The International Biometric Society.

http://biomet.oxfordjournals.org/

Biometrika: journal of statistics published by the Biometrika Trust and distributed by Oxford University Press

http://www.biom-hum.com/Default.htm

Société de Biométrie Humaine.

http://digital.library.adelaide.edu.au/coll/special/fisher/

R.A. Fisher Digital Archive.

http://www.biometrics.org/links.htm

Numerous links to biometric technology websites, including biometric communication venues, university biometric curricula/programs and scientific Journals.

http://www.ifc.cnr.it/sib/

The official site of the Società Italiana di Biometria.

NOTE: All the references to the *Morpologia del corpo umano* (1891) are from the english edition (1909).

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