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ACROMEGALIC-GIGANTISM:

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A

HYPOTHESIS

by

A. CAMPBELL GEDDES.

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VOL. I.

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ACROMEGALIC GIGANTISM ;

A

HYPOTHESIS

by

A. CAMPBELL GEDDES.

"De nihilo nihilum, in nihilum nil posse reverti."



## PREFACE.

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This thesis on Acromegalic Gigantism gives an account of a small portion of the work with which I have occupied myself in the years that have elapsed since I received the degree of M.B. from the University.

For five years I have been working towards a distant goal, an understanding of the influence of environment in the determination of human growth and body form.

In the autumn of 1907 Professor D.J. Cunningham handed over to me, for examination, the body of an acromegalic subject which had come into his department.

From that examination and from my previous work and reading this thesis has grown: it advances an hypothesis, but it is less a record of completed work than a programme. It is incomplete; but its incompleteness is to me its merit for through it I am rich in work for years to come.

I have sought to find a satisfying explanation of the cause of Acromegaly and of Giantism and to demonstrate/

## PREFACE.

demonstrate the relationships which exist between them and I hope that I have in some measure succeeded. Incidentally it has been necessary to discuss in detail the theory of growth; but in all that I have written I have striven to build upon the rock and the foundation that I have selected is the undoubted fact that protoplasm cannot create matter, that the growth of all living things is, in the absence of absorbable nutrition, impossible.

But here I touch the fringe of the difficult problems of heredity and it is necessary for me precisely to state the views which I hold with regard to the transmission of characteristics from one generation to another.

I do not believe that acquired characteristics can be transmitted, but I do believe that the inborn potentiality of making acquirements is transmissible. For I think that it is clear that no structural acquirement can be made by any living thing unless the power of making that acquirement was from the first inborn within its tissues. In a word all structural acquirements must be the result of environment stimulating to fruition the inborn potentialities of the cells.

The/

## PREFACE.

The human ovum possesses, within its narrow compass, a wide range of potentialities. but the range is not unlimited. No stimulation will induce it to develop wings and feathers and similarly no stimulation of an avian ovum will induce it to develop a cerebrum-like man's. Such things are not within the range of the potentialities of these cells, but within the range of an ovum's potentialities there is no characteristic which may not be acquired, there is no characteristic developed which is not acquired.

A fertilised ovum possesses neither eyes nor mouth. give it food such as it desires and it will acquire them; it possesses no limbs, give it its proper food and it will acquire them: a blacksmith's boy has no special development of the muscles of his arm, exercise the muscles, make the blood course through them and bring them food and he will acquire it. His father had the inborn power of developing his arm muscles so has he.

Thus I believe that each fertilised ovum possesses certain potentialities and that under the stimulus of food it inevitably develops its latent characteristics, but that if the food which it desires be in whole or in part withheld all or some of its potential characteristics will fail of development. In this/

## PREFACE.

this I follow Dr. Archdall Reid and what he has already demonstrated there is no need for me to redemonstrate.

The essential points to an understanding of human growth and body form, therefore, are:--

1. Protoplasm does not create matter. Protoplasm, therefore, can only increase its mass by absorbing matter from its environment.

2. Every fertilised ovum possesses certain potentialities of development, some of which are common to other fertilised ova of the same kind, some of which are peculiar to itself.

3. The food that the ovum absorbs enables it to increase in mass, the amount of food that it absorbs limits its ultimate mass; the shape and composition of the mass which it ultimately acquires is wholly dependent upon the potentialities which it possessed at the moment of completed fertilisation.

Therefore nothing, the potentiality for which is not inborn, can be acquired and nothing but the potentiality of making acquirements can be inborn and the human fertilised ovum differs from the avian fertilised ovum in its potentialities and the man from the bird in his acquirements. But everything we are which the fertilised ova from which we have grown were not/

## PREFACE.

not is the result of acquirements governed by potentialities and acquirements cannot be transmitted.

The governance of the transmission of potentialities is unknown, but there can now be little doubt that a partial solution of that problem will be found along the lines indicated by the Abbé Mendel.

There is nothing new or original in this. I place it here in the preface, because the thought which it embodies runs through the thesis; but I do not build upon it. My foundation is the incontrovertible fact that protoplasm does not create matter.

My design may be unpleasing; my fabric too florid and yet the bricks may be both well and truly made. In the hands of a more skilful builder they may be built into a structure which will endure. Che sarà, sarà.

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A. Campbell Jones,

University of Birmingham,

April 1933.

CHAPTER I.

INTRODUCTION.

THESIS SUBMITTED FOR THE DEGREE OF M.D.

ON THE DEFINITIONS AND SOME PROBLEMS.

by

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University of Edinburgh.

April 1908.

## CHAPTER I.

## INTRODUCTORY.

## SOME DEFINITIONS AND SOME PROBLEMS.

An obvious and indeed indispensable preliminary to a discussion of giant growth is briefly to review the outstanding facts with regard to normal body form and normal growth.

From all ages artists have sought to establish some canons to guide them in proportioning the human figure. Vainly, they still seek an ideal being whose limbs, whose stature shall bear some fixed proportion to one of his members. It has been taught that the perfect man is eight times as tall as his head is high, that the symphysis pubis is four head lengths from the soles of the feet and that the nipple is two head lengths above the symphysis. This may be art; it is not anthropology.

Two men of the same stature may be dissimilar in length of limb and yet neither may be deformed. There are in fact several types of body form to be met with among men of the same race. A tall man is not a small man magnified; every part of his body is bigger than usual it is true, but the increase especially affects the limbs. Similarly in short men every part of the body is smaller than usual, but the decrease especially affects the limbs.

Fortunately it is not necessary fully to discuss all the varieties of body form. It is sufficient, for present purposes, to consider the peculiarities of build associated with increase of stature.<sup>(1)</sup>

In men of more than average height, the trunk measured from the great trochanter to the external auditory meatus is slightly, and the vertebral column considerably, diminished relatively to the total stature. In this relative diminution the segments of the column are not equally affected, the cervical is increased both actually and relatively, the dorsal, though actually longer than usual is, relatively considerably reduced. Of all parts of the body the pelvis/

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(1) Papillault, L'homme moyen à Paris, Bull. et Mem. de la Soc. D' Anthropologie, 1902.

pelvis and lower limb show the greatest actual and relative increase; although the shoulder girdle and upper limb are also actually and relatively larger than normal. The unusual length of the limbs being due more to growth of the leg and forearm than to growth of the thigh and arm. The hand, as a rule, shows a very slight relative increase; the foot a relative diminution. The brain does not increase proportionately to the other parts of the organism. <sup>(1)</sup> As a result it is relatively small in tall men and relatively large in short men, in women and in children.

Taking as the basis of classification the proportion,  $\frac{\text{length of lower limb}}{\text{length of trunk}}$  two types of individuals can be distinguished, the "long shanks" or macroskels, and the "short shanks" or brachyskels.

Among both brachyskels and macroskels two sub-types can be recognised; the men of "sturdy" build, or megasomes, and the men of light build, or microsomes.

Underlying these two types of body form are two types of body growth; growth in stature, or macroplasty, and growth in circumference, or euryplasty. These/

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(1). Manouvrier, La quantité dans l'encéphale. Mem. de la Soc. d'Anthropologie, 1883.

These in turn are the visible results of two different growth processes, macroplasty being associated with endochondral ossification, euryplasty with periosteal.

That macroplasty and euryplasty are, in some way, opposite processes is evident from the manner in which the long bones grow. During adolescence they increase in length neither continuously nor regularly. Godin<sup>(1)</sup> finds:--

1. that the growth of the long bones shows alternating phases of activity and quiescence;
2. that the periods of activity and of quiescence for the two segments of a limb are not simultaneous but opposite; for example, that when the tibia is growing the femur is stationary, and conversely;
3. that the period of cessation of elongation is utilised by the bone to grow in thickness; that a long bone thickens and elongates alternately: that macroplasty and euryplasty do not take place simultaneously.

This suggests that the conditions favourable for the one are little favourable for the other.

Unfortunately, little is known with regard to the/

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(1). Paul Godin, Recherche anthropométrique sur la croissance des divers parties du corps. Paris 1903.

the conditions which favour growth. In a somewhat rough and ready way, however, it is known that the richer the food supply the greater will be the growth. This was shown, long ago, by John Hunter, who, experimenting on young cocks, found that it was possible to cut the spur off from the foot and to graft it upon the head where it grew to an unprecedented size.

Only one explanation of such giant growth is possible, namely, that after union with the vascular scalp the tissues of the spur received a blood supply greater than that which in their normal position they could receive and that under the stimulus of increased nutrition they grew abnormally. But if this be inconclusive there are the experiments of Bidder and of Stirling<sup>(1)</sup> which show that giant growth is the physiological response of young tissues to an increased nutritive supply. These observers cut on one side the cervical sympathetic of young rabbits and of puppies and found that not only did the blood vessels of the ear on the affected side dilate but also that that ear grew to an unusual size.

But, indeed, it is a truism that nutrition is/

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(1). Stirling--Journal of Anatomy and Physiology, Vol.X., pp.511-512, 1876.

is the stimulus to growth. Every farmer, every horticulturist dungs his fields or his beds that his plants' protoplasm may receive all the food that it requires that it may grow and flourish exceedingly. Water to dissolve the food stuffs and food stuffs to be dissolved by the water these are the determinants of vegetable growth. Withhold water and the germ within the seed will lie dormant for a thousand years: give water and the food stuffs within the seed will be in part dissolved and by the presence of absorbable food the germ will be stimulated to grow.

Every gardener knows that he can multiply a fine rose, a fine apple or a fine orange tree by grafting and that by grafting alone can he turn his discovery or his luck to commercial profit; and the essence of grafting is food supply. The romance of the navel orange is evidence enough of the extraordinary growth possibilities of protoplasm, from one single chance variation, a bud appearing upon a single tree, the orange growers of California have produced trees whose weight of timber is beyond computation and whose fruit, season by season, supplies the markets of the world. Art, by increasing food supply, has produced a forest from a bud which normally would have formed a single branch upon a single tree.

But/

But this extraordinary power of growth is not restricted to vegetable protoplasm; experimental work on tumours has shown that the animal cell supplied with unlimited food by being grafted from mouse to mouse is capable of growing until the resulting mass outweighs three hundred times or more the little creature in which it had its origin.

Less sensational, but not less striking, is the growth of the gamin of some city slum enlisted into the army and regularly fed. No professed physiological experiment has been performed on so large a scale or has yielded results more free from doubt than the work of making men from starvelings carried on day by day, year by year, in the depots and in the battalions of the British Army. Sufficient food, sufficient light, sufficient air, sufficient exercise, these are the essentials for proper growth and in their absence growth does not take place. But in their essence and on the protoplasmic level these are one and the experiments of John Hunter, of Bidder and of Stirling, the results of manuring fields and gardens, the triumphs of the fruit grower, the results of tumour grafting, the achievements of the army depots have one explanation and only one which is that growth is determined by the amount of nutrition which/

which the protoplasm absorbs. It matters not whether the protoplasm has become capable of extracting more nutrition from its environment, which it probably does under the influence of sunshine and of fresh air, or, whether the environment has become more loaded with nutrition, thus diminishing the difficulties of absorption which is probably what happens in growing plants when manure is dug about their roots, the result is similar, the protoplasm is enabled to utilise more nutriment and growth results.

Before it is possible, however, to analyse further the factors determinant of growth it is necessary to limit in some measure the connotation of the verb "to grow." We speak indifferently of a growing population, a growing child and a growing cell and we mean that the population, child or cell is getting larger, however different the underlying processes may be. It is obvious that a cell can only grow as the result of intussusception; a population as the result of an increase in the number of its component individuals: whereas, hypothetically, a child might become larger because of an increase in the bulk of its somatic cells, their number remaining constant; or because of an increase in the number of its cells, their bulk remaining constant; or because of a relatively/

relatively greater increase in the number of the cells, their individual bulk suffering reduction.

These three types of growth are known to occur; the first is seen in the pregnant uterus; the second in proliferating epithelium; the third in the segmenting ovum. But the second is the most common and there is little doubt that most young organisms grow because of an increase in the number of their component cells, the cells remaining of approximately constant bulk.

This postulate has the important corollary that the growth of a multicellular organism is influenced by the laws of the multiplication of population.

PART I.

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OF THE FACTORS DETERMINANT OF THE DETAILS  
OF BONE FORM.

## CHAPTER II.

## THE THEORY OF GROWTH.

## SECTION I. THE GROWTH OF THE CELL.

Ceaseless expenditure of energy is an essential characteristic of living protoplasm. Hunger, coterminous with life, is the physiological expression of the protoplasm's need of finding a source of potential energy in its environment. This "food" it intussuscepts and uses to replace the de-energized matter within itself. But, if there be food absorbed surplus to the actual needs of the moment, and if the surplus be retained, the cell of necessity is larger than before and with its larger bulk must expend more energy in the performance of its routine activity and so require more food. Now Spencer has pointed out that as a sphere becomes larger its mass increases as the cube, its surface as the square of its diameter. The importance of this is too obvious to be overlooked, for /

for it is only through its surface that a cell can absorb, "thus, the cell, as it grows must get into physiological difficulties, for the nutritive necessities of the increasing mass are ever less adequately supplied by the less rapidly increasing absorbent surface. The early excess of repair over waste secures the growth of the cell. Then a nemesis of growing wealth begins. The increase of surface is necessarily disproportionate to that of content and so, there is less opportunity for nutrition, respiration, and excretion. Waste thus gains upon, overtakes, balances and threatens to exceed repair. Suppose a cell to have become as big as it can well be, a number of alternatives are possible. Growth may cease and a balance be struck. On the other hand, waste may continue on the increase and bring about dissolution and death; while closely akin to this there is the most frequent alternative, that the cell divide, halve its mass, gain new surface, and restore the balance."<sup>(1)</sup> This restated in terms of protoplasmic activity reads as follows:--"The early growth of the cell/

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(1) Geddes and Thomson, "The Evolution of Sex."

cell, the increasing bulk of contained protoplasm, the accumulation of nutritive material, correspond to a predominance of protoplasmic processes which are constructive or anabolic. The growing disproportion between mass and surface must, however, imply a relative decrease of anabolism. Yet the life, or general metabolism continues and this entails a gradually increasing preponderance of destructive processes or katabolism. So long as growth continues the algebraic sum of the protoplasmic processes must be plus on the side of anabolism. The limit of growth, when waste has overtaken and is beginning to exceed the income or repair, corresponds in the same way to the maximum of katabolic preponderance consistent with life. The limit of growth is the end of the race between anabolism and katabolism, the latter being the winner." <sup>(1)</sup> Again restated, but this time in terms of the cell and its environment--Growth is primarily dependent upon the physiological capital which the cell possesses or, in other words, upon the start which anabolism gets at the outset, but varies directly as the surplus of nutrition over expenditure and directly as/

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(1) Geddes and Thomson, "Evolution of Sex."

as the rate at which this surplus decreases. The moment the surplus of nutrition over expenditure falls below zero the cell must die or divide. The moment division takes place the problem becomes complicated by the action of the laws governing the multiplication of living organisms.

## SECTION II. THE LAWS OF MULTIPLICATION.

Before proceeding to discuss further the problems of growth it is necessary, briefly, to state the laws of multiplication. The first of these is a modification of the law of Malthus. It reads, "a healthy population tends to increase beyond the limits of its food supply." The second is, "since all living organisms have a fixed period to their individual existence they must, in order to exist at all, establish with their environment an equilibrium sooner or later to be overthrown in death." The corollary of this is, to prevent extinction, the organism must meet the effects of its environment in two ways, by individual adaptation and by genesis. The third law is important: it is "when favourable circumstances cause any species to become unusually numerous competition becomes keener and enemies that prey upon it more abundant/

abundant." The fourth is, "in a species which survives, given the forces destructive of race as a constant quantity, those preservative of race must be a constant quantity also, and since the latter are two, the individual and the reproductive, these must vary inversely." To this law every species must conform or cease to exist. Tersely restated it reads "individuation and genesis vary inversely." The corollaries are, first, "advancing specialization must be accompanied by declining fertility" and, second, "if the difficulties of self-preservation permanently diminish there will be a permanent increase in the rate of multiplication, and conversely."<sup>(1)</sup>

### SECTION III. APPLICATION OF THE LAWS OF CELL GROWTH AND OF MULTIPLICATION TO THE GROWTH OF A MULTICELLULAR ORGANISM.

It is convenient here to draw attention to the importance of these laws of cell growth and of multiplication/

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(1) For a full discussion of these laws and for the evidence on which they are based see Spencer "Principles of Biology" or Geddes and Thomson, "Evolution of Sex" to whose summary of Spencer's Analysis I am greatly indebted for the above short statement of the rules of multiplication.

multiplication with regard to the growth processes of a multicellular organism. From what has been said with regard to the growth of the cell it follows that true hypertrophy, that is, increase in bulk of an organ or an organism resulting from an increase in the size of the component cells, their number remaining constant, depends upon an increase in the supply of food, or upon a supply of more absorbable food, or upon the fact that the cell as the result of food already absorbed, has become more absorptive, in short, that as the result of a more favourable environment, the cell metabolism has become relatively anabolic.

Katabolic growth, that is increase in cell numbers with reduction of cell size has the exactly opposite environmental significance and corresponds to a relatively less abundant supply of food or a supply of less absorbable food or to a diminished absorptive power.

We have already defined the physiological capital of a cell as the amount of start which its anabolism gets at the outset. Now, all the somatic cells of a multicellular organism belong to a race, doomed to extinction, not one of them can ever receive the anabolic stimulus of sexual refreshment. From this/

this it follows that there is generation by generation a reduction in the amount of the physiological capital of the cells, and that, although, favourable nutrition may delay, it cannot prevent the ultimate triumph of katabolism. This is the essential difference between a race of somatic cells and a race of men, and it must not be overlooked in determining the influence of the laws of multiplication upon the growth of multicellular organisms.

The application of the first law, a healthy population tends to increase beyond the limits of its food supply, is obviously affected by the law of katabolic rise which has as its intimate meaning the fact that a food supply, just equal to the demands of a colony of young actively absorbing cells, will be inadequate for the same colony in old age; unless, the cells have decreased in size or assumed a form of specialization which makes little demands upon protoplasmic activity. From this it follows that if cell multiplication proceed unchecked to the limit of food supply, the organism will die young. This most probably is the explanation of the short life of giant variations.

With regard to the second law of multiplication/

multiplication it is only necessary to point out that for cells individual adaptation must mean specialization which by enabling the cell to procure an increased supply of blood renders its environment more favourable.

The third law, "when favourable circumstances cause any species to become unusually numerous, competition becomes keener" is important to a discussion of giant growth; its meaning in terms of metabolism is obvious.

The fourth law, "individuation and genesis vary inversely," with its corollary, "advancing specialization must be accompanied by declining fertility" is at the root of the phenomena of cytomorphosis, <sup>(1)</sup> for histologically, it means that it is useless to expect to find an active, fully developed, highly specialized cell undergoing karyokinetic division. This opens up a field for the study of the life history of cells and of cell colonies. The whole process with its successes and failures is well exemplified in muscle.

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(1) The word cytomorphosis was introduced by Minot in 1901, "to designate comprehensively all the structural modifications which cells or successive generations of cells undergo from the earliest undifferentiated stage to their final destruction."

The colony of highly specialized cells which we call a muscle is at its first appearance and in the earliest stage of its development a mass of undifferentiated mesoblastic cells. This stage of muscle development must be and obviously is synchronous with a high level of cell absorbent power and with a period of plentiful food supply.

In time some of the cells begin to differentiate into embryonic muscle fibres: this corresponds to a period of slowly declining anabolism, individual adaptation, specialization, taking place to bring the individuals into completer harmony with their environment. This exemplifies the working of the second law of multiplication.

In the next stage the individual cells that are undergoing specialization become still more fully specialized and ultimately individuation is complete. This theoretically excludes genesis: practically, completely specialized muscle fibres are known never to divide. The continuance of the life of the cell colony has, therefore, to be provided for by unspecialized cells; but, the unspecialized cells in the colony are, in a sense, parasitic upon the specialized cells which by their activity attract blood to the part./

part. Their demands upon the food supply are of necessity great, there is, however, a surplus which is utilized by the undifferentiated cells. If now the difficulties of self-preservation permanently diminish there will be a permanent increase in the rate of multiplication. General anabolic conditions will, therefore, be associated with the presence of a large number of undifferentiated cells in the muscle substance. In other words general increase in the mass of an organism associated with the presence of numerous undifferentiated cells in the so-called specialized tissues is certain evidence of the prevalence of an highly anabolic metabolism.

When the food supply is very limited cytomorphosis must pursue a different course. Regression of muscle and the formation of tendons and aponeuroses attest this. Here the specialized cells, and the undifferentiated genetic cells are alike exposed to a shortage of nutrition. If this be absolute the cells must die and their debris be removed by the scavenger cells of the body. If not absolute, the cells specialize along lines of low nutritional requirement, and become converted into fibrous tissue.

The possible types of muscle cell colony, therefore, /

therefore, are:--

1. A completely unsuccessful colony which becomes extinct and is removed by the scavenger cells.

2. A partially unsuccessful colony in which the cells are compelled to specialize along lines of low nutritional requirement. This leads to the formation of tendons and aponeuroses.

3. A more or less successful colony in which the cells can attain to a high degree of specialization forming actual muscle fibres. Of such colonies three types will be recognisable.

(a) An anabolic type in which undifferentiated cells are numerous lying among the active fibres.

(b) A relatively katabolic type in which the cell-specialization is complete and undifferentiated cells rare.

(c) An absolutely katabolic type in which the highly specialized cells are dying and being removed by the scavenger cells.

From this it is evident that growth is the expression of the interplay of two forces, cell absorbent power and food supply. It follows that the amount and type of an individual's growth will be largely determined by the relative nutritive value of his/

his body fluids which in turn will be partly determined by the activity of his cytogenetic glands for these by their excretion of formed living matter reduce the supply of food available for the cells of the body.

As an example of a cytogenetic gland I select the testicle and propose to study the effect of testicular activity upon growth. The relation is intimate and the activity of the one is found to be inversely proportionate to the activity of the other.

#### SECTION IV. THE ANTITHESIS BETWEEN GROWTH AND SEXUAL REPRODUCTION IN MULTICELLULAR ORGANISMS:

A survey of the animal and vegetable kingdoms reveals a curious antithesis between growth and reproduction, between the effects of a plenteous food supply and a growing scarcity. For example, the common hydra in abundant nutritive conditions produces numerous buds and even these sometimes begin themselves to bear another generation and so obviously is this asexual reproduction continuous with growth that we may say, that when food is plentiful the polype appears to grow indefinitely. A check to the nutritive conditions, however, brings on the development of the sexual/

sexual organs and the occurrence of sexual reproduction. Planarian worms yield another excellent example: so long as they are provided with a favourable nutritive environment they form asexual chains. A check to nutrition, however, brings about the separation and the sexual maturity of the links. A still further example is provided by the practice of fruit growers who root-prune their apple trees to increase the yield of fruit. These three examples are sufficient to illustrate the generally applicable law that the rise of katabolism is associated with an increased tendency to sexual reproduction. The application of this law to the vegetable kingdom is well stated by Geddes and Thomson. They point out that the position of a flower at the end of a vegetative axis is an example of this. "The end of the axis is furthest from the source of nutritive supply: with exaggeration we might call it the starvation point. There with katabolic conditions tending relatively to predominate, the reproductive organs are situated. The flower occupies a katabolic position and is often the plant's dying effort. In the tiger lily, growth at first tends to remain continuous and the base of the/

the bulb bears simple vegetative buds. Further up, however, where nutrition reaches its maximum, the axils of the leaves contain buds, which are separable though still asexual. Finally, further up still, where nutrition is relatively less active and katabolism is maximized the formation of flowers indicates the appearance of sexual reproduction.<sup>(1)</sup> And so we might search on through the whole gamut of the vegetable kingdom and not fail of finding examples of the law that growth is conditioned by anabolism predominant, sexual reproduction by katabolism predominant.

It is exceedingly interesting to notice that in man the testicles are placed in a position analogous to that occupied by the flower and fruit of plants. The extraordinarily long, thin spermatic artery suggests that the testicular cells are so placed that they are exceedingly likely to outrun their food supply; a condition in which katabolism must ever tend to predominate.

The law, in illustration of which these examples have been cited is, "the decline of anabolism in a multicellular organism is marked by an increasing tendency/

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(1) Geddes and Thomson. Ibid.

tendency to sexual reproduction." The converse, "the absence of sexual reproduction in a multicellular organism is marked by an unusual continuance of anabolism," is also true.

Theoretically, it follows that castrated animals should be larger than entire males; practically, they are larger as the observations quoted in the following chapters show. It is, therefore, permissible, provisionally, to conclude that the activities of the cytogenetic glands determine in part the somatic nutritive value of the body fluids.

## CHAPTER III.

## THE EFFECTS OF CASTRATION IN ANIMALS.

## SECTION I. PRELIMINARY.

Castration is an exceedingly frequent operation. Breeders castrate their bull calves in order that they may obtain better and more beef from each animal. Poultry farmers capon their cockerels in order that they may obtain a larger and more succulent bird for table use. The quality of the beef and the succulence of the capon are due to the cellularity of the flesh; their increased bulk appears to be due to the absence of testicular drain upon the general food supply of the body. But not only is the bullock bigger than the bull of the same species he is also of a different build. The bull's back slopes most markedly from the withers to the croup; the bullocks from the croup to the withers. Kon-<sup>(1)</sup>delka has shown that this peculiar difference is due to/

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(1). Kondelka Das Verhältniss der Ossa longa zur Skelet Höhe bei dem Sagenthieren Verhandl de naturf Vereins Brunn, 1855.

to the increased length of the bullocks' bones, more especially of the tibia and femur. Such facts as these are open to the serious objection that they lack scientific exactness; fortunately, laboratory experiments, of which the general accuracy is beyond dispute, are amply forthcoming. Of these I propose to quote five: the first, upon cocks; the second, upon guinea pigs; the third, upon cats; the fourth, upon rabbits; the fifth, upon dogs.

SECTION II. EXPERIMENTS TO INVESTIGATE THE INFLUENCE OF THE TESTICLES UPON SOMATIC GROWTH.

EXPERIMENT NO. I.--COMPARISON OF THE CAPON AND THE COCK.

Exp.1. Two cocks of the same brood and of the same strain (Ardennes) were selected.

Exp.2. Two cocks of the same brood and of the same strain (Italian) were selected.

One animal in each pair was castrated; the other was kept entire. They are distinguished as No.1.Capon; No.1.Cock; No.2.Capon; No.2.Cock.

Before the operation was performed the weights of the animals were

No.1/

PLATE I.

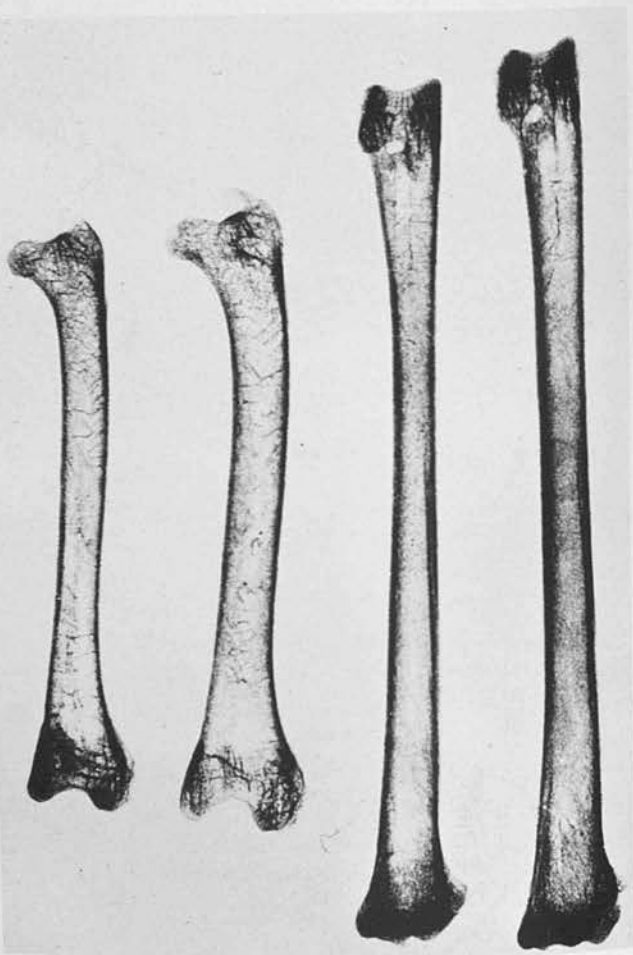


PLATE I.

Radiograph of the bones of one of the capons and the corresponding bones of its control.

The capon's bones are the longer and the more strongly marked marginal shadow shows that in them the compact bone was considerably thicker. The great size of the marrow cavity is also well shown.

Copied from Pirsche's Thesis, "De l'Influence de la Castration sur le Développement du Squelette," page 38.

No.1. Cock 980. grammes.

No.1. Capon 845. grammes.

No.2. Cock 785. grammes.

No.2. Capon 805. grammes.

The age of all the animals was three months and twelve days.

For a week after the operation the caponed birds were kept in separate cages and then were set at liberty and lived in common with the other birds of the same race. At the end of about two months the capons had stopped crowing, their sexual desire was completely suppressed and they were very fat.

Eight months after operation the animals were killed when their weights were

No.1. Cock 1955. grammes.

No.1. Capon 2800. grammes.

No.2. Cock 2105. grammes.

No.2. Capon 2650. grammes.

On examination the bodies of the capons were found to be much fatter than those of the cocks.

#### EXAMINATION OF THE SKELETON.

The bones of the capons were longer, thicker and denser than those of the cocks, as the accompanying radiograph shows. The actual measurements for the/

the long bones of the hind limbs were:--

	<u>Femur.</u>	<u>Tibia.</u>
No.1. Cock	9.	13.4
No.1. Capon	9.8	15.1
No.2. Cock	7.4	12.2
No.2. Capon	8.3	13.2

The muscular impressions were slightly marked upon the capons' bones; outstanding and sharp, upon the cocks'.

Section of the capons' bones showed that in them the medullary canal was longer than usual and contained more fat.

#### NOTES UPON THE EXPERIMENTS.

These experiments give some indication of the expense of the testicles to the body. At the outset cock No.1. was 135 grammes heavier than capon No.1., eight months later cock No.1. was 845 grammes lighter. During the same period the cock had just doubled its weight whereas the capon's weight was trebled. If now we take the weight of the capon as representing the maximum growth attainable by a bird of this particular strain subjected to a particular set/

set of environmental influences we see that the possession of sexual organs cost the cock some 900 grammes which is roughly one-half of the weight that he attained. Therefore, it is permissible to say, that in this particular case the sex organs directly, in spermatogenesis, and indirectly, in the glories of sexual plumage cost the bird nearly one-third of its potential growth. In experiment No. 2. the difference is not quite so great, but it is of the same kind, the cost being approximately one-fifth.

The differences found in the bones are also of exceptional interest. Firstly, the record makes it clear that unusual bone growth takes place in the absence of reproductive drain. Secondly, the absence of muscular ridges, which is a characteristic of feminine bones, is interesting, as it suggests the possibility that rugged bones will be found to be definitely associated with katabolic growth and not with muscular power. This question is dealt with later.

In the particular experiments which have been quoted the epiphyseal cartilages were obliterated;  
 (1)  
 Sellheim has, however, shown that in the capon the union/

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(1). Sellheim, "Kastration und Knochwachstund Beitrage zur Gebartshilfe Gynakologie," II. 1899.

union of the epiphysis and diaphysis is delayed. This is interesting as it is a complementary observation to the preceding, suggesting the generalisation that endochondral bone formation is a manifestation of local or general anabolic predominance. In the course of this thesis a large number of facts suggestive of the truth of this will be adduced.

(1)

EXPERIMENT NO. II. -- THE EFFECT OF CASTRATION UPON  
GUINEA PIGS.

Three guinea pigs of the same litter, age 45 days, were taken. One was left entire, two were castrated.

The weight of the animals at the time of operation was,

No. 1. Castrated 325 grammes.

No. 2. Castrated 400 grammes.

No. 3. Entire 355 grammes.

After the operation the three animals were placed in one cage and were treated absolutely alike. They were weighed regularly and a most interesting series of observations was recorded. At first the castrated animals./

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(1) Pirsche, op. cit.

animals got rapidly heavier. No.1. castrated which to start with weighed 30 grammes less than No.3. entire, surpassed him in weight and at the end of four months was the heavier by 150 grammes.

Weights:--

No.1. Castrated 770 grammes.

No.3. Entire 625 grammes.

For the next four months the weight of these animals remained stationary at the end of which time they were killed.

No.2. castrated, which to start with weighed 45 grammes more than No.3. entire, gained weight up to three months at which time he weighed 655. No.3. entire at the same time weighed 595 grammes. From the third month onwards the weight of No.2. castrated did not materially alter until the end of the eighth month when he was killed. As stated, No.3. entire increased in weight to a total of 625 grammes.

Weights:--

No.2. Castrated 655 grammes.

No.3. Entire 625 grammes.

In each of the castrated animals the penis was atrophied.

In spite of their slightly greater weight there was no marked increase in the amount of fat in the/

the castrated animals.

The bones of the skeletons of the castrated animals were somewhat bigger than those of the entire male, being not only longer, but thicker. The measurements are given in the accompanying table.

TABLE NO. I.

MEASUREMENTS OF THE BONES OF ENTIRE AND  
CASTRATED GUINEA FIGS.

	No. 1. Castrated.		No. 2. Castrated.		No. 3. Entire.	
	R.	L.	R.	L.	R.	L.
Femur	46 $\frac{1}{2}$	47.	47 $\frac{1}{2}$	47.	44.	44.
Tibia	49 $\frac{1}{2}$	50.	50 $\frac{1}{2}$	50 $\frac{1}{4}$	46 $\frac{1}{2}$	46 $\frac{1}{2}$
Humerus	39.	39.	40 $\frac{3}{4}$	41.	38.	38.
Ulna	44.	43.	43.	43.	42.	42 $\frac{1}{4}$

The bones of the castrated animals were heavier than the corresponding bones of the entire male.

The epiphyseal cartilages persisted in the castrated animals but had entirely disappeared in the entire male.

In/

In all three animals the osseous tissue was very compact.

There were other important differences. The castrated animals had dolichocephalic skulls and their paws were distinctly larger than the entire male's. This was so striking that their pituitaries were examined, but no visible alterations had occurred.

#### NOTES UPON THE RESULTS.

These results are in general agreement with those obtained in Experiment 1.

In the castrated animals the long bones are longer and heavier and, as in Sellheim's capons, the epiphyseal cartilages persist. The peculiarities of the increase of weight are particularly interesting.

With regard to these it is to be noted that the entire male was not accorded the opportunity of going with females, therefore, it seems permissible to say that his body was subjected to a less intense sexual drain than that which it would have had to meet in a state of nature. Secondly, the manner of increase of weight of the castrated animals is interesting. In the space of four months they reached their maximum weight and during the next four months neither gained nor lost. From this it appears that the/

the actual mass had reached the limit of support and had become stationary, probably very much in the normal condition of slowly rising katabolism. The absence of fat seems to support this deduction.

It is essential to realise that the rise of katabolism does not presuppose an absolute food shortage, but an aggregate cell surface insufficient for the needs of the contained protoplasm, either because its mass has increased or because the absorptive power of the cell surface has diminished. The period of rapid growth of the animals evidently corresponded to a time of marked anabolic metabolism, and their practically stationary weight thereafter to a period of slow katabolic rise.

(1)

EXPERIMENT III.--THE EFFECTS OF CASTRATION UPON CATS.

Kittens of the same litter and as nearly as possible of the same weight were taken. Some were castrated; others, kept entire, were used as controls. The operation was performed when the animals were about three months old; three months later they were killed.

The bones of the castrated animals were stronger/

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(1). Poncet, see reference Experiment IV.

stronger and longer than those of the entire animals. The difference in length was plainly visible in the long bones especially in the femur and tibia. In addition the compact tissue of the bones was in the castrated animals slightly increased in amount; the medullary canal was increased in size. The long bones were of the usual form, the normal curves being well marked.

EXPERIMENT IV.--AN EXACTLY SIMILAR EXPERIMENT WAS  
 CARRIED OUT ON RABBITS WITH EXACTLY SIMILAR  
 (1)  
 RESULTS.

#### NOTES ON THE EXPERIMENTS.

Poncet's results exactly confirm those obtained by Pirsche in his experiments. Unfortunately the weight of the animals is not stated, nor is the presence or absence of fat noted. The bone changes that were found are, however, of sufficient interest to warrant their inclusion as they help to prove that the changes found by Pirsche were not due to some peculiarity of the animals upon which he experimented.

EXPERIMENT/

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(1). Poncet quoted by Pirsche *ibid*, read at "Le congrès de l'association française pour l'avancement des sciences." 1877.

## EXPERIMENT V.--EFFECT OF CASTRATION UPON DOGS.

(1)

Briau experimented upon dogs taken from the same litter. The operation was performed when the animals were a fortnight old. At the age of six months the experimental animals and the controls were killed. The weight of the skeletons was compared with the following result.

Average weight of skeletons of castrated animals 240 grammes. Average weight of skeletons of entire animals 175 grammes.

This gives definite evidence of the greatly increased amount of bone formation in animals not subjected to the sexual drain.

(2)

Poncet also carried out experiments upon dogs and upon bitches.

A litter of five pups, two dogs and three bitches, was taken. While still quite young one dog and two bitches were castrated, the remaining dog and bitch being kept as controls. Seven months later the five/

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(1) Briau, "De l'influence de la castration testiculaire et ovarienne sur le développement du squelette" *Guy. hebd. de Méd. et de Chir.* 15 August 1901.

(2) Poncet, *loc. cit.*

five animals were killed and their bones examined with the following results.

TABLE NO. II

MEASUREMENTS OF THE BONES OF CASTRATED DOGS  
AND BITCHES.

	Length of tibia.	Length of femur.
No.1. Dog castrated	0.56	0.17
No.2. Dog entire	0.50	0.14
No.3. Bitch castrated 1.	0.54	0.15½
No.4. Bitch castrated 2.	0.54	0.15½
No.5. Bitch entire	0.50	0.15

NOTES ON THE RESULTS OF THE EXPERIMENT.

These results are interesting and important.

Firstly, it is to be noted that the females, as well as the male, grew to a larger size in the absence of their sexual glands: secondly, that the excess of growth was less in the females than in the male.

Sufficient/

Sufficient has, I think, been said to show definitely that castrated animals are larger than entire animals of the same species. This is a fact about which there can be no reasonable doubt although there are certain apparent exceptions to the rule. These I discuss in the next Section.

### SECTION III. APPARENT EXCEPTIONS TO THE RULE THAT CASTRATED ANIMALS ARE LARGER THAN ENTIRE ANIMALS OF THE SAME SPECIES.

In spite of what was said above of the relative size of the bullock and the bull there is little doubt that, in this country, the average bull is distinctly larger than the average bullock. Probably everyone who has superficially considered the matter has assumed that this was the natural and ordinary state of affairs. But, practically, every bull in the country is a carefully selected, carefully fed animal, whereas the average bullock is, on its dam's side, without pedigree and it is not surprising that it is smaller than its sire. The essential point is that it is larger than it would have been, had it not been freed from sexual drain.

With/

With regard to the comparative size of the horse and stallion there is considerable difference of opinion. The magnificent stallions of this country are practically without exception larger than the horses of the same breed. Here too, we are dealing with a selected class and it is necessary to go to a country like France where stallions are regularly worked to get a basis of comparison. But even there other disturbing factors have to be considered and allowed for. Horses from an early age are subjected to heavy work. A sexual drain is replaced by a muscular drain. That this is so receives proof from the fact that hard worked stallions show very little sexual desire. On the protoplasmic level this must mean that the overworked body cells starve the testicles and that the food supply available is insufficient to force on multiplication of the testicular cells.

In a problem so beset by disturbing factors it is not surprising to find that a difference of opinion exists among veterinary surgeons. De Nathusi-  
(1)  
us, however, who has operated upon two hundred and sixty/

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(1) De Nathusius quoted by Pirsche, loc.cit.

sixty Belgian horses and studied the effects of the castration upon their skeletons, has shown that the hind legs of geldings are longer than those of stallions. Apart from the apparent exceptions here discussed I know of no evidence against the conclusion that removal of sexual drain in early life is associated with increased body growth.

#### SECTION IV. SUMMARY OF THE OBSERVED RESULTS OF CASTRATION IN ANIMALS.

In animals which have been castrated there is--Firstly, an increase in the length of the limb bones; Secondly, there is an increased density of compact bony tissue and absence of the normal muscular impressions; Thirdly, there is delay in the obliteration of the epiphyseal cartilages; Fourthly, there is a tendency to increased fat formation.

The third of these results is so important that it is desirable to lay considerable stress upon it. Becher, as the result of observations in the slaughter house, states that a bull's epiphyses have joined/

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(1) Becher quoted by Pirsche, op.cit.

joined and the cartilages disappeared by the time the animal is two years old, but that in bullocks the diaphysis and epiphyses of the long bones are separate until the animal is fully three years old. (1)

The effects of the castration of boys and men is discussed in the next chapter.

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(1) Bonnet states that they do not join until the end of the fourth year.

## CHAPTER IV.

THE EFFECT OF THE CASTRATION OF BOYS IN MODIFYING  
SUBSEQUENT GROWTH AND NUTRITION.

## SECTION I. ANTHROPOLOGY OF THE SKOPTZY EUNUCHS.

The material available for the study of the effects of the castration of men is limited. In Mohammedan countries eunuchs are plentiful, but accurate observations upon them are rare. Fortunately, there exists in Russia and Roumania a sect of religious fanatics, the Skoptzys<sup>(1)</sup> or "White Doves" who believe that only those who have known no sexual desire are worthy to mount the "White Horse" of the Apocalypse.

To/

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(1) Full information about the Skoptzys will be found in "Progrès Médical" 1876-77. E. Teinturier, in Gerithtlich Medicinisch Untersuchungen uber das Skoptzenthum in Russland. Deutsch von Iwanoff, Giesen 1876, in "Comptes rendus de l'Académie des Sciences," Pelikan, 8th June 1903, p. 1411, where a paper by E. Pittard is published; in the Bulletin de la Société des Sciences de Bucarest 1903, or in Launois and Roy, "Etudes Biologiques sur les Géants," upon whose excellent summary of the facts I have made somewhat liberal demands.

To secure this happy fate for their sons parents have them castrated when they are from three to five years old.

This interesting sect was founded in the beginning of the seventeenth century and in spite of pitiless persecution has steadily gained adherents. No actual figures are available for the first two centuries of its existence, but in 1866 it numbered 5,500 souls. About 1880, harried from Russia the Skoptzys emigrated to Roumania where the majority now live peacefully in special Skoptzy villages. The cessation of persecution has been followed by a great increase in their numbers and to-day there are certainly not less than sixteen thousand of them.

## SECTION II. PHYSICAL PECULIARITIES OF MEN CASTRATED IN INFANCY.

The Skoptzy eunuchs are taller than the men of the same race. Pelikan gives figures based upon an examination of seventeen Skoptzy skeletons and of twenty-six skeletons of normal men of the same race. The average of his measurements is:--

	<u>Skoptzy</u>	<u>Normal</u>
Stature	1690mm	1656mm
Arm and forearm	550 "	
Tibia	476 "	

The proportionate length of the tibia to body height is as 1 to 4.32 - 4.80<sup>(1)</sup>. This gives a tibia length 345 - 378.7 for a stature of 1656. The tibia of the Skoptzy is, therefore, actually longer than that of normal men, but it is also relatively far longer, for a tibia length of 476 should be associated with a stature of between 2051 and 2285. But not only is the tibia relatively and absolutely longer than normal, the trunk is relatively and absolutely shorter. Pitard gives confirmatory figures. He examined thirty individuals, these he divided into three groups, each of ten individuals, and obtained the following averages:--

	Stature.	Height seated.	Length of lower limbs.
1st group 10 individuals, without beard and sexual hair.	1751.8	1278.6	875.4
2nd group 10 similar individuals.	1718.8	1277.6	844.2
3rd group 10 individuals possessing beard and sexual hair.	1704.2	1287.0	818.2

The/

(1) Text-book of Anatomy, edited by Prof. D. J. Cunningham

The third group is composed of Skoptzys who have been converted after adult life has been attained or of Skoptzys who have had only one testicle removed, they may, therefore, be regarded as furnishing a control and as giving a useful standard for comparison. The existence of the second class of Skoptzys, the one testicle men, is a peculiar feature of this strange sect: presumably they have no hope of mounting the "White Horse" of the Apocalypse, but they are the fathers of the next generation.

Pittard, in a communication to l'Académie des Sciences introduced by Laveran, 8th June 1903, gives further particulars arrived at as the result of an anthropometric survey of thirty of these eunuchs. His conclusions are:--

1st. In the case of individuals castrated before puberty the ablation of the testicles determines an increase of stature. This increase is considerable; the average stature of the eunuchs easily surpasses the average for normal men of the same ethnic group.

2nd. The increase in length of the lower limb is the important factor in the general increase, the trunk developing relatively little. The proportion between the length of the lower limb and height is greater in eunuchs than in men of the same stature.

3rd./

3rd. The length of the upper limb of eunuchs is relatively greater than that of men.

4th. On the other hand, the height of the head is relatively less in eunuchs than in men.

5th. The maximum antero-posterior diameter of the cranium which, normally, increases proportionately with increased stature, in the Skoptzys shows an inverse proportion.

6th. The maximum transverse diameter also bears an inverse proportion to the increase of stature.

7th. Castration retards the growth of the skull; it must also affect adversely the growth of the brain.

8th. It retards or restrains equally the transverse growth of the forehead. The development of the frontal minimum which, in normal men is proportional to increase of stature becomes inversely proportional.

9th. The effects of castration are also seen in the development of the height of the skull. (auriculo-bregmatic diameter.) This development is normally inversely proportional to the total stature. This order of growth persists, but it is retarded.

10th. Castration retards and probably ultimately arrests the lateral development of the face (represented by the bizygomatic diameter) and also, probably, its/

its vertical height. It is especially the lower part of the face which is affected, and probably more especially the height of the inferior maxilla.

11th. In the Skoptzy eunuchs the region of the ophryon appears to be less developed.

12th. Castration causes an arrest in the growth of the nose especially in height.

13th. It appears on the other hand to produce an increase in the depth of the orbit.

These results may be summarised:--

I. Castration diminishes or restrains the actual and relative growth of the trunk, of the head, of the cranium in its three chief diameters, of the forehead and of the face in height and breadth.

II. Castration increases or accelerates the actual and relative growth of the whole stature and especially of the upper and lower limbs and probably of the eye.

The eunuchs of Mohammedan countries are frequently referred to in books of travel, but scientific observations upon them are rare. The earliest of these that I have discovered was published in 1867

by/

(1)

by E. Godard. Referring to the eunuchs of Egypt he writes "The eunuchs are thin, tall and stupid. Their legs are of monstrous length. The negroes of the country may be large, but never so ill-proportioned as the eunuchs. M.le Dr. Rossin, whom I asked to tell me the reason of this, said that the grotesque misproportion developed after the proper age of puberty. Thus a eunuch of Alim Pasha's who now has long legs was like anyone else when he was young. The extraordinary development of the legs has only come on since the normal time of puberty." Describing the eunuch attendant on a princess the same observer writes: "He is a great big fellow nearly six feet high, tall and thin with a frost bitten look; he has long bony fingers. One would say that castration determines a great development of the body."

(2)

(3)

Mantignon and Hikmet and Regnault publish observations confirming and completing this description of Godard's. In a letter addressed to Pirsche and reproduced by him Mantignon records some observations that he made upon the great stature of the Chinese/

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- (1). E. Godard "Observations médicales et scientifiques Egypte et Palestine." Paris 1867, p.115.  
 (2). Mantignon "Les Eunuques du Palais Impérial." Bull. de la Société d'Anthropologie, 7th May 1896, p.323.  
 (3). Hikmet and Regnault "Les Eunuques du Sultan." Bull. de la Société d'Anthropologie, 1901, p.3.  
 (4). Pirsche, loc. cit. p.11.

Chinese eunuchs attached to the Imperial Palace at Peking. "Before the last war in China," he writes, "I had had only a limited number of eunuchs at my hospital, five or six at most, two of them who had been castrated before puberty, were sixteen or seventeen years old and were considerably taller than the average lad of that age. After the taking of Peking by the allies I had the opportunity of seeing several groups of eunuchs in the Palace. These fellows were very big certainly not less than 1m. 80 in height. Some of them were still quite young and had been operated on when mere children. If there be any connection between castration in early life and development of stature I can tell you another very suggestive fact. On the sixteenth August I was with an advance guard of marines and as we advanced into the park of the Imperial Palace a group of eunuchs came to meet us and flung themselves down at our feet. One of them then came on and begged for mercy. He was tall fully (1) 1m. 85. I showed him to several of my friends and asked him how long it was since he was castrated. He said/

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(1) The average height of the Chinese is 1m.68, Topinard Anthropology.

said that he had been operated on when he was about ten years old.

I have seen another very tall eunuch. It was at Seoul. He was standing, an imposing figure, behind the Emperor of Corea when I was received by that sovereign. His height led me to think that he must have been castrated when he was quite young."

(1)

Korsakow records practically similar observations upon Chinese eunuchs.

Pirsche also quotes a letter from his "colleague and friend Dr. Amir-Khan" who records the result of observations in Persia. He says that the eunuchs he had examined either at the court of the Shah or in other parts of the country were tall and ill-proportioned. We thus see that the general impression is that eunuchs whether in Turkey, Egypt, Persia or China are taller than the men of the same race. Definite observations upon the skeletons of eunuchs are rare, but four which I quote below show that this general impression is well founded.

### SECTION III. OBSERVATIONS UPON THE SKELETONS OF EUNUCHS./

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(1) Korsakow. Med. Wochenschrift, Berlin und Leipzig 1898.

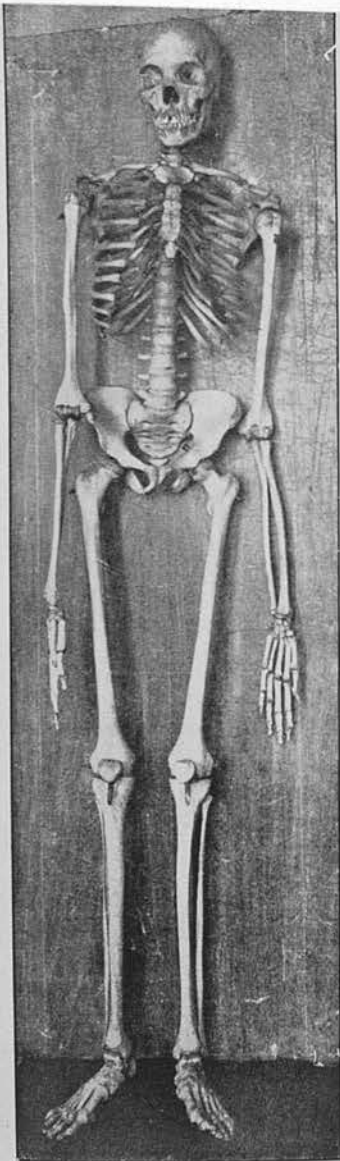


PLATE II.

Photograph of the skeleton of an Egyptian Eunuch, probably a Schilluk. It shows well the characteristics of the long bones of the lower limb. They are remarkable for their length and for the texture of their surface which is very similar to that normally met with in the bones of females.

The photograph is copied from Launois and Roy's reproduction of Lortet's original illustration. See "Etudes Biologiques sur les Géants" page 83.

Ulna

Humerus

Radius

Radius

Humerus

Ulna

On calculating the stature from the length

of the long bones the following results were obtained:

Stature

## EUNUCHS.

(1)

NO.1. LORTET.

Increase in length of the lower extremity due to castration in an Egyptian eunuch.

The subject was an eunuch, aged twenty-four or twenty-five years, apparently a Schilluk from the district between Khartoum and the Bahr-el Gazal. The skin was dark bronze in colour. The head was small, but well-shaped although maxillary and dental prognathism were probably less marked than usual. The exact measurements of the limb bones were:--

	Right.	Left.
Femur	535mm.	530mm.
Tibia	463mm.	464mm.
Fibula	442mm.	445mm.
Humerus	372mm.	372mm.
Ulna	325mm.	324mm.
Radius	306mm.	305mm.

On calculating the stature from the length of the long bones the following results were obtained:

The/

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(1) Lortet, Archives d'Anthropologie criminelle  
Lyon 1896. p.361.

The femur indicates a stature of			1m.94.
The tibia	"	"	1m.99.
The fibula	"	"	2m.02.
The humerus	"	"	1m.88.
The ulna	"	"	2m.07.
The radius	"	"	2m.09.

The length of the lower limb would, therefore, indicate a stature of -- -- -- -- -- 1m.99.

The length of the upper a stature of 2m.

The total stature of the skeleton, however, is 1m.79 allowing 3 centimètres for the difference between the stature of the skeleton and the living individual, the actual height of this eunuch in life was about 1m. 82. Although it is difficult to calculate from the length of the long bones the height of an individual at the extremes of stature, it is permissible, in view of the great divergence between the actual and calculated heights, to say that this individual presented an altogether abnormal length of limb.

The excess of length especially affected the longer bones being less marked in the case of the humerus.

The/

The thorax appeared short compared to the length of the limbs and to the total stature.

The pelvis was wide, but the bones were thin, almost atrophic in appearance.

The thyroid foramina were very large and were separated in front by a very narrow pubic symphysis.

The long bones were exceedingly slender and of feminine type. They showed no projecting crests for muscular attachment.

The humerus was relatively short, the radius and ulna were long and weak. The metacarpals and phalanges were so elongated that the hand looked almost simian.

The femur was very weak and showed no curve. The tibia and fibula were very slender and of exaggerated length.

The feet were flat as in almost all negroes. The phalanges and metatarsals were long and slender.

(1)  
OBSERVATION NO. 2. PIRSCHÉ.

(Note:---I am not quite certain whether this observation refers to a different skeleton from that described/

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(1) Pirsche, op. cit.

PLATE III



PLATE III.

Photograph of the skeleton of a Schilluk Eunuch aged twenty-two years. The important points in connection with this skeleton are:--

1. The great length of the long bones of the lower limb.
2. The persistence of the epiphyseal plates in the long bones up to the time of death.

The photograph is copied from that published by Pirsche in his Thesis, page 48.

described in observation No.1. Many of the measurements are identical, but the accompanying photograph is certainly that of a different skeleton. In Lortet's illustration there is no sign whatever of the epiphyseal lines: in Pirsche's illustration they stand out distinctly.)

DESCRIPTION OF THE SKELETON OF A EUNUCH  
STUDIED IN THE LABORATORY OF PROFESSOR  
LACASSAGNE.

Schilluk Eunuch age 22 years. Height 1m80.

The cranium is markedly dolichocephalic.

We do not wish to insist upon this feature although the cephalic index of 70 shows it to be considerable. Dolichocephaly is, however, not uncommon in the negro races and indeed it is sufficiently evident in the two negro skulls used for comparison. The sutures are clearly visible.

In the limbs there is marked delay in the ossification.

Upper Limb:---

The epiphyseal cartilages of the scapula persist as do those of the head of the humerus, of the lower/

lower end of the ulna, of the radius and of the metacarpals.

Lower Limb:--

None of the epiphyseal cartilages show any sign of ossifying except those of the two first metatarsals which have almost disappeared.

Pelvis:--

The pelvis is very wide and roomy: the tri-radiate cartilage is still visible.

Vertebral Column:--

Ossification is almost complete throughout; the junction of the epiphyses is obviously very recent. The pieces of the sacrum are still distinctly separate.

An X. ray examination of the skull shows that there is a considerable increase in the size of the clinoid processes. The dimensions of the sella turcica are much reduced.

In order to demonstrate that the proportion between the length of the limb bones and the actual stature shows a definite departure from the normal. Pirsche compares the measurements with those of two men of the same age and race.

His/

His figures are:--

Schilluk Eunuch                      age 22      height      1m80.  
 Schilluk Man No.1.                  age 20.      height      1m51.  
 Schilluk Man No.2.                  age 23.      height      1m80.

Index.

	Eunuch	Man No.1.	Man No.2.	Eunuch	Man No.1.	Man No.2
Height	1800	1510	1600	100	100	100
Humerus	372	285	300	20.66	18.81	19.25
Ulna	325	266	255	17.9	16.9	15.94
Radius	306	236	240	16.9	15.58	15.00
Femur	535	399	450	29.7	26.34	28.81
Tibia	463	347	365	25.72	22.9	22.89

The stature-bone-length indices show that the limb bones are all relatively longer than normal. This is especially well marked in the tibia.

(1)

OBSERVATION NO.3. ECKER OF FREIBURG.

Negro Eunuch age 25 years, height 1m83.

Cranium prognathous, forehead low, occiput prominent.

Upper/

(1) Ecker "Zur Kenntniss des Körperbaues schwarzer Eunuchen Abhandlungen herausgegeben von der Lenkenbergischen Naturforschenden Gesellschaft 1864.

Upper Limb:--

The head of the humerus is separate from the shaft of the bone. The epiphyseal cartilages at the lower end of the radius, ulna and four inner metacarpals, and that at the upper extremity of the first metacarpal, still persist.

Pelvis:--

Triradiate cartilage is still present.

Lower Limb:--

None of the epiphyseal cartilages have become obliterated.

Measurements compared with those of Pirsche's two negroes.

Height	Ecker's Eunuch 183.9	Negro Man No.1. 1510	Negro Man No.2. 1600	Index.		
				Ecker's Eunuch 100	Man No.1. 100	Man No.2. 100
Humerus	365	285	300	19.9	18.81	19.25
Ulna	322	256	255	17.5	16.9	15.94
Radius	300	236	240	16.3	15.58	15.00
Femur	556	399	450	30.9	26.34	28.81
Tibia	470	347	365	25.6	22.9	22.89

OBSERVATION/

(1)  
OBSERVATION IV. BECKER OF HEIDELBERG.

Negro Eunuch age 23. Height 1m85.

The cranium has none of its sutures obliterated even the occipito sphenoidal synchondrosis is still open; there is marked dolichocephaly.

Upper Limb:--

All the epiphyseal cartilages persist except those at the upper ends of the radius and ulna.

Pelvis:--

The triradiate cartilage is still distinctly seen.

The sacral intervetebral discs are altogether unossified: the lines of junction with the alae are well seen.

Lower Extremity:--

All the epiphyseal cartilages are present.

Becker says of this skeleton--"One could believe oneself to be looking at the skeleton of some young/

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(1) Becker, Ueber des Knochensystem eines Castraten  
Archiv für Anat. Leipzig 1899.

young person of seventeen years: it is surprising to find such delay in the completion of ossification."

After comparing it with skeletons of men of the same race he arrives at the conclusion that "as the result of the exaggerated length of the femur and tibia there is a very marked disproportion between the length of the lower extremities and the height of the skeleton."

Pirsche sums up the different observations upon eunuchs as follows:--

"The head is as a rule dolichocephalic. The pelvis is feminine in type; the ilia are out-turned; all the diameters are larger than those of a man. The thyroid foramina are very high and are separated by a very narrow symphysis. The long bones of the limbs are slender and the muscular impressions are slightly marked; their length is altogether out of proportion to the stature. There is an extraordinary delay in the obliteration of the epiphyseal cartilages."

The ages at which the epiphysis unite with the shaft normally are:--

Humerus	upper epiphysis	about 25 years.
	lower epiphysis	about 17 years.
Radius/	upper epiphysis	about 19 years.

Radius	lower epiphysis	about 23 years.
	upper epiphysis	about 16 years.
Ulna	lower epiphysis	about 23 years.
<u>Pelvis,</u>	triradiate cartilage	disappears about 16 yrs.
	head	about 19 years.
Femur	great trochanter	about 18 years.
	lower epiphysis	about 21 years.
	upper epiphysis	about 23 years.
Tibia	lower epiphysis	about 18 years.
	upper epiphysis	about 23 years.
Fibula	lower epiphysis	about 19 years.

Now in Ecker's skeleton, aged 25, none of the epiphyses in the lower limb have joined, and the triradiate cartilage is still present. In the upper limb the epiphyses round the elbow have joined. In Becker's skeleton, age 23 years, none of the epiphyses have disappeared except those at the upper end of the radius and ulna.

This certainly seems to show that there is delay in ossification in eunuchs. Grüber<sup>(1)</sup> has recorded an observation very interesting in this connection/

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(1). Grüber Untersuchung einiger Organe eines Castraten. Müller Archiv für Anat. Phys. und Wissenschaft, medicin Berlin 1847.

connection. He states that he dissected the body of a eunuch, aged sixty-five, and found the hyoid cartilaginous.

The probable mechanism of these growth changes will more profitably be discussed after the psychical manifestations of testicular activity and inactivity have been considered.

## CHAPTER V.

THE PSYCHICAL MANIFESTATIONS OF TESTICULAR ACTIVITY  
AND THE MECHANISM OF THEIR CONNECTION.

## SECTION I. THE PSYCHOLOGY OF THE EUNUCH.

The psychology of the eunuch has not been studied with the care that so important and interesting a subject deserves. I have been unable to find any record of observations even pretending to scientific exactness. From a not unextended course of general reading and from the results of a strictly limited personal observation I would say that the eunuch differs mentally from the man in two ways. First, he never puts away childish things; as a child he thinks, as a child he speaks, as a child he acts. Second, he never shows in word or deed an appreciation of, or a share in, those qualities which we regard as the crown and glory of manhood. Pirsche says  
of/

of eunuchs, "they are effeminate and perpetually indolent. Cowards, they know nothing of the higher attributes of men. They are, however, fond of children and capable of dog-like attachment to their masters. Such, in brief outline, are the characteristics of these morally and physically degraded creatures."

For comparison, however, it is sometimes better to deal with extremes and mental extremes I find in men of renowned sexual activity and in eunuchs.

## SECTION II. THE RELATION BETWEEN CREATIVE GENIUS AND SEXUAL ACTIVITY.

(1)

Moebius, as the result of a careful and painstaking investigation concludes that "artistic proclivities are to be regarded as secondary sexual characters."

(2)

Metchnikoff writes:--"Just as the beard and some other male characters are developed as means of attracting the female sex, so also bodily strength, strong voice and many of the talents must be regarded as due to the need to fulfil the sexual relations.

In primitive conditions woman worked more than man:  
man's/

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(1). Ueber die Wisungen d. Castraten. Halle 1903, p. 82.  
(2). Metchnikoff "The Prolongation of Life." English Edition, London, 1907.

man's superior force served him principally in fighting other males, the object of the combats usually being possession of a woman. Just as a victorious combatant covets the presence of a woman as witness of his prowess, so an orator speaks better in the presence of a woman to whom he is devoted. Singers and poets are stimulated in their arts by the love which they awaken. Poetic genius is intimately associated with sexual power and castration inhibits it. Just as castrated animals retain their physical strength, but become changed in character, losing in particular their combative nature, so a man of genius loses much of his quality with the sexual function. Amongst the eunuchs on record, Abelard is the only poet, but Abelard was forty years old when he ceased to be a man, and at the same time he ceased to be a poet. Many singers have been eunuchs, but they have been merely executants, and have taken no part in musical creation. Some musical composers have been eunuchs, but these were of mediocre ability and their names have been forgotten."

The history of the lives of the poets is full of instances of the close relation existing between their sexual activity and the blaze of their genius. Burns, Byron, Shelley, Goethe were prominent among their fellows for more than their power of/

of writing poetry. In other spheres Victor Hugo and Ibsen are as stars, but they rivalled the poets in their sexual prowess. Not only poetic creation, but other forms of genius are intimately associated with the sexual function. The philosopher Schopenhauer at the age of twenty-five, when he was in full creative activity, wrote:--"In the days and at the hours when the voluptuous instinct is strongest, when it is a burning covetousness, it is then that the greatest forces of the mind and the greatest stores of knowledge are ready for the most intense activity."

"At such moments life is truly at its strongest and most active, for its two poles are then operating most actively; and this is plain in the man of the highest intelligence. In these hours one sees more than in years of passivity." (quoted in Moebius' Schopenhauer p.55) "This means that in Schopenhauer intellectual creation was linked with erotic excitement." (ibid.p.57)

Facts of this nature led Brown-Séguard to the idea of strengthening cerebral activity by injections of the substance of testes. To obtain the same effect, he prescribed another means, the value of which was proved in the case of two individuals aged from forty-five to fifty, the observations being continued over several years. "By my advice," he said, "when these/

these had to perform any great physical or intellectual work, they got themselves into a condition of sexual excitement." "The testes being in this way thrown into functional activity, there was soon produced the desired increase in the power of the nerve centres." <sup>(1)</sup> "Although I insist on the existence of a close relation between intellectual activity and the sexual function I do not mean to assert that there have not existed exceptions to the rule." <sup>(2)</sup>

### SECTION III. THE MECHANISM CONNECTING SEXUAL ACTIVITY AND MENTAL VIGOUR.

The whole animal kingdom is rich in examples of the close relationship of katabolism and energy. In every animal there appears to be an optimum minimum of nutrition corresponding to the greatest output of force. The restless energy of the starving wolf; the laziness of the pampered lap-dog: the energy of the wild pig; the somnolence of the prize sow; the rapid heart-beat, the high temperature, the strictly limited size, the quick movements of the bird; the slow heart-beat, the low temperature, the unending growth, /

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(1) Comptes rendus de la Société de Biologie 1889, p.420.

(2) Metchnikoff, *ibid.*

growth, the sluggish movement of the crocodile are the visible effects of katabolic and anabolic nutrition. The antithesis is universal: in man hunger heightens mental energy, surfeit depresses it. The idea has become proverbial in such popular expressions as "fat and lazy," "thin and active." Anabolism is the cause of mental stagnation, katabolism of mental activity. Genius, the highest form of mental activity must, therefore, be associated with relatively high katabolism, but its greatest glories are undoubtedly associated with notorious ill health or with high testicular demands upon the available food supply of the body. Therefore, from a consideration of the psychological effects of sexual activity and castration I conclude that the testicular drain upon nutrition is sufficient appreciably to affect the food value of the body fluids and to determine an essentially katabolic type of metabolism.

SECTION IV. OBJECTION TO THE HYPOTHESIS THAT THE DIMINISHED PSYCHICAL ACTIVITY OF EUNUCHS IS THE DIRECT RESULT OF ANABOLISM PERSISTENT IN THE ABSENCE OF TESTICULAR DRAIN..

The obvious objection to this hypothesis, is that such small glands as the testicles are little likely/

likely to have such a preponderating influence in the distribution of the bodily nutriment in view of the relatively enormous amount of food stuffs ingested and absorbed. The counter-objection is that it is biologically inconceivable that any living thing supplied with unlimited food should possess much energy. As a result, it is theoretically essential that the body should possess some means of limiting the amount of food supplied to its component cells. That a mechanism to this end does exist is proved by the fate of the absorbed nitrogen and its division into nitrogen of the exogenous and nitrogen of the endogenous metabolism. We are in effect not concerned with the food absorbed, but with the food made available for the use of the body. That this is very small in amount was shown by Folin. <sup>(1)</sup> It is not, therefore, at all inconceivable that a small number of cells actively dividing should occasion a relatively severe drain upon the total available nutriment.

SECTION V. AN APPARENTLY POSSIBLE SOURCE OF FALLACY  
IN ESTIMATING THE INFLUENCE OF CASTRATION UPON PSY-  
CHIC PROCESSES.

The/

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(1) Folin, Amer. Journal of Physiology XIII. p.117, 1905  
See also Chap. XXIII of this thesis.

The observations upon the Skoptzys quoted in Chapter III. show that castration diminishes or restrains the actual and relative growth of the trunk, of the head, of the cranium in its three chief diameters, of the forehead and of the face in height and breadth.

Pirsche in his observation upon the skeleton of a eunuch notes that the cranium is markedly dolichocephalic, the index being 70. Ecker notes in connection with his skeleton "The skull is prognathous, the forehead, low; the occiput, prominent." Becker writing of the cranium of his eunuch's skeleton says, "there is marked dolichocephaly."

In the observations upon the effects of castration upon guinea-pigs quoted in Chapter II, it is recorded that the skulls are markedly dolichocephalic.

The meaning of this is not obvious. Darwin records observations made by himself on rabbits which are of interest in this connection. "Some kinds of domestic rabbits," he says, "have become very much larger than the wild animal, whilst others have retained nearly the same size, but in both the brain has been/

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(1) Darwin "Variation of Animals etc." Vol.1. p.117.

been reduced relatively to the size of the body. Now I was very much surprised to find that in all these rabbits, the skull had become elongated or dolichocephalic: for instance, of two skulls of nearly equal breadth, the one from a wild rabbit and the other from a large domestic kind, the former was 3.15 and the latter 4.3 inches in length."

"One of the most marked distinctions in different races of men is that the skull in some is elongated, and in others round; and here the explanation suggested by the case of rabbits may hold good; for Welcher finds that short men incline more to brachycephaly and tall men to dolichocephaly; and tall men may be compared with the larger and longer-bodied rabbits, all of which have elongated skulls, or are dolichocephalic. At first sight these observations might be regarded as affording a fairly satisfactory explanation of the shape of eunuchs' heads. A eunuch is of greater stature than the average man of the same race; but he is long in the leg and short in the body not only relatively, but absolutely and there is considerable evidence to suggest that the length of the skull/

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(1) Compare Manouvrier's observations quoted in Chap. I.  
 (2) Darwin, "Descent of Man" New Edition, Murray 1901 page 84.

skull base is in some way directly proportionate to the length of the vertebral column. If it were permissible to assume that the eunuch's skull base is larger than the man's it would be permissible to deduce that the dolichocephaly was the expression of an increase in cranial base without any associated increase of the brain mass for "if one of the diameters differ from the normal, in being excessively large, the other will tend to be too small."<sup>(1)</sup> A eunuch's vertebral column is, however, shorter than a man's: it, therefore, seems probable that the marked dolichocephaly of eunuchs is a sign that they possess a smaller brain than do the men of the same race. This assumption is supported by the facts of microcephaly<sup>(2)</sup> for Professor D.J. Cunningham has shown the skull of the microcephalic idiot to be markedly dolichocephalic, as the result of the association of an undiminished base with a much diminished cubic capacity.

This introduces a disturbing factor into the consideration of the cause of the psychical differences of eunuchs and men, but no such influence can have been at work in the case of Abelard the poet who ceased/

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- (1) Prof. Boas, *The Cephalic Index*, *American Anthropologist*, N.S. vol.1.1899, p.448.  
 (2) Prof. Cunningham "The Scientific Transactions of The Royal Dublin Society" Vol.V.Series ii.

ceased to be a man and a poet at the age of forty.

SECTION VI. SUMMARY OF OBSERVATIONS RECORDED.

Apart from any consideration of the mechanism involved I have so far quoted evidence to show:--

1st. That castration causes increased growth of the body.

2nd. That castrated animals tend to be fatter than sexually active animals.

3rd. That castration is associated with increased length of the long bones, more especially those of the hind limb.

4th. That this increase is at least partly the result of a delay in the spread of ossification into the epiphyseal cartilages.

5th. That the bones of castrated animals are more slender than those of normal animals.

6th. That muscular impressions are not marked on the bones of castrated animals to anything like the same degree that they are in the bones of normal animals.

7th. That castration does not necessarily determine any loss of muscular power as in animals which are compelled to work such as the horse.

8th./

8th. That the secondary sexual characters are not developed after castration in early life.

9th. That castrated animals are psychically different from normal animals and that eunuchs do not show the mental brilliance and higher moral attributes of men.

10th. That the brain of eunuchs is possibly smaller than the brain of men.

11th. That the skull tends to dolichocephaly.

12th. That the pelvis of a eunuch is feminine in type, with wide out-turned ilia and wide subpubic angle.

These changes of body form can in the terminology of Manouvrier be tersely summarised:--"Castrated animals are macroskelic as the result of marked macroplasia."

In the next chapter I bring forward evidence to show that macroplasia is the physiological outcome of a plentiful supply of food to the body cells, in other words, that macroplasia is a symptom of absolute anabolism.

## CHAPTER. VI.

## THE RELATION OF METABOLISM TO BONE FORMATION.

SECTION I. THE SEXUAL PECULIARITIES OF THE BONES  
OF THE SKELETON.

Thoroughly to understand the factors involved in determining the secondary characteristics of the bones of the skeleton it is necessary to review as briefly as may be the existing beliefs and to consider in terms of the theory of growth the histology of ossification.

(1)

Topinard speaking of the sexual differences in the skeleton says, "the principles which govern the sexual differences in adult age may be summed up in a few words. All the parts of the female skeleton are lighter and more frail; the general contour is more soft and graceful; the eminences, processes, or tubercles/

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(1) Topinard, Anthropology, Chapman and Hall, London 1878.p.143.

tubercles are smaller and less marked. If there be one well established physiological fact it is this: that the asperities which serve for the insertion of muscles are developed in proportion to the activity of those muscles. Less marked in the studious man than in the labourer, these asperities are still less so in the woman, especially in women residing in towns. This law is so exact that we can tell by the degree of prominence of the crests and processes what muscles the individual was most in the habit of using, and hence judge as to his profession or calling. As a sequence of these prominences, the depressions, grooves and marks are more distinct in the man." "A woman who had worked hard all her life would have the bony prominences and the processes for the articulations of muscles more developed, probably, than a man who had not worked at all." This doctrine of Topinard's is practically universally believed and taught and yet it is on the face of it impossible to regard the prominence of the bony ridges as necessarily associated with muscular action in view of the age differences in the bones of the skeleton described by Topinard on the same page. Still speaking of the sexual differences in the skeleton, he says, "there is/

is no appreciable difference in the skeleton in infancy, and up to puberty its features are rather of a feminine character. At puberty the line of demarcation commences, but the characters are not thoroughly defined until twenty years of age and upwards. At about forty-five, or upwards, the distinctions of sex become less marked and at advanced age are but trifling, though the general character of the skeleton is rather masculine." If Topinard's statements be freely but fairly paraphrased, and a legitimate deduction from them be made, they read, "prominence of the eminences, processes and tubercles upon the bones is associated with muscular action and is in direct proportion to the activity of the muscles. The bones of old women show more marked ridges than the bones of young men, therefore, old women are more muscular than young men."--which is absurd. In the course of this and the succeeding chapters I shall produce evidence which will, I think, conclusively demonstrate that the roughness of the bones is directly associated with euryplasia which in turn is associated with katabolic metabolism. It is interesting here to notice that the roughest and most extraordinarily marked bones in the Anatomy Department of the University are those of a/

a feeble old woman. These are described later.

SECTION II. THE PROCESSES OF OSSIFICATION IN TERMS  
(1)  
OF THE THEORY OF GROWTH.

The bones of the skeleton with few exceptions are preceded by cartilage which by its form indicates in a general way the shape and relations of the bone to be. The primary formation of the bone takes place within the cartilage and the process is appropriately enough termed endochondral development, although the true bone is essentially formed in all cases by an ossification of connective tissue.

Endochondral Bone Development.

At the end of the second month of intra-uterine life the principal segments of the foetal cartilaginous skeleton have been formed. The rapid proliferation of the young mesoblastic cells is followed by condensation and by the formation of embryonic cartilage. This permits of restatement in terms of the laws/

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(1) The account of ossification here given is based primarily on that given by Professor Schäfer. The account of ossification by Dr. G.A. Piersol in "Human Anatomy" Lippencott and Co. Philada. and London 1907 has also been consulted.

laws of multiplication, the rapid increase in the number of the cells leads to difficulty in obtaining adequate nutrition; individual adaptation is substituted for rapid genesis, the specialisation is towards the formation of cartilage cells; the embryonic cartilage of the primitive skeleton results. Each cartilaginous segment is surrounded by an immature form of perichondrium or primitive periosteum which consists of an outer fibrous layer and a looser more cellular internal layer, the osteogenetic layer.

The "centre of ossification" now appears about the middle of the cartilaginous bar which marks the site of the developing shaft. The actual changes are interesting. The cartilaginous tissue undergoes a true hypertrophy. This can only mean that the environment is favourable. The cells, however, being specialised are unable to divide, for individuation excludes genesis. They increase in size until the nemesis of cell growth overtakes them and they die because their surface is too small to support the contained mass. The matrix in the neighbourhood, unrefreshed by the activity of the cells degenerates and lime salts are deposited in it. This interpretation of the meaning of the calcification of the cartilage matrix/

matrix brings it into line with the pathological calcifications, "which occur almost without exception in degenerating, dying or dead tissue."<sup>(1)</sup> To recapitulate, "on acquiring their maximum growth the cartilage cells soon exhibit indications of impaired vitality as suggested by their shrinking protoplasm and degenerating nuclei."<sup>(2)</sup> The struggle for existence is too keen to permit of the cells in the neighbourhood leaving an area of rich nutrition cumbered by dead and dying tissue. The cells of the osteogenetic layer of the primitive periosteum rapidly multiply and enter into the possession of their heritage. While they are thus spreading into the centre, absorbing the debris of the cartilage, let us consider what these phenomena mean from the point of view of the cartilage cells.

In some of the lower animals, the skeleton remains cartilaginous throughout life. This means that the supply of nutrition to the cells is balanced so that a specialised cartilage cell just receives sufficient nutriment to enable it to perform its function of keeping the cartilaginous matrix refreshed and healthy. But in the higher animals, as in man the supply of nutrition is more than the cells can profitably use. Overfed, they increase in bulk, the increase/

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(1) Hektoen and Reisman, Text Book of Pathology  
Saunders, 1901.p.113.

(2) Piersol. loc. cit.

increase of surface is necessarily disproportionate to that of content and so there is less opportunity for nutrition, respiration and excretion. Waste gains up, overtakes, balances, exceeds repair and brings about dissolution and death. <sup>(1)</sup> This is an excellent example of the rule that highly specialised forms do not undergo evolution.

The cells from the osteogenetic layer penetrate right to the centre of, and there absorb, the cartilage eating out a space, the primitive marrow cavity, which they occupy, and in which they proliferate to form a tissue, the primitive marrow. From this there arise the cells which are known in histology as the osteoblasts and the osteoclasts. Around the primitive marrow cavity the surfeit and the death of the cartilage cells continue, but before the cells attain to their fatal specialisation the safety of the race has been, temporarily at least, provided for by genesis, one of the daughter cells apparently always escaping to the side furthest from the advancing doom. The result of this is seen histologically in the arrangement of the cells in columns. Between the columns/

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(1) V.S. Chapter II.

columns, the matrix unrefreshed by its guardian cells undergoes calcification. As a result, the edge of the dying cartilage is serrated by the advancing swarm of osteoblasts, the dead bodies of the cartilage cells being more easily absorbed than the intervening columns of calcified matrix.

While this process of removal of the unsuccessful cartilage is in progress the rapidly multiplying cells of the successful race begin to feel the pinch of shortening food supply. Those next the cartilage satisfy their needs by devouring the debris of their predecessors, but those left behind have no corresponding reserve to draw upon. A shortening food supply is met in the usual way by specialisation which enables the cells to avoid increasing the amount of their protoplasm and enables them healthily to exist upon a supply of nutriment formerly inadequate. Histologically they now appear as small cells which secrete a mineral envelope. Thus is formed the primitive central spongy bone. In the course of time, however, the cells begin to suffer, even their specialisation is insufficient to ensure due economy and they and their bony envelopes are removed by the osteoclasts.

It/

It is unnecessary to follow out all the changes leading to a higher and higher specialisation towards economy which are undergone before the adult bone is formed, but the type of the adult osteoblast is important. Its specialisation is all towards reduction of mass and increase of absorbing surface. The fact that it gets rid of a large part of its absorbed nutriment rather than increase in bulk is evidence that it can deal with nutriment in excess of its momentary needs. Its flattened shape with its numerous branching processes is typical of a cell prepared against a threatened food shortage, for the flat surfaces and branching processes yield far more surface per unit of mass than could be given by any shape approaching the spherical. Such dodges, if one may so speak, are old in the history of the evolution of the cell and are found wherever mass and available nutrition tend to become disproportionate, witness the stellate cells of dense connective tissue and the flat form of the ancient nummulites which were sometimes as large as half-crowns.

The conclusions consequent upon this interpretation of the phenomena of ossification are, first, the cartilage cells of the primitive shafts of long bones are little able to endure high nutrition and are/

are, in the higher animals, soon destroyed by their own excessive growth, second, the osteoblasts of the primitive marrow are derived from the periosteum, third, all osteoblasts are specialised to ensure economy of nutrition, but they are not adversely affected by high nutrition as they have acquired the power of excreting a great part of their absorbed nutriment. From these conclusions it follows that in conditions of high nutrition the cartilage cells absorb a large proportion of the available nutriment and proliferate rapidly so that increase in the length of bones results, but that in conditions of nutritional supply too low to surfeit the cartilage cells the osteoblasts are able to obtain the unused food and proliferate rapidly so that increase in the diameter of bones results. Restated, anabolic conditions determine macroplasia; relatively katabolic, euryplasia. The mechanism of these types of growth is discussed in the next paragraph.

### SECTION III. MECHANISM OF MACROPLASIA AND EURYPLASIA.

Macroplasia is the result of a highly nutritive environment. The reason for this appears to be that the fully specialised cartilage cell is too absorptive, is too anabolic, to cope with a large supply of/

of food. Individuation and genesis, however, vary inversely and, from the point of view of the species, individuation is low, therefore, genesis is high. In result the cartilage grows rapidly, but is rapidly replaced by bone; the limb bones increase in length and, because of the high level of genesis, the epiphyseal plates persist. This condition is characteristic of the bones of castrated animals. In relatively low nutritive conditions the individuation of the cartilage cells is less unsuccessful, they can longer withstand the threatened surfeit; in result, the proliferation of cartilage cells is less and the bones do not increase so markedly in length. But the specialisation of cartilage cells is not only unsatisfactory from the point of view of their resisting the action of a too favourable environment, it is also unsatisfactory in that it does not give a sufficiently wide margin to permit them to prosper in an unfavourable environment; this is clearly shown by the calcification of the cartilages of old men. Cartilage cells are, therefore, to be looked upon as imperfectly specialised. On the one hand they are not economical cells, on the other they perform no very active functions and are, therefore, unable to use up much of the potential energy of their food supply, in/

in short, they are primitive organisms which have been left hopelessly behind in the race of evolution by the osteoblasts. Phylogenetic as well as ontogenetic evidence supports this conclusion.

Euryplasia on the other hand is the result of a more lowly nutritive environment. In such a condition, as we have seen, there is no rapid multiplication of cartilage cells to be provided for out of the limited blood supply of the developing bone. The muscles in the neighbourhood are highly specialised and genesis of muscle fibres is at a minimum. The most highly economical cells are alone able to multiply and these are the osteoblasts. Without the scaffolding provided for them by the cartilage they cannot add much to the length of the bone, they, therefore, add lamina after lamina to its circumference. Nor is it difficult to understand why in this condition the areas of bone and muscle articulation are particularly selected for osteogenetic proliferation. The muscle by its activity secures an increased blood supply in which the adjacent bone surface must to some extent share and with the increase of nutrition there will be increase of cell proliferation, and the more intense the general food shortage is the more intense will be the local osteogenetic activity. Therefore, in/

in cases in which bone cells are starving to death and being removed, (osteoporosis) the formation of bone at the site of muscular attachment will be especially active for as the success of individuation diminishes the activity of genesis increases. This raises problems which far transcend the limits of the present chapter. Some of them are dealt with in detail later. At present it is permissible to state that smooth and graceful bones are associated with anabolism; rugged, strongly marked bones with katabolism.

#### SECTION IV. THE METABOLISM OF THE MALE COMPARED WITH THE METABOLISM OF THE FEMALE.

Geddes and Thomson in their work "The Evolution of Sex" have conclusively shown that not only do male and female metabolism differ, but that the essential difference between maleness and femaleness is a difference of metabolism. "The female is the outcome and expression of predominant anabolism: the male of predominant katabolism." The proof of this would involve, however, too long a digression to permit of its inclusion here.

SECTION/

SECTION V. THE AGE-SEX CHARACTERISTICS OF THE  
SKELETON IN TERMS OF METABOLISM.

In Section I. of this chapter I quoted from Topinard's Anthropology. Speaking of the age-sex characteristics of the skeleton, he said, "There is no appreciable difference in the skeleton in infancy and up to puberty; its features are rather of a feminine character. At puberty the line of demarcation commences, but the characters are not thoroughly defined until twenty years of age and upwards. At about forty-five, or upwards the distinctions of sex become less marked and at advanced age are but trifling though the general character of the skeleton is rather masculine."

This can be rewritten in terms of metabolism. "There is no appreciable difference in the skeleton either in infancy or up to puberty, its features indicating a metabolism of the anabolic type. At puberty the line of demarcation commences. The metabolism of the male becomes markedly katabolic, this favours the multiplication of the economical osteoblasts (euryplasia.) The metabolism of the female, however, remains anabolic, the environment is sufficiently favourable to permit cells of a more expensive type holding their own: there is thus no tendency to special/

special bone formation and the long bones remain smooth. In old age the decrease in the physiological capital of the body cells compels a more katabolic type of nutrition and the less expensive bone cells are peculiarly suited to the changed environment.

#### SECTION VI. CONCLUSIONS AND PROBLEM.

The conclusions arrived at in this chapter are:---

1. Macroplasia is the result of high nutrition acting primarily upon the cartilage cells.
2. Euryplasia is the result of a nutritional environment too little favourable for the cartilage cells, such food stuffs as are present in the fluids being utilised by the more highly specialised osteoblasts to grow and multiply.
3. The sexual differences of bone are the results of different types of metabolism.

The problem raised by this chapter is:--

If general anabolic conditions determine macroplasia, why is a woman smaller than a man?

Until this problem be solved, or at least until possible lines for its solution be indicated it is not permissible to accept the hypothesis that macroskely is/



## CHAPTER VII.

## THE RELATIVE SIZE OF MEN AND WOMEN.

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SECTION I. THE RELATIVE SIZE OF MALE AND FEMALE  
ANIMALS.

In the lower animals, up to the level of amphibians the female is usually larger than the male. In the fishes, as is well known, the males are sometimes not half the size of their mates; among insects the male is almost invariably smaller than the female, as, for example, in the frequently quoted case of the spider: among the crustaceans the male is usually the smaller, while among the parasites, pigmy males, parasitic on the female, occur.

Among the higher animals the reverse tends to be the case. In the snakes the female tends to predominate; in the lizards, the male; among birds and mammals/

mammals the male is, as a rule, both stronger and bigger than the female. This is a most striking fact and at once suggests that in the course of evolution some means of limiting the size of females has been developed for the good of the next generation, for as the importance of the mother to the offspring increases, her size relatively to her mate's decreases.

We have seen that a male animal castrated in early life grows to a bigger size than the entire male of the same species and we have seen that its metabolism as well as the females' is markedly anabolic. But females are smaller than males, therefore, it must be that their growth is checked for the good of the race, for it is obvious that given a fixed power of intestinal food absorption the smaller the female's body the more she will be able to spare for her young. That there is some mechanism to check the growth of the female is indisputable. For if the limit of her size were determined by food shortage katabolism would be induced, sterility ensue and the race be exterminated. This fact is absolutely certain, the mechanism of the arrest of body growth is uncertain.

## SECTION II. EVIDENCE INDICATING THE NATURE OF THE MECHANISM CONTROLLING THE GROWTH OF WOMEN.

The/

The average adult European man is about  
 (1)  
 12 centimetres taller than the average woman of the  
 same class and country. "Before puberty, however,  
 girls of European races are both taller and heavier  
 than boys of the same age. The amount of this dif-  
 ference varies, but in Great Britain girls grow more  
 rapidly than boys between the ages of ten and fifteen;  
 at the ages of eleven-and-a-half to fourteen-and-a-half  
 they are actually taller and between the ages of twelve-  
 and-a-half and fifteen-and-a-half they are actually  
 heavier than boys of the same age. The acceleration  
 in the growth of girls seems to be coincident with a  
 retardation in the growth of boys. At the age of  
 fifteen boys again take the lead, growing at first  
 rapidly, and then more slowly, and their complete  
 growth is attained practically about the age of twenty-  
 three. Girls, on the other hand, grow very slowly  
 after the age of sixteen, and attain their full sta-  
 (2)  
 ture about the twentieth year."

These facts can readily be restated in terms  
 of metabolism. The retardation in the growth of boys  
 between the ages of eleven and fifteen corresponds to  
 the period of declining anabolism which precedes the  
 rise/

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- (1). Report of Anthropometrical Committee, British  
 Association 1883, also Quetelet Topinard and Rollet.  
 (2). Havelock Ellis, "Man and Woman" 1904, p.34.

rise of katabolism. The growth of girls during the same period leads to a body form in many respects resembling that of the eunuch, and is essentially anabolic. In the midst of a prosperous anabolism the growth is suddenly checked. The cessation of growth is coincident with the establishment of sexual maturity and the commencement of ovulation. There is only one satisfactory explanation of this phenomenon. It is, that at the time of sexual maturity something is added to the fluids of the female body which causes the somatic cells to adopt a more conservative type of metabolism, something which compels the body cells to be unselfish for the good of the next generation, something which is a "hormone" of cellular inactivity, if such a contradiction can be conceived as meaning anything. Guessing, I should be inclined to attribute this "hormone" to the new factor introduced into the metabolic equation, the corpus luteum. The source of the secretion is for present purposes immaterial and would be better left unsuggested were it not that the mere statement of a not impossible source helps the imagination and lends concreteness to the idea.

My conclusion is that the growth of women differs from the growth of the eunuchs, in being controlled for/

for the good of the race, and that the most probable method of application of this control is through some internal secretion which acts as a "soporific" to the somatic cells.

### SECTION III. EFFECTS OF CASTRATION OF FEMALES.

Theoretically if something within the ovary elaborates a secretion which controls growth by reducing the activity of the cells, operative removal or functional obliteration of the glands should be followed by increased activity of the somatic cells. A castrated woman should, therefore, resemble the eunuch, the potential nutrition wasted month by month in the menstrual flow becoming available for body growth. If the woman be young, with vigorous cells, this should be macroplastic; if old, with relatively exhausted cells euryplastic with an approximation to the masculine type as in the growth of hair on the face.

Practically this is a known effect of the menopause, that of castration in early life.<sup>(1)</sup>

I, therefore, conclude that in the females of the higher animals there is some mechanism, non-existent in the male, for the control of growth and that the/

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(1) See Chapter III. Poncet's Experiments, page 35.

the fact that women are smaller than men in no way invalidates the hypothesis that macroskely and macroplasia are symptoms of an anabolic metabolism.

## CHAPTER VIII.

KATABOLISM PREDOMINANT, RELATIVE ANABOLISM

AND

BONE FORMATION.

## SECTION I. PRELIMINARY.

A point has now been reached in the review of the problems of growth and of the factors involved in the determination of bone form, at which it becomes possible, in some measure, to adumbrate the phenomena necessarily associated with precocious senility. By this term I wish to convey the idea of an organism young in years, but old in its metabolism: in other words a relatively young organism with a metabolism of markedly katabolic type.

Hypothetically, this might be the result of an absolutely or relatively deficient intestinal absorptive power, or of a marked deficiency of cell absorptive power. But it matters not what is the cause: the essential fact is, food shortage of a relatively young protoplasm.

The/

The difference between normal and precocious senility, therefore, is, that in the one case the katabolism is of protoplasmic origin, in the other of environmental origin. From this it follows that, in cases of precocious senility if there be local or general increase of food supply the persisting anabolic power of the protoplasm will assert itself and the result will be a local or general rejuvenescence.

Unfortunately, the growth changes normal to precocious senility are at present classed with growth changes dependent upon various toxæmic conditions under the vague title of rheumatoid arthritis. The principle underlying them is simple. The normally existing tissues become weakened by starvation and unable to support the weight or strain which, formerly they supported with ease. As a result abnormal strains are thrown upon ligaments which become irritated and have their blood supply increased. In this manner the points of irritation become points of increased nutritive supply. Local rejuvenescence is established and the rejuvenated cells proliferate to buttress the strained and weakened framework; in short the process is one of repair.

(1)

Julius Wolff has formulated a generalisation which/

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(1) Quoted from Léri's paper in the Review of Neurology and Psychiatry Vol VI, No.2, February 1908, page 68.

which has been called "the law of the transformation of bones." Its applicability to the growth changes of precocious senility is so striking that I quote it in full. "There exist," he says, "in conditions in which pressure has become abnormal new formations of bony substance in the soft parts. These new formations compensate in a crude, and therefore all the more striking way, for the impaired equilibrium of the bones. They supervene when the skeleton can no longer compensate the disturbance by a transformation of its own internal substance. They do not occur accidentally here and there. They do not appear to be primary, but are always secondary, and the primary modifications are always coarse destructions of the skeleton which on the one hand markedly diminish its solidity and on the other produce this modification." This explanation applies absolutely to the ossification of ligaments and to the formation of osteophytic outgrowths which follow upon the primary rarifying osteopathy of starvation.

The only difficulty which presents itself in connection with the adoption of this view is:--Why are the strained ligaments replaced in part at least by bone and not merely strengthened by a fibrous tissue proliferation?/

proliferation? The answer is, I think, not far to seek. Different kinds of tissue cells are possessed of different degrees of absorptive power and of different degrees of vitality. Thus is explained the extraordinary resistance of the tissues of the central nervous system to the effects of starvation, thus, too, must be explained the wonderful fertility of extremely old men. Now of all tissues in the body fibrous tissue is the least expensive and the least vital; whereas, bone is both more expensive and more full of vitality. It is a commonplace of pathology that well nourished tissues like an aneurismal sac or a rapidly growing sarcoma can compel the erosion and absorption of the less vital tissues in their neighbourhood. In the same way I explain the replacement of the lowly fibrous tissue, by the more absorptive bone whenever the conditions of local food supply are raised sufficiently for its support.

From this point of view the association of a local hypertrophy with a general atrophy of bone appears less surprising than it has often been regarded as being. To avoid the appearance of consciously or unconsciously arranging the facts to suit my hypothesis I propose to follow a readily accessible account of the growth/

growth changes of precocious senility written by W. Arbuthnot Lane and published in the Transactions of the Pathological Society of London Vol. XXXVII, 1886, pp. 387-447. Unfortunately Mr. Lane uses the title "Rheumatoid Arthritis;" I partially adopt his nomenclature and throughout use the title "The Rheumatoid Arthritis of Precocious Senility." I do not, however, mean to convey the idea that there is anything essentially rheumatoid or arthritic about the condition. Throughout the summary which I give I interpolate what I believe to be the metabolic explanations.

## SECTION II. THE GROWTH CHANGES OF THE RHEUMATOID ARTHRITIS OF PRECOCIOUS SENILITY.

The condition occurs much more frequently among the poor than among the well-to-do. When it affects an individual in good circumstances, only one joint, as a rule, suffers and it has almost invariably been the seat of injury. It arises at an earlier date and is more destructive in feeble than in vigorous subjects: it also tends to affect persons in whom the general nutrition of the body has been lowered by habitual exposure to the vicissitudes of climate under unfavourable circumstances: it affects men much more frequently than women.

All these are conditions in which katabolism naturally tends to predominate.

The essential changes, as seen in the freely movable joints such as the shoulder and hip, are fibrillation and removal of the cartilage accompanied by an increase in the thickness of the subjacent articular lamella of bone; sometimes the cartilage is completely removed and the subjacent bone eburnated. Coincident with these changes, bone is deposited on the margins of the opposing articular surfaces and, later, in the ligaments and even in the synovial membranes. In an enarthrodial joint, fusion of the opposing bones but rarely ensues, but in arthrodial joints, as in those of the tarsus and spinal column bony union is more common. In cases of locomotor ataxy the amount of eburnation and osteophytic growth is slight; sometimes the process is purely destructive, there being no bone deposited in the opposing surfaces.

This I interpret as meaning that in the absence of efficient nerve connection damaged or strained tissues cannot make known their need of increased blood supply. Without the increased blood supply there is no increased nutrition and consequently, no cell proliferation.

To resume, in the more fixed joints, as in those of the spinal column and pelvis, besides the destruction/

destruction of the intervening cartilage there is a marginal osteophytic growth which frequently leads to the formation of large bosses or processes which extend towards and often fuse with similar projections from adjacent bones. Not uncommonly the opposing bony surfaces, freed from the intervening cartilage fuse together throughout a portion or throughout the whole of, their extent. The amount of eburnation and osteophytic growth depends directly upon the vitality of the osseous system of the individual; in feeble subjects the changes are chiefly destructive; in largely built, powerful men there is but slight bone destruction, but very considerable eburnation of the opposing surfaces. With this there is extension of the area of the articular surfaces, by the growth of dense bone on their margins and, sometimes, great development of bone in the ligaments and in the synovial membrane.

Mr. Lane continues "In every body of every labourer who had worked hard, I found these so-called rheumatoid changes present and their amount depended directly upon the heaviness of the labour and consequently upon the amount of pressure to which the bones and joints had been exposed." This thesis he elaborates and brings to bear a great mass of evidence which/

which shows that the site of the formative changes is largely dependent on pressure and on strain.

Thereafter he passes on to discuss the appearances found in the spinal column and recognises three main types.

The first is seen in cases of increased pressure acting directly through the bodies of the vertebrae, as in strong, but badly nourished men accustomed to lift heavy weights. In such a case the intervertebral discs, the articular cartilages, the interspinous ligaments and the ligamenta subflava are absorbed. As this progresses the underlying bone becomes dense and ultimately the centra fuse. The nutritive meaning of this is:--

In poorly nourished men subjected to heavy strain the metabolism is highly katabolic. The intervertebral fibro-cartilages are in an unfavourable environment and are subjected to continual stress; they starve, and are partly absorbed. The jar of the bone surfaces sets up irritation, the blood supply and, therefore, the local food supply is reflexly increased, and bone formation proceeds rapidly, the vertebral bodies becoming welded together by a dense mass of new bone.

The/

The second type is seen in cases in which the ligaments and bones are subjected to great strain which may be the result of weight lifting or of a difference in the length of the legs. The metabolic explanation is the same, the strained and irritated ligaments receive more blood and, therefore, more nutriment. The osteoblasts spread into the anabolic areas and multiply.

The third type is seen where the strain is oblique, as it must be at places owing to the curves of the spine. In such regions the tension on the ligaments is great, the pressure on the intervertebral discs, slight. In result, the discs escape, but the ligaments are ossified.

### SECTION III. SOME FURTHER EXAMPLES OF THE BONY GROWTHS OF PRECOCIOUS SENILITY.

Pierre Marie has described a condition met with in field workers who are constantly stooping over their spades and ploughs. He has given it the name of "duplicature champêtre" (peasants' stoop). It is characterised by the ankylosis of the lumbar vertebrae in a position of marked kyphosis. As a rule it is not accompanied by ankylosis of the whole spine nor by pronounced ankylosis in the joints of the limbs. Its definite/

definite association with predominant katabolism and strain is too obvious to need elaboration. It differs from the kyphosis of normal senility in its association with ankylosis, and therefore is beyond doubt a condition of precocious senility.

(1)  
Léri, adopting the title "Spondylose Rhizomelique" introduced by Pierre Marie in 1898, has described the effects of precocious senility induced by the long continued action of a slight toxaemia. One paragraph in his paper is so important that I quote it.

"The ankylosis," he says, "is limited to the spinal column, to the hips and shoulders, often to the knees; frequently also to the sterno clavicular and tempero-maxillary joints. . . . The ankylosis never attacks the joints of the extremities with the exception of some very rare cases, in which, at a very late period, it may also involve the small joints of the limbs; but in general the ankylosis is clearly spondylotic and rhizomelic."

The importance which I attach to this observation will become more evident in Chapter XVII.

#### SUMMARY OF CHAPTER VIII.

1. Precocious Senility is associated with general atrophy/

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(1). Review of Neurology and Psychiatry, January 1908, pp.12-19  
February 1908 pp.65-77

atrophy and local hypertrophy of bone.

2. The atrophy and hypertrophy are of nutritional origin.

3. The local nutritional plethora is consequent upon strain which is, in turn, consequent upon the weakening effects of the atrophy.

This concludes what I have to say, at the present time, of the factors determinant of bone growth and of bone form. In the next chapter I summarise the ideas which have been set down.

## CHAPTER IX.

## CONCLUSIONS AND APPLICATIONS

## OF

## PART I.

## SECTION I. THE INDIVIDUAL CELL.

1st. The activities of protoplasm are two, up-building or anabolic, down-breaking or katabolic.

2nd. Division of the cell occurs when the cell surface becomes unequal to the task of providing for its contained mass: this may be the result of a too favourable or of a too unfavourable environment. In the first case the cell becomes too large for its surface; in the second the surface, too small for its cell.

3rd. Cells may avoid increase of mass by excreting a portion of their absorpta as a dead envelope.

4th. Cells may gain surface, out of proportion to their mass by flattening or by throwing out numerous irregular processes.

SECTION/

## SECTION II. THE MULTIPLICATION OF CELLS.

1st. The multiplication of cells is influenced by the laws of the multiplication of living organisms, but their applicability is not absolute, because the absorptive power of a given area of cell surface diminishes with age.

2nd. The multiplication of cells is anabolic or katabolic. Growth of an organism is, therefore, anabolic, or katabolic.

## SECTION III. THE GROWTH OF BONES.

1. Anabolic Growth.

Macroplasia is the result of an highly nutritive environment acting, primarily, upon the cartilage cells; it is evidenced by the existence of long smooth bones and by delay in the disappearance of the epiphyseal cartilages. The resulting body form is macroskelic.

2. Katabolic Growth.

Euryplasia is the result of an environment too little nutritive to surfeit the cartilage cells, but of sufficient nutritive value to permit of the proliferation of the osteoblasts: it is evidenced by the existence of rugged bones and by the early disappearance of the epiphyseal cartilages. The resulting body/

body form is brachyskelic.

Further, when the nutritional value of the environment is so low that precocious senility is established, disturbances of blood distribution determine unusual bony growths. These, as a rule, take the form of buttresses to support weakened bones and to replace weakened ligaments.

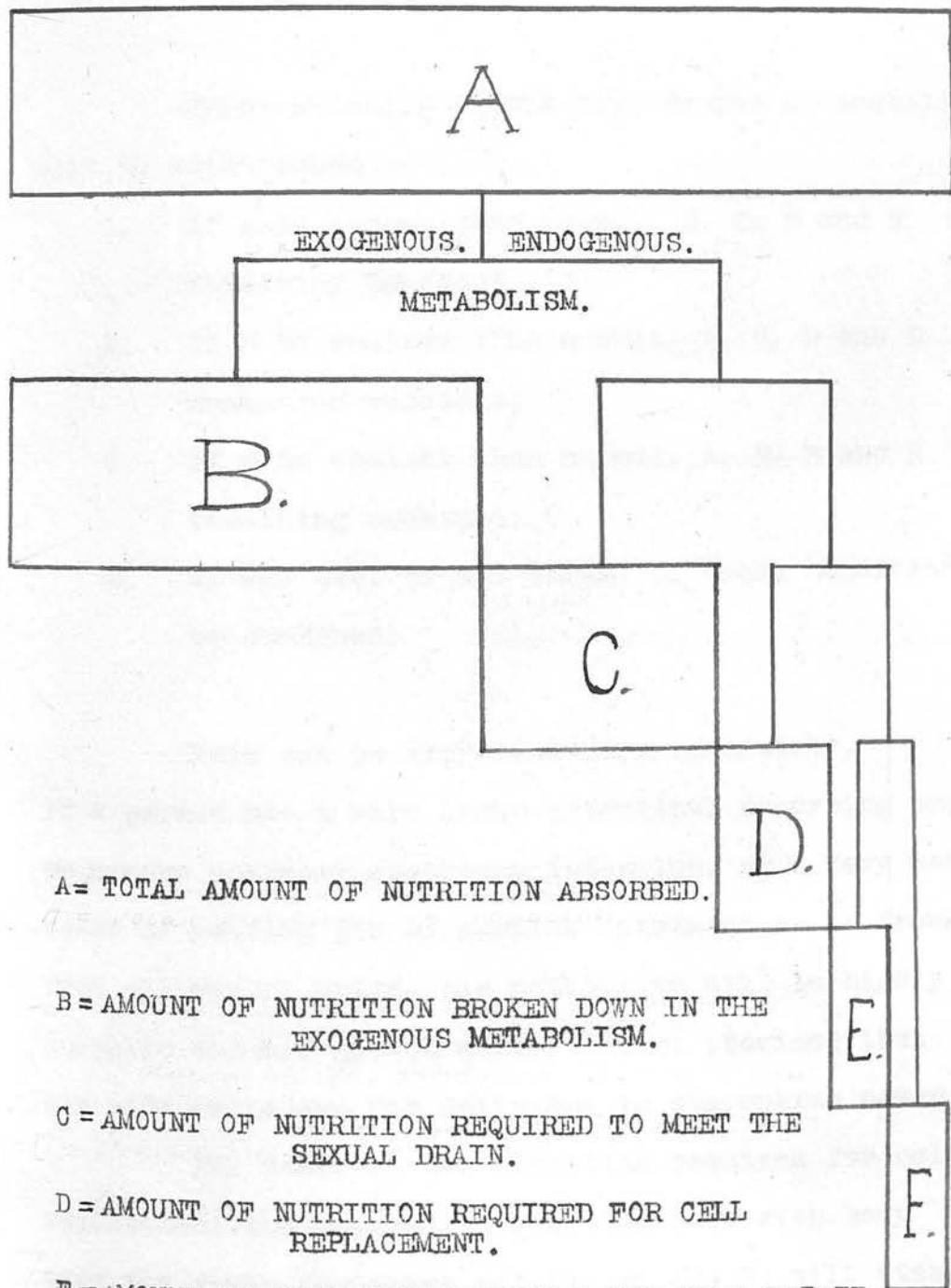
#### SECTION IV. SOME THEORETICAL DEDUCTIONS AND APPLICATIONS.

The growth of a young individual is dependent upon two factors, first, the anabolic power or physiological capital of the cells, second, the nutritional value of the body fluids. The latter is, in turn dependent upon two factors, the amount of nutrition absorbed by the individual and the amount of potential nutrition lost to the body by excretion. The former depends upon the amount and quality of the food ingested and upon the absorbing area and power of absorption of the intestine: the latter upon the amount broken down and got rid of in the exogenous metabolism, and the amount taken from the supply available for endogenous metabolism to meet the sexual drain. The growth/

growth value of the remaining nutrition is further diminished by the necessities of cell replacement and repair.

The fate of the absorbed nutrition admits of diagrammatic representation:--

DIAGRAMMATIC REPRESENTATION OF THE FATE OF THE  
ABSORBED NUTRITION.



A = TOTAL AMOUNT OF NUTRITION ABSORBED.

B = AMOUNT OF NUTRITION BROKEN DOWN IN THE  
EXOGENOUS METABOLISM.

C = AMOUNT OF NUTRITION REQUIRED TO MEET THE  
SEXUAL DRAIN.

D = AMOUNT OF NUTRITION REQUIRED FOR CELL  
REPLACEMENT.

E = AMOUNT OF NUTRITION REQUIRED FOR CELL REPAIR.

F = AMOUNT OF NUTRITION AVAILABLE FOR PURPOSES  
OF GROWTH.

This can be expressed as an equation.

$$F = A - (B + C + D + E.)$$

Hypothetically then a high degree of anabolism will be established:--

1. if A be larger than normal, B, C, D and E remaining constant.
2. if B be smaller than normal, A, C, D and E remaining constant.
3. if C be smaller than normal, A, B, D and E remaining constant.
4. if any two, or all three, of these conditions be combined.

This can be expressed more concretely.

If a person has a very large intestinal absorbing area, or a very actively absorbing intestine, or a very weak power of getting rid of surplus nutriment or is freed from all sexual drain, his metabolism will be highly anabolic and his growth macroplastic, provided that his body cells are not deficient in absorptive power.

As, however, the nutrition required for cell replacement and reparation must increase with body mass the drain for these activities (D + E) will steadily increase and will, ultimately, cause growth to stop, but/

but, in all cases in which this happens the life of the individual must be short and must be accompanied by high katabolism, because the food supply just sufficient for the needs of a young colony must be insufficient for the same colony as it grows older. If, however, sexual drain has been heavy, a reduction in the amount of nutrition allotted to it will permit of the balance being maintained for a time with resulting prolongation of the period of decline. As in males, however, the onset of katabolism is necessary for the establishment of sexual maturity, active macroplasia must be associated with sexual infantilism.

It, therefore, follows that macroplasia and infantilism are doubly connected.

1. Macroplastics must be infantiles, because they are macroplastics.

2. Macroplastics may be macroplastics, because they are infantiles.

To recapitulate, unusual, or hyper-macroplasia may be the result:--

1. of an unusual power of intestinal absorption,
2. of a deficiency in the safety valve excretion, the exogenous metabolism.
3. of an absence of sexual drain; provided, in all/

all cases that the anabolic power of the somatic cells be not diminished.

Later we shall see that hyper-macroplasia and giantism are one.

END OF PART I.

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PART II.

OF GIANTS AND GIANTISM.

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## CHAPTER X.

## GIANTS IN LEGEND AND HISTORY.

An amusing, but a not unamiable, foible of men is to magnify their ancestors and to impress upon their children the decadence of the rising generation. Until exact methods and rigorous enquiry were able to give the lie direct to the tales of greybeards, one of their favourite themes was the appalling physical degeneracy of the race. By dint of ceaseless iteration men were persuaded that, physically, they were not what their forefathers were. Thus legends grew, and if any doubted the hoary tales, the bones of mastodons were produced to stifle their unbelief.

Plutarch says that the skeleton of a giant sixty cubits high was seen by Sertorius near Tangier; Pliny, slightly more moderate, that the skeleton of Orion was found in Crete and that it was forty-six cubits in length. With such physical demonstration vouched for it is little wonder that peoples and tribes loved/

loved to assert that they were descended from some ancient hero of enormous prowess and appalling bulk. The tale of a giant progenitor is common in the folklore of Spain, of France, of the Low-countries, of Germany, of Austria. Year by year Metz, Barcelona, Lille, Douai, Dunkirk, Bayeux have celebrated the feast of a founder or protector or hero, in every case, a giant.

Even men of science succumbed to the alluring descriptions of the men who had been and of the past magnificence of the human race. Henrion, in 1718, communicated to L'Académie des Inscriptions et Belles Lettres a paper in which he "conclusively" showed "that--

Adam was 123 feet 9 inches,

Eve " 118 feet 9 inches,

Noah " 103 feet,

Abraham 28 feet,

Moses 13 feet,

Hercules 10 feet,

Alexander 6 feet,

and Julius Caesar 5 feet in height.

In the days of Julius Caesar when the Messiah was born the fearful havoc of sin was stayed." These astonishing discoveries were not "sublime visions", but the /

the result of the most complicated calculations.

"There were giants in the earth in those days."

Legend and romance have gathered round the doings of these giants which were of old mighty men, men of renown; Anthropology has torn to shreds their physical reputation; Pathology has still to prepare the way that Medicine may save their successors from their doom.

There never has been a race of giants. The tallest men known are the Scots of Galloway and their average height is just under 6 feet. <sup>(1)</sup>

But though giantism has never been endemic, it does occur sporadically in all countries and among all peoples. There is an endless number of cases recorded in the literature, but truth and giantism are scarce acquainted. No giant is quite what the imagination has depicted a giant to be, and nearly everyone who has written of them, has permitted his judgment to be biased by his preconceived ideas. The beautiful proportions, the graceful figure, the mental force, if not there, have been supplied, while their chronicler's weakness for round numbers has added inches to their stature. It is, therefore, quite useless to quote the recorded/

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(1) Deniker, 1.79.

recorded measurements of the majority, but probably the tallest man that ever lived was "the Giant Scot" who served in Frederick of Prussia's famous regiment of the "Giants of the Guard."

Voltaire tells how every morning the King went out to inspect his soldiers. They were his greatest joy and he considered no expense too great if he could secure a recruit who was at least seven feet in height. "One day he took the ambassadors of Spain, France and England to see his men and asked them if an equal number of their countrymen would engage these monsters. The Spaniard and the Frenchman said "No". The Englishman replied that, though he could not assert that an equal number could beat them, he could confidently affirm, that half the number would try." That the attempt would most likely have been successful is shown by the anecdote of the giants and the dwarfs.

"Once upon a time, to gratify a whim of the Empress of Austria, all the giants and dwarfs to be found within the limits of the Germanic Empire were assembled at Vienna. As circumstances required that all should be housed in an extensive building, it was feared that the imposing proportions of the giants would terrify the dwarfs and means were taken to assure the/  
the/

the latter of their perfect safety. But in confirmation of the proverb "A dwarf threatens Hercules" the result was very different from that anticipated. The dwarfs teased, insulted and even robbed the giants to such an extent that the overgrown mortals with tears in their eyes complained of their stunted tormentors, and sentinels had to be stationed in the building to protect the giants from the dwarfs. It is said that one of the dwarfs and one of the giants actually came to blows with the result that it was the dwarf, a new David, who triumphed.

(1)

Another Austrian anecdote is worth the telling.

A giant and a dwarf were kept as pets at the court of the Archduke Ferdinand. "The dwarf, seeking revenge for the incessant taunts and jeers of the giant who lost no opportunity of turning him into ridicule, begged the duke to drop one of his gloves as he took his place at table and to order the giant to pick it up. The dwarf hid himself beneath his master's chair and when the poor giant stooped he sprang out and hit him a violent blow on the face, to the intense amusement of the bystanders and the complete discomfiture of/

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(1) Garnier, *Les Nains et Les Géants*, Paris 1884, page 275.

of the unhappy victim who, unable to stomach this insult, died soon afterwards of injured pride."

These stories illustrate the undoubted fact, that giants are almost always characterised by mental and bodily weakness; while dwarfs are generally active, intelligent and healthy. Giants seldom have strength or valour commensurate with their physical proportions and are, as a rule, sickly, knock-kneed, splay-footed and feeble in mind and body. Virey says, "Tall men are mostly tame and insipid like watery vegetables." (1) Thus Peter Tuchain, who is said to have been 8 feet 7 inches in height, had no beard and possessed a little thin voice; he died at the age of twenty-nine. The St. Petersburg giant is said to have stood 8 feet 8 inches in his stocking soles; he was thin and weak and wasted. William Evans, the giant porter of Charles I, was equally without vigour. The German Giant, Max Christopher Miller, stood 7 feet 8 inches, was badly built and had an enormous head out of all proportion to his frame. W. Blair says that Patrick Cotter, whose stage name was "O'Brien the Irish Giant," was really extraordinarily tall, but very badly built.

"He/

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(1) Quoted from Professor D.J. Cunningham's notes on giants.

"He absolutely refused to get up and walk when I was in his room and I think the reason to have been that he feared lest I should discover his extreme weakness. In general appearance he was feeble and almost imbecile. He looked to me like a great, big, unhealthy child who had grown too quickly. His voice was feeble, his pulse slow and soft." The newspapers of the time tell us that he usually sat and ventured to go out but rarely and that at night. A witness of one of his nocturnal promenades gives the following description of what he saw. "He walked with difficulty, his hands supported upon the shoulders of two strong men of ordinary stature just as we sometimes see convalescents steadying themselves upon the shoulders of children of eight or ten."<sup>(1)</sup>

How different are these painful promenades, taken under cloak of night, from the Herculean exploits attributed to the giants of legend and romance. There is truth in the scathing proverb,

"Long and lazy, little and loud."

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(1). Quoted from Launois et Roy, Géants, Paris, 1904.

## CHAPTER XI.

## THE PHYSICAL CHARACTERISTICS OF GIANTS.

SECTION I. The giant of legend and romance is superman, his form is large but human in its proportions; the giant of the freak show is a sprawling creature, with deformities scarce concealed by his loose clothes. There is, however, a fairly definite giant form. A cursory glance at the accompanying photographs is sufficient to show that in each of these cases the length of leg was out of all proportion to the total stature. To this must be added three facts which will become apparent as we go on, first, that a giant's growth is long continued, second, that his sexual maturity is long delayed, third, that his mental vigour is conspicuous by its absence. In result, we have a perfect picture of the hyperanabolic. This chapter is devoted to the demonstration of these points.

SECTION/

PLATE IV.



PLATE IV.

Miss Ella Ewing.

PLATE V.



PLATE V.

The Lady Aama.

PLATE VI.

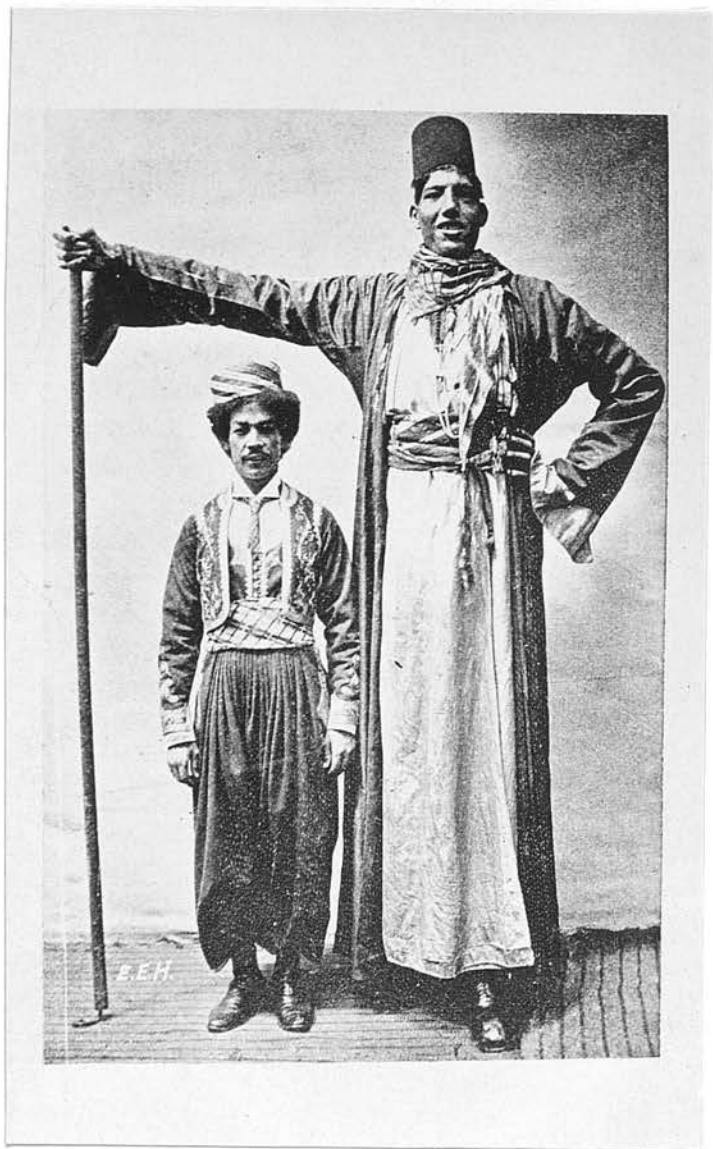


PLATE VI.

The Giant Hassan.



PLATE VII.

The Giant with the pail.

PLATE VIII.



PLATE IX.



PLATES VIII. & IX.

Liska, The Russian Giantess.



PLATE X.

The German Guardsman.

PLATE XI.



MARIAN. *Said to have died at 18*

SECTION II. HISTORY OF A CASE OF HYPERMACHROPLASIA.

LA MARIE CHARLES.

Charles F., age 30, Hiversham Paris.

FAMILY HISTORY.

PLATE XI.

His father was, died at the age of 45 of apoplexy; he was short, 1.60m. His mother is alive; she is an old charwoman, and, though she says she is only 55, quite deaf and very emphysematous; her height is only 1.50m.

Five children were born to this pair. The first, a boy, died in infancy. The second is a carpenter now aged 32, he stands 1.60m; the third is the patient; the fourth is a jeweller's assistant, aged 28, 1.64m in height, and the fifth a boy, a jeweller, 1.61m. The two brothers and the sister have married and have had children.

The Giantess Marian.

In the direct family the stature is short, but a paternal uncle was two metres in height and it has always been believed that she giant obtained her great stature from him.

Personal History.

Charles/

[1]. Lancet & Nov. op. cit.

(1)

SECTION II. RECORD OF A CASE OF HYPERMACROPLASIA.

LE GRAND CHARLES.

Charles F. age 30. Birthplace Paris.

FAMILY HISTORY.

His father, a sewer man, died at the age of 48 of asthma; he was short, 1m54. His mother is alive; she is an old charwoman, and, though she says she is only 55, quite deaf and very emphysematous: her height is only 1m48.

Five children were born to this pair. The first, a boy, died in infancy; the second is a copper moulder aged 33, he stands 1m61; the third is the patient; the fourth, a girl, now a jeweller's assistant, aged 28, 1m54 in height, and the fifth a boy, a jeweller, 1m61. The two brothers and the sister have married and have had children.

In the direct family the stature is short, but a paternal uncle was two metres in height and it has always been believed that the giant obtained his great stature from him.

Personal History.

Charles/

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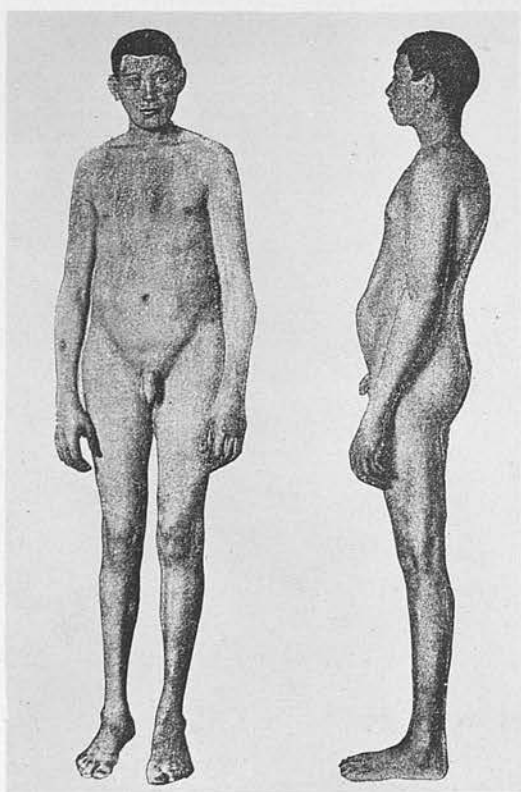
(1). Launois & Roy, op.cit.

Charles F. was large when he was born and since infancy has never stopped growing. At birth he is said to have weighed 21 lbs. (?) He was nursed by his mother and was strong and vigorous. As a small child he had measles; when he was nine, smallpox; when he was eleven, typhoid fever.

At the age of 12 he went to live at Auteuil with the Abbé Roussel where he was trained as a shoemaker. His stature must have been already remarkable for he remembers that when he went for the first time the director was unable to conceal his surprise and exclaimed, "This is no child, it is some lad of twenty that they have sent us!" He stayed at Auteuil for two years-and-a-half, and then joined a travelling show, but not as a freak for sometimes he took money at the entrance and sometimes he acted as outside showman. In 1893, after various vicissitudes, he became liable for military service and was enrolled in a regiment of Garrison Artillery at Givet. (For appearance at this time see Plate XII)

At/

PLATE XII.



at this time, age 21, he was well built, and during the three years of his service he continued, without the slightest intermission, the military exercises. His strength, by 1860, when his services expired, was the very PLATE XII. It is remarkable indeed that the latter had a general order was issued that he was to receive two double portions: that is to say, he ate four times as much as an ordinary soldier, his bread allowance, for example, being two whole regulations (fourteen per day).

PLATE XII.

Full face and profile views of Le Grand

Charles at the age of twenty-one. His stature at this time was 1m86.

The photograph is copied from Launois and Roy's reproduction of MM. Capitan and Papillault's original figures. The originals were consulted but were found even less favourable for reproduction.

(1) Head of Launois & Roy. The figures of the left hand figures obtained by Charles F. which we regard as not quite, perhaps, absolutely reliable information. On the other hand, this figure is obviously contradicted by the observation of M. Capitan made in 1860, and it is sufficient to show the persistence of his growth after his conscription. The growth still persists. Plate III. shows Charles as he was at that time, and we give it to you as a souvenir for allowing us to see it.

Although, unfortunately, the figures were rather pitted by corrosion, they are the sufficient proof of the fact that the other photographs were not taken.

(1)

At this time, age 21, he was only 1m86.

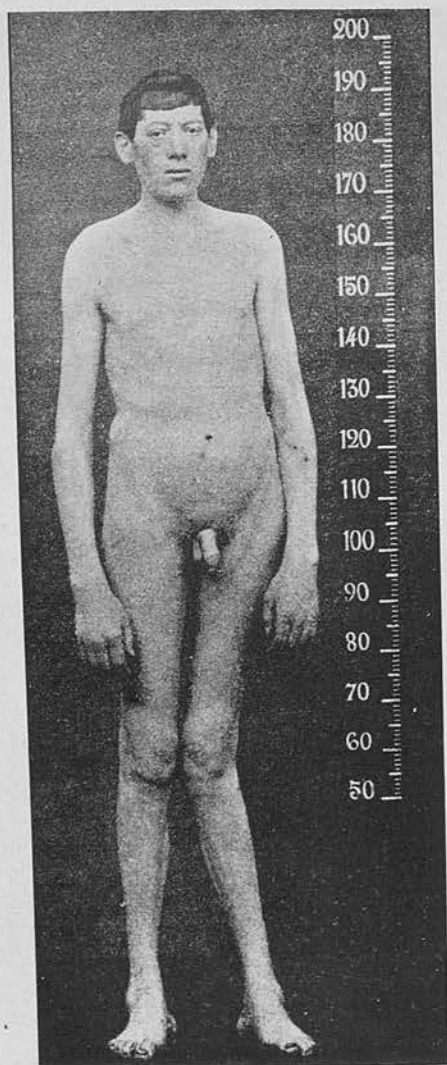
During the three years of his service he performed, without the slightest fatigue, all the military exercises. His strength, no less than his enormous appetite, was the envy of his comrades. So remarkable indeed was the latter that a general order was issued that he was to receive two double rations; that is to say, he ate four times as much as an ordinary soldier, his bread allowance, for example, being two whole regulation loaves per day.

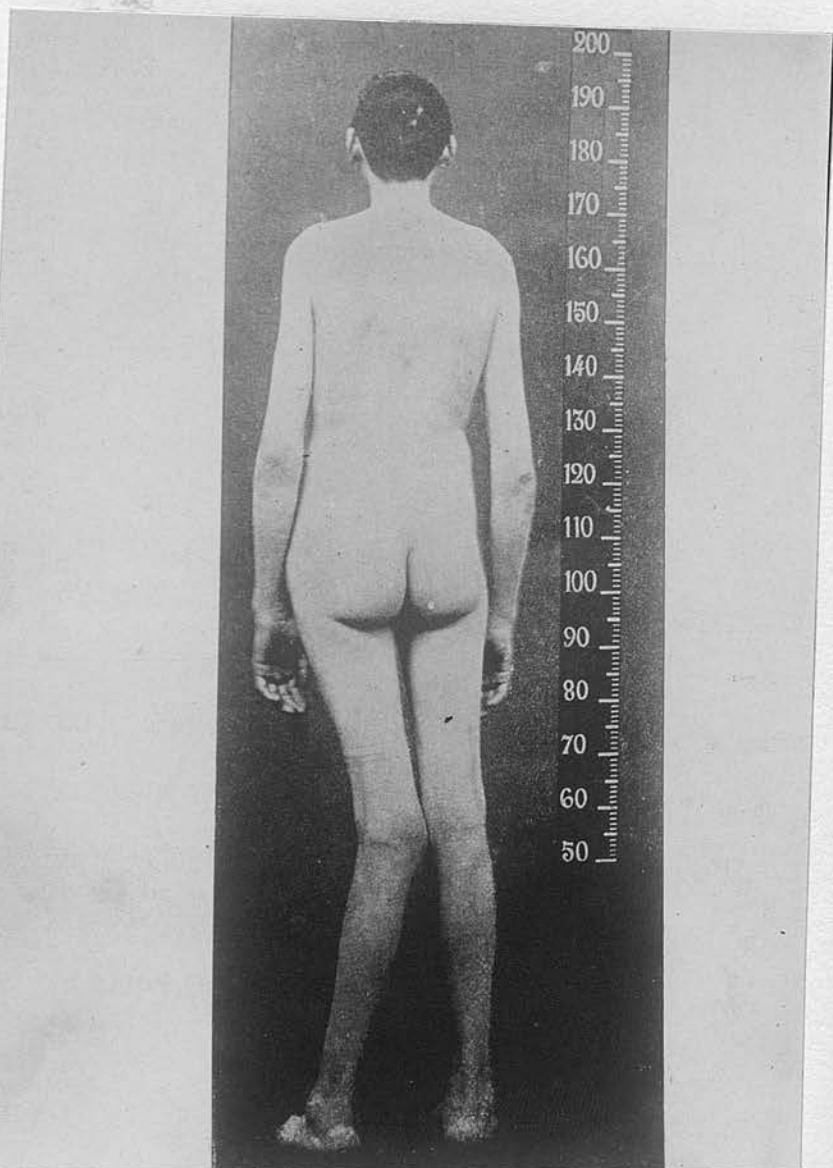
When he left his regiment in 1896 he was measured and was found to have reached the height of 1m96. His strength was proportionate to his height, and he became a carter and furniture remover, being able to lift great weights with consummate ease.

Then, once again, he became haunted by the desire for a nomadic life and he returned to the fairs, but/

(1). Note of Launois & Roy. The figures of the different statures attained by Charles F. which we report below, do not give, perhaps, absolutely reliable information. On the other hand, this first figure is officially confirmed by the observation of M. Capitan made in 1893, and it is sufficient to show the remarkable persistence of his growth after his conscription. This growth still persists. Plate XII. shows Charles as he was at that time, and we thank MM. Capitan and Pappillault for allowing us to use them.

Although, unfortunately, the blocks have got rather pitted by corrosion, they show the general outline sufficiently well to make their comparison with the later photographs interesting.





PLATES XIII. & XIV.

Le Grand Charles at the age of twenty-seven:  
his stature at this time was 1m99. The points of  
special interest with regard to these two photographs  
are, first, the extreme juvenility of appearance for  
a man of 27; second, the commencing left-sided genu-  
valgum.

— After Launois & Roy.

but this time as a freak with the style of "Giant." He became "Le Grand Charles," and his stature still increased, measuring 1m96 in 1897, 1m99 in 1899, (Plates XIII. & XIV.). In 1901 he was 2m03. He travelled over nearly the whole of France, and to this day tells with satisfaction of the great success he had in some of the towns he visited. For the rest he was a clever advertiser, allowing doctors, soldiers and children in to see him free of charge, while his subtitle "The Only Parisian Giant" assured him, it would appear, large receipts.

After a four years tour he came home; pains in his legs which had troubled him for the first time when he left his regiment had increased and now prevented his doing anything which fatigued him. Simultaneously his left knee became deformed, being the seat of a marked genu valgum which compelled him to take to the use of crutches. Severe headache commenced to interfere with his sleep: he got steadily thinner, and, to his great regret, the strength and vigour formerly his pride diminished and disappeared.

Now, a beggar, he wanders the streets of Paris hawking songs and ballads.

PLATE XV.

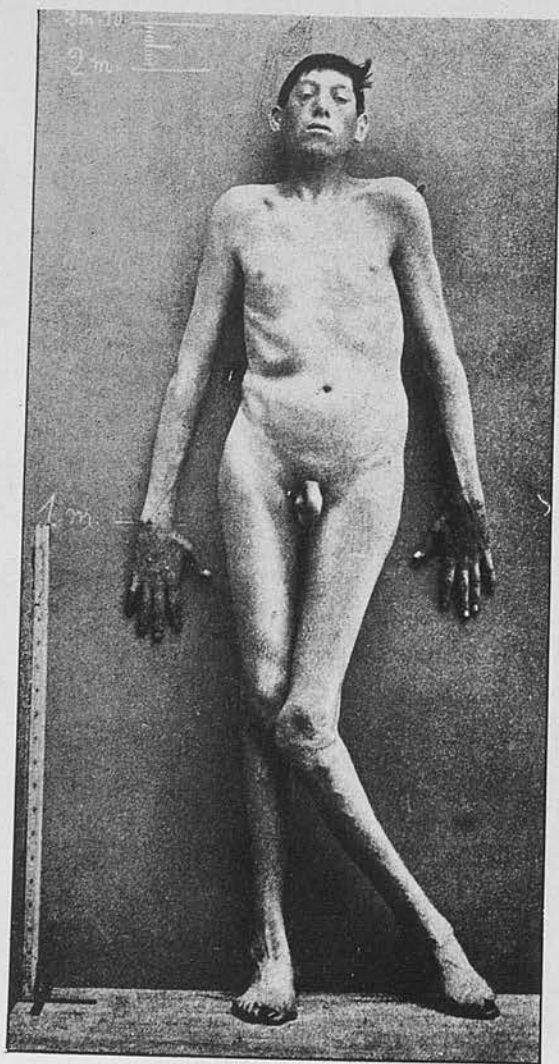


PLATE XVI.

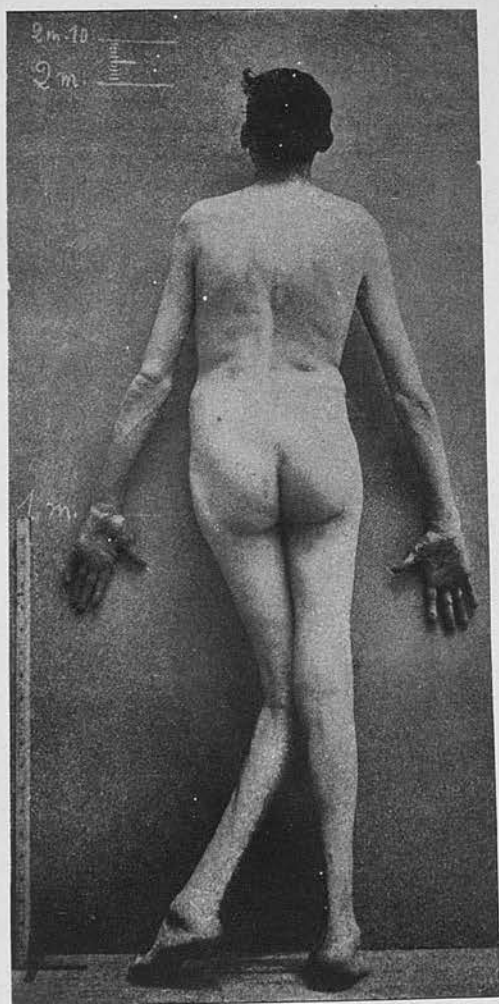
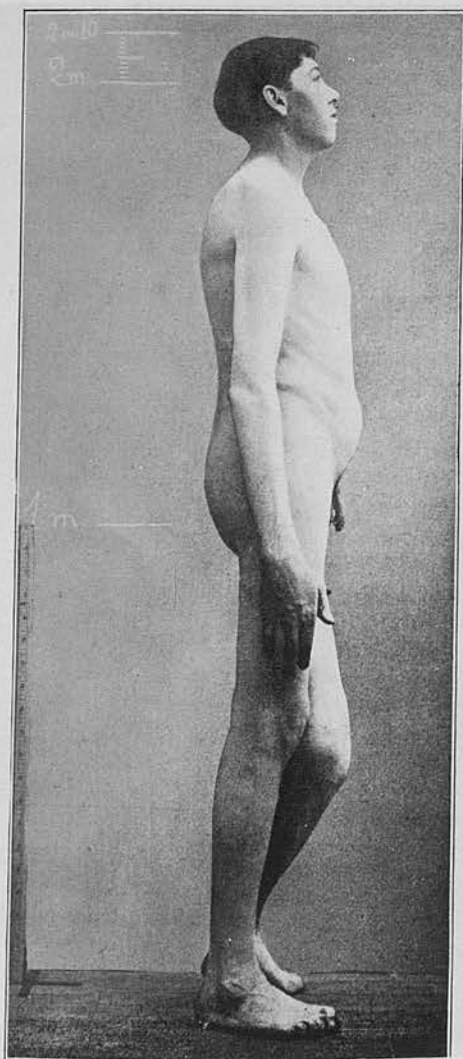


PLATE XVII.



PLATES XV. XVI. AND XVII.

These three plates show "Le Grand Charles" at the age of thirty, when his stature was 2m04. Points of special interest are the slight asymmetry of the face, the greatly increased prominence of the facial bones, the twisting of the trunk and the extraordinarily high degree of genu valgum which exists.

--- After Launois and Roy.

ACTUAL CONDITION, OCTOBER 1902, (AGE 30).

(See Plates XV., XVI. & XVII.

When "Le Grand Charles" takes off his clothes two facts seize upon and hold the attention.

- 1. The extraordinary degree of left genu valgum.
- 2. The complete absence of any sign of puberty.

His height standing is 2m04, but in making up this the greatest part is played by the lower limbs which are very long, the height of the great trochanter is 1m129. Now, although we can regard the artistic canons of the Egyptians only as approximations, we can say that normally the length of the lower limb is about 10/19 of the stature. For a stature of 2m04 the length of the lower limb should, therefore, be 1m07; "Le Grand Charles'" limb surpasses this by 59mm.

Using Quetelet's tables an almost identical result is obtained. A man of 30 with a stature of 1m686 should have a great trochanter height of 0m876: therefore a man of the same age similarly developed, but with a stature of 2m04, should have a great trochanter height of 1m061. The lower limb of our subject surpasses this by no less than 68mm.

The difference is sufficiently marked for one to neglect the inevitable sources of error and to conclude/

conclude that:—

"Le Grand Charles" has lower limbs which are remarkably long in comparison to his height.

On the other hand, the measurements of his trunk correspond closely to the normal (episternal notch to symphysis 620mm.) The head seems small for such a large man (height of head vertex to chin 225mm.).

The extraordinary degree of deformity of the left lower limb (the thigh and leg form an angle of about  $135^{\circ}$ ) gives his body a twist. There is a compensatory dorso-lumbar scoliosis with its concavity to the right; this tends to affect all the measurements.

As a matter of fact, "Le Grand Charles" can walk without using his crutches; his strides are unequal, depending on which leg is supporting his weight. When he walks in this way he is soon tired out, and so for the last two or three years he has made a habit of using two crutches with which he cannot now dispense: one of his crutches is remarkable for nothing but its unusual length, this he uses under his left arm; the other, but half the length, he uses as a cane supporting himself with his right hand upon it.

The slope of his shoulders, of his nipples,

of/

PLATE XVIII.



PLATE XVIII.

The hand of "Le Grand Charles" compared to that of a normal adult.

---After Launois & Roy.

of his iliac spines, with the deep thoracico-lumbar notch on the right side and the folds of skin at that level indicate the degree of twisting which is necessary to maintain his balance. The chest is well made, its circumference at the level of the nipples is 1m04.

All the limbs are much increased in length; we have already referred to the disproportionate increase of length of the lower limbs, that of the upper is nearly as marked; his full stretch from tip to tip is 2m90. The different segments of the limbs are fairly well proportioned. If we except a slight muscular atrophy dependent upon the reduced function of the left lower limb, we can say that the circumference of the arms and legs is excellent and that neither at the wrists (circumference 19cm7) nor at the ankles (circumference 24cm.) is there any disproportionate increase of size.

The hand is very large. (Plate XVIII.); compared to a normal hand it looks as if it were uniformly increased in proportion to the increase of the body. The right foot is large, but not at all deformed, nor out of proportion: the left, as a consequence of the genu valgum, is fixed in a position of equino-varus, it is considerably thickened and on walking the bearing points are the toes and outer border. The toe-nails, more/

more especially the nail of the left great toe, are transversely striated.

The face is pale and covered with freckles. There is no sign whatever of a beard. There is slight facial asymmetry, the right half of the face being a little less developed than the left half; the patient has noticed for two months or so that the left cheek-bone was more prominent than the right. The left orbit is obviously larger than the right; each is about 42mm in breadth, but the left is 73mm<sup>5</sup> in height against the 68mm for the right.---The mandible is not markedly increased in size; the mouth is normal, the tongue is not of unusual bulk. The eyes are small and the skin round them is wrinkled. The cranium does not show any marked abnormality. The forehead is but slightly developed. The voice is not particularly deep nor particularly sharp and the patient sings, in a not unpleasing voice, the ballads which he tries to sell.

The development of the external genitals is markedly imperfect; the penis is small, though well shaped. The scrotum is slightly developed and contains two rudimentary testicles; the right is about the size of an almond, the left, of a hazel nut. On rectal/

On rectal examination, no prostate can be felt. It is the rule in congenital atrophy of the testicles for the prostate not to be developed. <sup>(1)</sup> Functionally the sterility is, and has always been, absolute; there have been a few erections but never ejaculations.

It is necessary to group with the testicular atrophy the other signs of infantilism present. If there be occasional hairs on the pubic region, the axillae and face are most certainly completely glabrous. The beardless hairless body has an appearance of extreme juvenility.

"Le Grand Charles" who formerly possessed remarkable strength still has a very fair muscular development, but his power is much diminished. The left quadriceps extensor is markedly atrophied as the result of its enforced inactivity.

For the last three years or so he has been getting much thinner; his present weight is 86 kilogrammes, he says that formerly he weighed 106 kilogrammes.

His urine has been analysed by M. Savinel with the following results.

#### ELIMINATION/

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(1). P.E. Launois, Castration et atrophie de la prostate. Association française pour l'avancement des Sciences, Caen, 1894.

## ELIMINATION IN 24 HOURS.

8th November 1902.

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	"Le Grand Charles."	Normal Adult.
Volume	2500cc.	12 to 1400cc.
Colour, Odour & Consistency	Normal	
Density	1020.	1020.
Chlorides	23gr5.	10 to 20gr.
Phosphates	4gr31.	2gr5 to 2gr8.
Urea	36gr.	20 to 25gr.

His urine is, therefore, abnormal in:--

1. volume

2. the amount of chlorides, phosphates and urea eliminated. If we compare the amounts eliminated per kilogramme of body weight we find that Charles excretes,--

Phosphates	0,051	in lieu of the normal	0,04.
Chlorides	0,30	" "	0,17.
Urea	0,42	" "	0,40.

So great an elimination of chlorides and phosphates is abnormal for an adult, but normal for a child of 5 or 10 years. <sup>(1)</sup> Without being sufficient to establish a urinary/

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(1). Carron de la Carriere et Monfet. L'Urine normale de l'enfant. Acad.de Med. 20th July, 1897.

urinary infantilism, it appears to us that the facts recorded by M. Savinel are of interest when compared with the other signs of infantilism shown by "Le Grand Charles."

The skin is uniformly hairless, thin and soft. Sensation of all sorts is intact; there are no sensory disturbances, but, since the genu valgum developed, there have been distressing pains in the limbs day and night.

In spite of the patient's physical distress his mental power is not bad. He obviously feels his infirmities and the loss of his physical vigour, yet he retains a certain amount of cheeriness. He is rather short in the temper and emotional: it was found impossible to keep him in the Bicêtre. His memory is excellent and he tells good stories and anecdotes of his tours in the provinces. His intelligence is well developed.

If his obligatory chastity has saved him from the greater risks of syphilitic contagion, his adventurous life has exposed him to the temptations of alcohol: as a matter of fact he drinks several glasses of absinthe every day.

M. Papillault, Professor at the School of Anthropology, has most kindly completed and corrected our/

our measurements. We have been able to compare these with the figures recorded in 1899 by M. Papillault and the following table, therefore, offers the unusual advantage of presenting an exact comparison of two sets of figures made by a skilled observer employing his own methods and technique.

MEASUREMENTS:	May 1899	November 1902
STATURE ERECT	1990	2040
" SEATED	-----	960
TRUNK		
Ext. Auditory Meatus to Pubis	740	
" " " to Spine of Ilium	640	
Biacromial Diameter	490	425
Circumference of Chest	1015	1040
" " Waist	892	925
Diameter at level of nipples	220	220
Transverse Diameter of Thorax		308
Antero-posterior " " "		265
Span		2090
PELVIS		
Iliac Spine to Symphysis Pubis	92	
Width between Iliac Crests	303	321
Width between Spines	263	
RIGHT/		

## Measurements of "Le Grand Charles" (continued)

	May 1899	November 1902
RIGHT LOWER LIMB.		
Height of Femur	529	541
" " Tibia	502	509
" " Internal Malleolus	87	79
Length of Foot	287	299
" of 1st Toe with Metatarsal	143	
" " 2nd " (alone)	82	
" " 1st " (free part)	48	
Bicondylar Breadth	108	
Bimalleolar Breadth	81	
Breadth of Foot	126	
LEFT UPPER LIMB		
Height of the Humerus	381	422
" " " Radius	298	298
Length of the Hand	233	243
" " middle Finger	118½	124
" " Thumb with Metacarpal	125	126½
" " " (alone)	72	78
" " Nail of middle Finger	16	16
Breadth of Humerus (lower extremity)	74	83
" " Wrist	67	69½
" " Hand	97	103

CIRCUMFERENCES/

## Measurements of "Le Grand Charles" (continued)

CIRCUMFERENCES	May 1899	November 1902
Neck	370	370
Chest	1015	1040
Waist	892	925
Arm	280	260
Forearm	271	250
Wrist	197	197
Thigh (superior right)	544	
" ( " left)	539	450
" (inferior right)	420	
" ( " left)	399	
Calf (right)	382	
" (left)	375	350
Malleoli (right and left)	240	
HEAD		
Naso-alveolar height	87	87
Naso subnasal	64	64
Breadth between internal angles of eyes.	36	37
Ophryo-alveolar height	102	102
Breadth between external angles of eyes.	96	
Bimastoid width	142 $\frac{1}{2}$	145
Antero/		

## Measurements of "Le Grand Charles" (continued)

	May 1899	November 1902
Antero-posterior glabellar diameter	199	200
Ophryo-Mental height	154	159½
Antero-posterior metopic diameter	195	197
Bi-Zygomatic Width	145	140
Bigonial Width	116	116
Gonio-mental diameter	108	111
Breadth of Nose	36	37
Transverse maximum diameter	156	159
"    minimum    "	104½	

From a consideration of the three statures confirmed by scientific observation,

at 21 years of age	1m88 (Capitan)
" 27 " " "	1m99 (Papillault)
" 30 " " "	2m04 (Launois and Roy)

it is possible to state that "Charles" has continued to grow since he was 21; in a period of 9 years he has gained 18 centimètres. This growth is the more important because it has been acquired at an age after that, at which the stature usually reaches its definite limit.

And now although he has attained his 30th year, he is still growing. The explanation of this persistence/

PLATE XIX.



PLATE XIX.

Radiograph of the hand of "Le Grand Charles" taken when he was thirty years of age.

The point of especial interest brought out in this plate is that the epiphyseal cartilages of this hypermacroplasiac's bones still persisted when he was thirty years of age. The smoothness and almost feminine delicacy of the shafts of the radius and ulna is, also, not without interest in view of Charles' great muscular power.

-----After Launois and Roy.

PLATE XX.



PLATE XX.

Radiograph of the left knee of "Le Grand Charles." The changes in the lower end of the femur, the bending of the upper third of the tibia and the persistence of the epiphyseal cartilages are especially interesting.

-----After Launois and Roy.

persistence of growth is made clear by the accompanying radiographs. In these remarkable plates, for which we are indebted to M. Infroit, one can see that the epiphyseal cartilages are not obliterated although at latest they should have disappeared about five years ago.

### SECTION III. OBSERVATIONS UPON THE CASE OF HYPER-MACROPLASIA.

The symptom complex presented by "Le Grand Charles" can only be explained upon the lines of the theoretical conclusions arrived at in Part I. The body cells of this individual must, for long, have been in an hyperanabolic environment, for his epiphyseal cartilages have persisted, and his sexual maturity has been delayed, probably entirely suppressed. His recent rapid loss of strength and vigour show that the nemesis of overgrowth is overtaking him. Mentally, he possesses none of the higher attributes as notes upon him by J. Lucas Champonnière show. It would be tedious to transcribe the tissue of falsehood which "Le Grand Charles" wove for that observer; it would be no injustice to our giant to call him a childish liar and idle braggart; his whole life history shows him/

him to be a man of no pronounced mental capacity.

And "Le Grand Charles" is a typical giant. It is only necessary to glance at the photograph of Miss Ella Ewing, the Missouri Giantess, (Plate IV) to see that the hypermacroscely is not an individual peculiarity. The length of Miss Ewing's legs is so remarkable that it is impossible to avoid the suspicion that her stature is aided by artifice. Woods Hutchinson who published the case expressly states that she was not mounted upon stilts. The photographs of Lady Aama, (Plate V) the Russian Giantess, (Plates VIII. and IX.) The German Guardsman (Plate X) and the Giant Hassan (Plate VI.) all show sufficiently well the great length of limb associated with excessive height. In this respect giantism is obviously in series with ordinary increase of stature. Tall men are by definition more macroplastic than short; giants are not simply tall men magnified they are the subjects of an hypermacroplasia.

Another point which the case of "Charles" illustrates is the delay in the obliteration of the epiphyseal/

(1) New York Medical Journal; July 1900.

(2) Woods Hutchinson, American Journal of Medical Sciences, 1895, page 192, states that the excessive length of Aama's lower limb accounted for nearly three fourths of her total excess of height. This is again referred to.

epiphyseal cartilages; this is not at all an uncommon phenomenon in giants although it is not invariable. From the point of view of age there are two distinct types of giant. In the first the giantism appears before the age of twenty and is in series with precocious growth and the not infrequent transient giantism of adolescence. In the second, the giantism develops later, growth being prolonged abnormally beyond its term. In all probability, however, this distinction is merely a physiological expression of the time of onset of the underlying cause of giant growth, the period of cessation of growth corresponding in both cases to the attainment of a body-bulk-food-supply balance. This, which in the meantime, is a mere guess, will later appear to be founded on fact.

It is with the group of giants characterised by delayed cessation of growth that we are at present concerned and examples of a thoroughly satisfactory kind are plentifully forthcoming. <sup>(1)</sup> Hinsdale describes the skeleton of the American Giant of the Mütter Museum, Philadelphia, as follows:--

"It is probable that the American Giant had attained/

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(1) Acromegaly, Warren Detroit, 1898.

attained the age of 22 or 24 at the time of his death. The bones seem to have attained their full development, although the epiphyseal junctions are plainly visible in all the long bones." Later, in the description of the Femora of the same skeleton we read "The shafts are no thicker than in ordinary individuals."

In the giantess Lady Aama at the time of death most of her epiphyses were ununited, but her age is not given with any pretence to accuracy. It was in fact estimated by Woods Hutchinson from the state of the epiphysis to be about 19. He adds, however, "that the condition of the epiphysis may have been a part of the general imperfect development of all her tissues." <sup>(1)</sup>

The best example of delay in ossification is given by Buday and Jancso. <sup>(2)</sup> It affected a man who died at the age of 37. Of normal stature (1m63) at the age of 20 he suddenly commenced to grow. The growth continuing steadily, at the age of 35 he attained a height of 2m02. In the two last years of his life he did not grow in stature and at the autopsy the epiphyseal cartilages were found to be ossified. There was, however, clear evidence of great delay in the/

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(1) This case from which this note is taken is given in detail later.

(2) See later.

the completion of the process of ossification. At the periphery of the long bones after maceration there was a groove marking the site of the epiphyseal cartilages, this was especially well seen at the lower end of the radius and ulna, and at the upper end of the femur. Microscopic examination showed that the cells in the remaining cartilage were for the most part active. Buday and Jancso concluded that the case was one of "delayed ossification."

Another good example is furnished by the case of the giant Constantin. <sup>(1)</sup> He was 29 or 30 years old when he died yet many of his epiphyses were still open and active.

For present purposes these records are sufficient to show that there is a group of giants characterised by persistence of the epiphyseal cartilages.

The third point of especial interest in regard to "Charles" is that he is an infantile: in this too he is a type of a large class of giants which includes Aama, the German Guardsman, Constantin, Mc Indoo <sup>(2)</sup> and Peter Rhyner. <sup>(3)</sup>

Now/

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- (1) This case is described more fully later.  
 (2) Woods Hutchinson, New York, Medical Journal 14 July 1900.  
 (3) Fritsche und Klebs, Ein Beitrag zur Pathologie des Reisenwachses, Leipzig 1884.

Now excessive growth of the long bones, delay in the obliteration of the epiphyseal cartilages, delay in the establishment, or even complete failure, of sexual maturity and mental powers of the childish type form a symptom complex indicative of hyperanabolism and are symptoms characteristic of a large number of giants. I, therefore, provisionally conclude that giantism is the result of hyperanabolism dependent upon an excessive physiological endowment of the body cells, upon an absence of sexual drain or upon a failure of the mechanism responsible for maintaining the amount of nutrition in the blood at a level commensurate with the requirements of the body.

Upon this I base my provisional classification of the giants.

## CHAPTER XII.

## PROVISIONAL CLASSIFICATION OF GIANTS.

Giants are hyperanabolics and anabolism is dependent upon the interplay of two forces.

1. the inherent anabolic power of the body cells.
2. the amount of nutritive material available for the use of the cells.

The inherent anabolic power of cells at present defies analysis.

The factors determining the amount of food supply made available for cell multiplication were, in the first part of this thesis seen to be:--

1. the amount of nutritive material absorbed;
2. the amount of potential nutritive material destroyed and thrown out by the mechanism controlling the exogenous metabolism:
3. the amount of nutritive material used up by the/

the sexual glands:

4. the amount of nutritive material required for cell reparation and replacement. The last of these, necessarily, varies directly with the bulk of the organism and, therefore, cannot conceivably be a direct factor in causing giant growth, but the others, either singly or together, are hypothetically possible causes of a relative increase in the available nutrition.

There will, therefore, be two main types of giantism: the second admitting of subdivision into four sub-types, thus:—

1. PHYSIOLOGICAL GIANTISM--

(A) The giantism of unusual anabolic cell endowment.

2. PATHOLOGICAL GIANTISM--

(B) The giantism of uncomplicated testicular failure.

(C) The giantism of deficient exogenous metabolism.

(D) The giantism of excessive absorption.

(Note:--This cause to be operative requires that the mechanism of exogenous metabolism be unable to cope with the increased demands made upon it and carries with it as a corollary the necessity of delayed or suppressed sexual maturity. This constitutes the/

the fourth sub-type.

- (E) The giantism of excessive absorption, deficient excretion and sexual failure combined.

I propose, temporarily, to class together sub-types C, D and E. under the title of the  
GIANTISM OF NUTRITIVE OVERLOADING.

To complete the classification other factors require to be taken into account, first, the reduction of cell absorptive power associated with advancing age, second, the limits of the possible maximum of nutritive material absorbed. From this it follows that the larger an individual becomes the less will be the concentration of nutritive material in his body fluids. The larger, therefore, a giant is at any age the "older" in type will be his subsequent development. It is thus impossible to conceive that an individual afflicted with nutritive overloading at 15 or 16 years of age will show the same growth changes between 24 and 30 as an individual afflicted at 23 or 24. Also, it is quite inconceivable that a person afflicted at the age of 30 should show the same growth changes as a person afflicted at the age of 23. It is, therefore, evident that in each subclass there will be three possible/

possible types of resulting body form. First a type developed by individuals afflicted in infancy and childhood, in whom increased body bulk will have led to the establishment of relative katabolism before the normal age of maturity; second, a type developed by individuals afflicted during adolescence, in whom increased body bulk will not lead to the establishment of relative katabolism until after the normal age of maturity; third, a type developed by individuals afflicted during maturity, in whom macroplasia is an impossibility. Further, in each case there will be developed a precocious senility due to the difficulty of supplying the increased body mass with food sufficient for the cells with their diminishing absorptive power and still further the more nearly the body mass has approached to the limits of support the more rapid will be the starvation decline and the earlier will the death of the individual occur. In the event, however, of unequal distribution of cell anabolic power, before the period of starvation decline, in any instance, becomes fully established there must be a period, long or short, during which the more anabolic cells will increase and multiply, the less anabolic remaining stationary or being in part absorbed.

The complete provisional classification of the giantisms can, therefore, be diagrammatically expressed thus:--

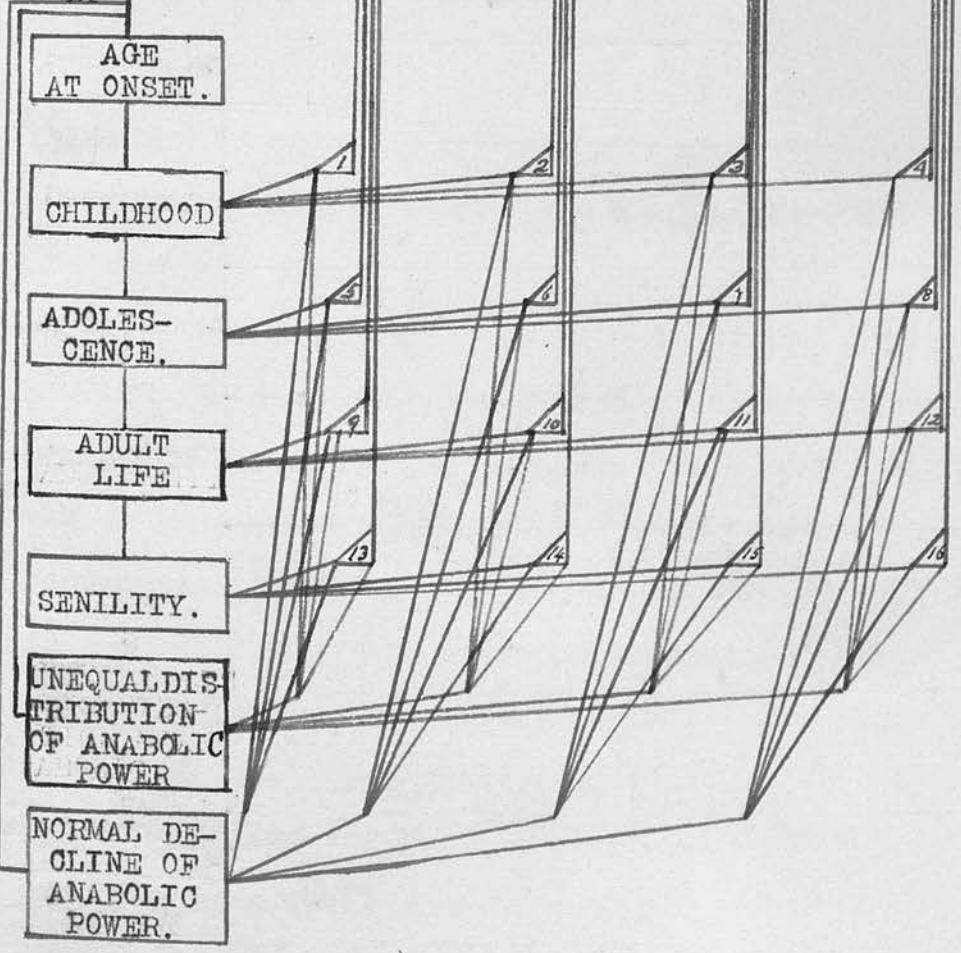
DIAGRAM TO ILLUSTRATE THE PROVISIONAL CLASSIFICATION OF THE GIANTISMS.

GIANTISM IS A SYMPTOM OF

PHYSIOLOGICAL PATHOLOGICAL

EXCESSIVE NUTRITIVE SUPPLY DUE TO:-

THE DEVELOPMENT OF THE GROWTH CHANGES IS MODIFIED BY



When A = Excessive Anabolic Power of Cells

B/

B = Failure of Sexual Drain.

C = Failure of Mechanism of Exogenous Metabolism.

D = Excessive Intestinal Absorption.

E = B, C and D Combined.

Nos. 1-16 and the lines leading to their containing triangles show the hypothetically possible forms of giantism and the influences which modify the development of the growth changes.

SECTION I. THE UNDERLYING CAUSE OF PHYSIOLOGICAL  
GIANTISM—EXCESSIVE PHYSIOLOGICAL EMPLOYMENT OF  
THE BODY CELLS.

The body cells of children of the same parents are not necessarily endowed with precisely the same amount of physiological capital. This is a truism and yet it is exceedingly difficult to prove, for it is inconceivable that any two individuals can be subjected to precisely the same environmental conditions and slight differences in the environment may be responsible for a great difference in the ultimate body form. It is, therefore, better to recognize the difference of all endowment in children of the same parents. In this way the influence of the facts of environment are avoided and the

## CHAPTER XIII.

## GIANTS OF THE FIRST CLASS.

## PHYSIOLOGICAL GIANTISM.

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SECTION I. THE UNDERLYING CAUSE OF PHYSIOLOGICAL  
GIANTISM---EXCESSIVE PHYSIOLOGICAL ENDOWMENT OF  
THE BODY CELLS.

The body cells of children of the same parents are not necessarily endowed with precisely the same amount of physiological capital. This is a truism and yet it is exceedingly difficult to prove, for it is inconceivable that any two individuals can be subjected to precisely the same environing conditions and a slight difference in the environment may, conceivably, be responsible for a great difference in the ultimate body form. It is, therefore, better to demonstrate differences of cell endowment in different parts of the same individual. In this way the disturbing effects of environment are avoided and accurate evidence of/

PLATE XXI.

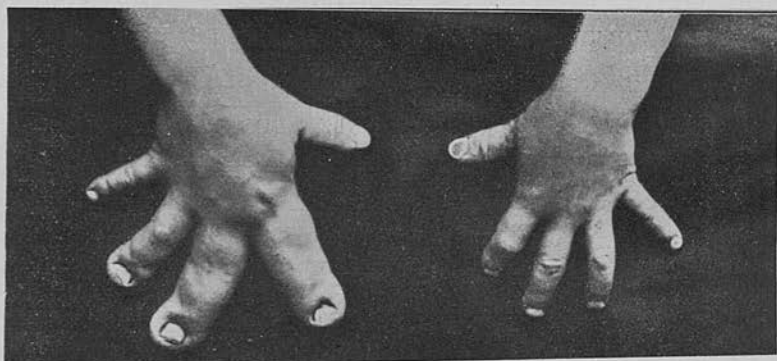


PLATE XXI.

Photograph of the hands of a boy of five years of age, illustrative of the condition of partial physiological giantism. So far as is known this case of partial giantism was entirely the result of a difference in the absorptive power of the cells of the affected parts: there was no obvious disturbance of nervous or vascular control.

---- After Klaussner.

of varying cell endowment is obtained.

(1)

The first case which I select to illustrate this point is that of a boy of five years. The accompanying photograph shows the hands; the left is normal; the right is remarkable for the enormous size of the fore and middle fingers and for the very considerable enlargement of the ring finger and for nothing else.

Such partial giantism only admits of one satisfactory explanation, there must have been an unequal distribution of the absorptive power at the time the cells destined to form the affected fingers were divided off from the cells destined to form the rest of the hand. For in this and the following cases there was no discoverable lesion of the nervous system or disturbance of the blood supply. This is important; for either of these might hypothetically be causes of excessive growth, but even if they were the cause in this case it would be immaterial; for, they would of necessity either be dependent upon some difference in the absorptive power of the vasoformative cells or of some difference in the absorptive power of the primitive nerve cells. In result some inborn peculiarity/

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(1). Klaussner *Über Missbildungen der Menschlichen gliedmassen* Neue Folge Bergmann Wiesbaden, 1905.

PLATE XXII.

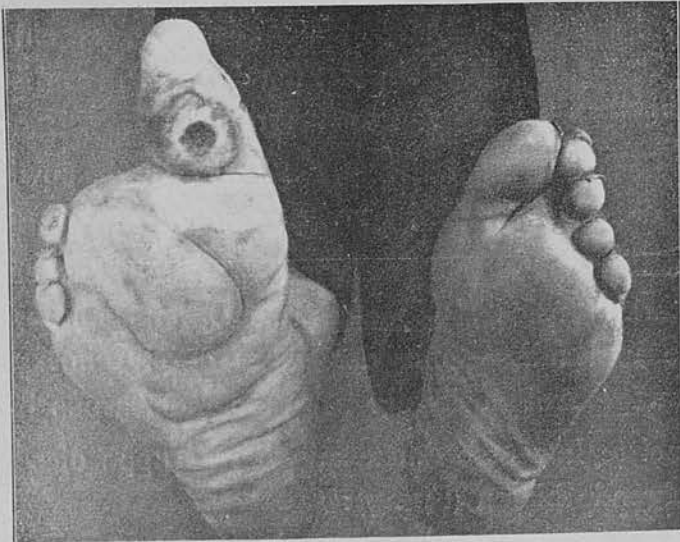


PLATE XXII.

Further illustrations of partial physiological  
giantism.

— After Klaussner.

peculiarity of some cells responsible for the right hand would have caused a condition of partial giantism.

(1)

The second and third cases are illustrative of giantism affecting the toes of one foot; the photographs are a sufficient demonstration of the condition that existed.

(2)

The fourth case is particularly interesting; it is not a case of paralysis and there has been no accident which could account reasonably for the condition. The photographs explain themselves. This is not an illustration of partial giantism, but of partial dwarfism. The existence of a true physiological partial giantism necessarily presupposes the existence of a corresponding partial dwarfism: in this respect this observation is complementary to the former.

The fifth case, unpublished, is that of a man aged 28 who suffers from a condition of most marked hemihypertrophy. When first observed twenty years ago he was a well built little boy, a good runner for his age and not inept at athletics. At the age of 14 he had the misfortune to contract an exceedingly severe attack of scarlet fever. He was so ill that  
for/

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(1). Klaussner *Über Missbildungen der Menschlichen gliedmassen* Neue Folge Bergmann Wiesbaden, 1905.

(2). *Ibid.*

PLATE XXIII.

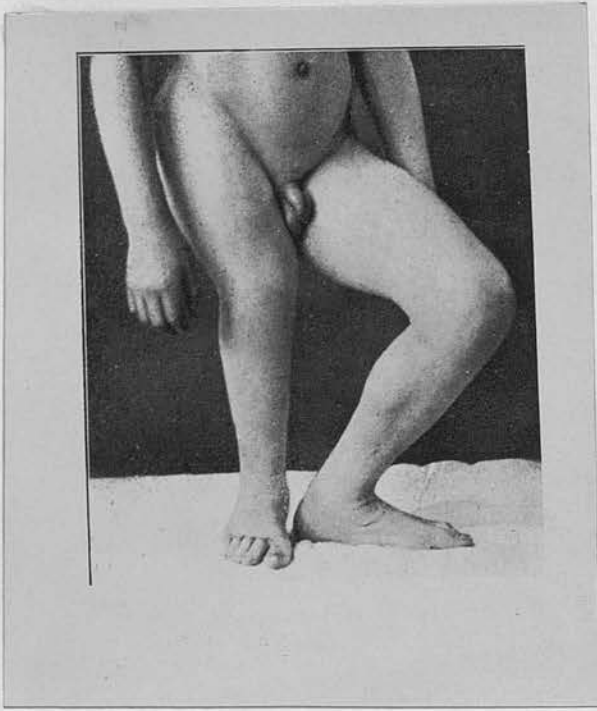


PLATE XXIII.

Photographs showing the condition of partial physiological dwarfism referred to in the text. The existence of such dwarfisms is hypothetically a necessity to the establishment of a class of physiological giantisms.

— After Klausner.

for several days he was believed to be dying, his convalescence was prolonged. When at last he got up and was allowed to mix with his schoolfellows it was noticed that he had grown enormously in height, but that he was no longer well built, being thin and weedy. As time went on it became apparent that the right half of his body and the left half were developing on different lines. The right half face and trunk and the right limbs were those of a powerful lad and ultimately man; the left half face and trunk and the left limbs were those of a slightly built short-legged, short-armed, weakly individual. This painful condition persists; the patient's right half body is built on lines corresponding to the family type as shown in his brothers; the left half body is small and weak. The right half face is handsome, the left half is not and does not fit on to the right half properly, the mouth and eye being far too near one another.

This condition has, I think, only one possible explanation, there must have been in the two halves of the body a difference in resistive power to the toxins of scarlet fever, so that the cells of the left half suffered permanent injury, the more resistive cells of the right half recovering completely. As will be seen later/

later a difference in the cell endowment in the two halves of the body frequently shows itself under the strain of excessive nutritive supply.

A consideration of such cases has convinced me that great differences of cell endowment exist. I am, therefore, prepared to accept them as a hypothetical cause of giant growth: a general excessive endowment being the cause of a general giant growth, a partial excessive endowment being one of the causes of partial giant growth.

SECTION II.      EXAMPLE OF PHYSIOLOGICAL GIANTISM  
AFFECTING THE WHOLE BODY.

The Giant Winkelmeier.

(1)

Virchow gives the following account of this famous giant. "Through the courtesy of M.B.Fraenkel I had about a fortnight ago the opportunity of making the acquaintance of Mr. Franz Winkelmeier, whom every one calls Franzl and who comes from Upper Austria. The proprietor of the "Concordia" hall, H.Holf Düsseldorf, has done me the great kindness of allowing me to measure the young giant and of allowing me to bring him/

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(1). Virchow Verhandlungen der Berliner anthropologischen Gesellschaft, Oct. 25, 1885. Zeitschrift für Ethnologie, 1885, p.469.

PLATE XXIV.

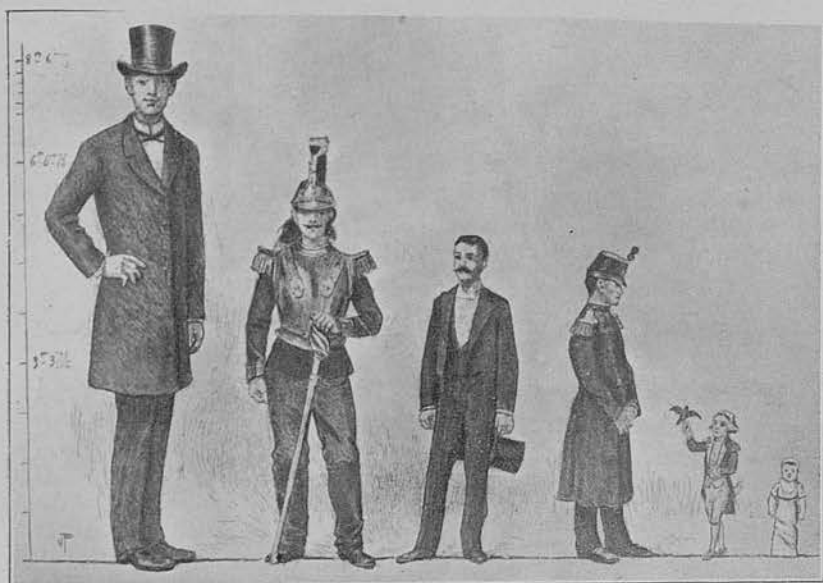


PLATE XXIV.

Figure showing the variations of human stature from the infant in arms to the giant Winkelmeier.

---- After Dana. Scribner's Magazine, Feb. 1895.

him before you to-day.

Winkelmeier is aged 26; he was born at Mattikhopen in Upper Austria. Speaking generally, he is well built, his general proportions being satisfactory. His complexion, however, is rather pale and his muscles are a little soft. This probably is to be accounted for by his rapid growth, for he was as a child of ordinary stature and only about the time of puberty did he commence to grow really rapidly. Even now we cannot say definitely that his growth is quite stopped. There is no heredity of giantism.

He is so unusually tall that the apparatus with which I tried to measure him was quite insufficient for the purpose. I was, therefore, compelled to adopt various makeshifts. As a result, there are probably some slight errors in my measurements. The general results, however, will not be much influenced.

I give at the end in a comparative table the measurements which I made more than 20 years ago upon the Giant Murphy, wherever these are comparable, and to them I add the corresponding measurements of a very tall fellow-countryman of Winkelmeier's who was 32 years of age when I measured him on the 14th of May 1866. His name was Lentz.

From these we see that Franzl is not only the tallest/

tallest of the three, but also that his structural form has best preserved its proportions. His total stature, 2m278, surpasses by 55 millimètres that of Murphy. There are, it is true, some authentic examples of a greater stature even than this, thus a Kalmuk, whose skeleton is preserved at Paris at the Musée Orfila, measures 2m53, and a Finn, named Cajanus, 2m83, (Topinard Anthropologie, p.436.) still, the majority of giants have not been so tall as Franzl. Langer, in his extended observations, gives the height of the Innsbruck giant as 2m226, and the St. Petersburg Giant, who really came from Pomerania, as 2m195.

With reference to Franzl's body form, I wish at the outset to draw attention to one important fact. The length of his foot is contained 8.5 times in the height of his body.

In Lentz the proportion is 6.7, in Murphy 7.1, in the Innsbruck skeleton 7.1, in the St. Petersburg skeleton only 6.

It would be tedious to compare in full detail other parts, but there is one point I wish to emphasize. Langer says that all giants have small heads; that does not apply here. In the individuals that I have measured the horizontal perimeter as well as the transverse diameter surpass the average, not only in proportion/

proportion to the face, but also in proportion to the brain. Only in one relation do they show a relative diminution and that is in relation to the length of the base of the skull: the distance from the root of the nose to the external auditory meatus is in Franzl and Murphy less than in Lentz in whom the measurement is extraordinarily large. In proportion to the extraordinary length of the head of Franzl (217mm) all the transverse diameters, even the bi-gonial and minimum frontal, are markedly below those of Murphy and even of Lentz. This surprising point in connection with Franzl's head certainly loses none of its interest when we think of the extraordinary length of his trunk and limbs.

TABLE OF MEASUREMENTS.

<u>HEAD.</u>	<u>Winkelmeier.</u>	<u>Murphy.</u>	<u>Lentz.</u>
Maximum length	217	205	197
Maximum breadth	161	162.5	167
Index	74.1	79.2	84.7
Breadth of Forehead	115	127.5	128
<u>HEIGHT OF FACE.</u>			
A.	225	220	187
B. Root of nose to chin	149	143	109
Middle/			

	<u>Winkelmeier.</u>	<u>Murphy.</u>	<u>Lentz.</u>
Middle segment root of nose to mouth	96	78	69
<u>BREADTH OF FACE.</u>			
(a) Bizygomatic	157	165	148
(b) Bimalar	91	---	---
(c) Bigonial	118	135	130
Internal angles of eyes	46	40	41
External " " "	114	116	105
Nose height	71	65	59
" breadth	67	---	---
" thickness	41	---	---
Mouth breadth	62	---	---
Orbit height	75	71	64
Root of nose to external auditory meatus.	141	140	153
Horizontal Perimeter.	615	640	612
<u>MEASUREMENTS OF THE BODY.</u>			
Total Stature	2278	2220	1905
Span	2503	2550	1970
Height of Chin	2052	2000	1643
" " shoulder	1991	---	---
" " elbow	1499	---	---
" " wrist	1091	---	---
middle/			

	<u>Winkelmeier.</u>	<u>Murphy.</u>	<u>Lentz.</u>
Height of middle finger	856	---	---
" " navel	1448	---	---
Height of iliac crest	1523	1390	1154
" " symphysis pubis	1297	---	---
" " the great trochanter	1353	1225	1023
" " upper border of patella	761	705	535
" " external mal- leolus	105	90	55
" " vertex seated	1012	---	---
" " shoulder "	689	---	---
Breadth of shoulder	505	475	402
Circumference of the Pelvis	1120	---	---
Hand length to tip of middle finger	261	245	191
" breadth 4 fingers	116	115	87
Foot length	358	310	283
" breadth	135	---	---

### SECTION III. SOME OBSERVATIONS UPON VIRCHOW'S RECORD.

On Virchow's authority I have classed Winkelmeier as a physiological giant. Probably this is in the main correct, but the fact that his growth became particularly active at the time of puberty certainly suggests/

suggests that there was some slight pathological disturbance of his metabolism. Winkelmeier was, however, not excessively anabolic, because he was far from being sexually impotent and unless we are prepared to assume that his testicular cells were peculiarly little absorptive we are compelled to believe that the concentration of food stuffs in his body fluids was not excessive. His height when seated is also considerable, amounting to about 45% of his total stature. This also is strong evidence that his growth was of the normal type, the pure anabolics tending to have a trunk not only relatively, but actually shorter than normal.

The Russian Giantess <sup>(1)</sup> (Plates VIII and IX.) is possibly another example of physiological giantism. Other cases of apparent physiological giantism are on record. Quételet (*Anthropométrie* 1871. p.300) describes a Neapolitan Giant exhibited at Brussels age  $18\frac{1}{2}$  years, height 2m15. This man was well built inclined to be fat, but very strong. The hands, feet and limbs were well proportioned. <sup>(2)</sup> Hinsdale records in a brief note the case of a giant now living "named Henry/

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(1) Described by Woods Hutchinson, *New York Medical Journal*, 1895.

(2) Hinsdale, *Acromegaly*. Warren Detroit, 1898, p.53.

Henry Alexander Cooper who was born in the county of York, England on the 12th of March 1860. He is seven feet, five inches in height with boots on, and the circumference of his head is twenty-five inches. There is no prognathism, no exophthalmos and no hemianopsia. There was formerly severe headache, and at one time pain in his eyes with some blurring of vision. This was about the period of greatest growth. The brows are rather prominent, the nose large; the chin, however, is not unduly prominent, considering the size of the face. The latter is of oval shape. The hands and feet are not disproportionate to the size of the skeleton. The abdomen is not prominent and there is neither excessive thirst nor hunger. The man seems to be losing flesh. It was not possible to ascertain his exact weight. The giant is not, therefore, a case of acromegaly. It should be stated that this man's intellect is perfectly clear, his manner pleasing and his voice agreeable."

There is, of course, one very obvious objection to accepting these cases of giant growth as physiological. Although there was nothing about them at the time of observation to suggest a diagnosis of pathological giantism that is no proof, as we shall afterwards see, that they were not doomed ultimately to develop/

develop unmistakable signs of pathological gigantism. Fortunately the point is not of great moment. Whatever the ultimate fate of these individuals there can be no doubt that the cells of some individuals or some of the cells of one individual may possess an undue amount of anabolic power and that this does cause in some cases unusual growth.

## SECTION I. THE GIGANTISM OF UNUSUAL GROWTH.

### CHAP. I. INTRODUCTION.

The present chapter of this book, the subject of which has already been mentioned in your earlier work, is devoted to a study of the conditions under which unusual growth with a double purpose. First, it is necessary to try to establish the existence of such growth of abnormal hyperplasia, secondly, it is necessary to determine the fact that particular cells or groups of cells are responsible for a limited growth, but that they are responsible for the most striking cases of abnormal growth. This statement is definitely supported by a large number of the observations which have been made themselves to the point that the growth of such plants.

## CHAPTER XIV.

## GIANTS OF THE SECOND CLASS.

## PATHOLOGICAL GIANTISM.

## SECTION I. THE GIANTISM OF UNCOMPLICATED TESTICULAR FAILURE.

The purest examples of this class, the eunuchs, have already been described in some detail: five observations upon eunuchoids are quoted in this chapter with a double purpose. Firstly, it is necessary clearly to establish the existence of this group of limited hyperanabolics; secondly, it is desirable to recognise the fact that testicular failure of itself is responsible for a limited giantism, but that it is not responsible for the most striking cases of giant growth. This statement is definitely controversial. A large number of the continental workers have committed themselves to the opinion that most giants are giants/

giants because they are infantiles. This in the majority of cases is reversing the proper order of the phenomena. That there are individuals whose metabolism is hyperanabolic because of the absence of testicular drain, is indisputable: the more striking cases of hyperanabolism are, however, not dependent upon testicular failure. In the true giants the sexually infantile condition is the result of their hyperanabolism. The French school represented by Launois, Roy, Méige and Brissaud is, I believe, in error when they speak of the giantism of infantilism; they would more correctly speak of the infantilism of giantism. I select four cases that have been used by the French writers themselves in their attempt to establish their hypothesis, and to these I add one English case which appears to me in conjunction with what follows to show that their position is untenable.

(1)  
OBSERVATION I.

On the 3rd of July 1901, X, aged 30 years, a herd, was admitted to Professor Bondet's Ward for an attack of hemiplegia. His personal history with regard/

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(1) Pirsche, loc. cit.

regard to previous illness is strictly negative; there is no sign whatever of hereditary syphilis.

The patient's father and mother are peasants; they are still alive and in good health. The father has a stature of 1m64.

#### Present Condition.

The patient has all the appearance of a true eunuch: he is tall, 1m80. The lower limbs are remarkable for their disproportionate length; the face and body are completely glabrous. The voice is small and surprisingly infantile for so tall a man. The breasts seem hypertrophied, the pelvis is very wide. Examination of the genital organs shows them to be markedly atrophied; the scrotum barely descends 4 centimetres below the root of the penis, the skin is slightly pigmented and hairless. The penis is well formed, but is hardly as thick as the little finger, it is like that of a boy of ten. The testicles are of the size of sparrows' eggs and devoid of normal sensation. The patient has never experienced sexual desire.

Psychically he is of low intelligence. He never had the slightest desire to go to school like his comrades and is now quite happy looking after cattle./

cattle.

(1)  
OBSERVATION II.

X, aged 53, navy, born at Mantes (Drôme) was admitted to Professor Pollosson's Ward to be operated on for a left sided inguinal hernia.

Previous History.

Up to the age of 18 the patient was quite healthy. At that time he suffered from a mild attack of typhoid fever which does not appear to have affected his testicles, at least, he never suffered from orchitis. At 35 he had inflammation of the lungs. The inguinal hernia for which he has been admitted began at a wholly indeterminate time, it has, however, been irreducible for a week.

The patient's parents are dead. The cause of their death is unknown. He has two brothers and a sister, all of whom are married and have children; they are of average stature.

Present Condition.

The patient is thin and tall 1m77, the lower limbs are very long and altogether out of proportion to his stature. The face is that of an oldish individual with a small wrinkled forehead and blue, deep set/

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(1) Pirsche, loc. cit.

set eyes. The face, axillae and pubis are alike devoid of hair. The voice is eunuchoid, the breasts are little developed, the pelvis is broad. The genital organs are abnormal, the scrotum is small, but more developed on the left side because of the hernia, the penis is small and atrophied. The right testicle feels like a small bean: the left is quite impalpable owing to the presence of a marked epiplocele. At the operation it was seen to be small, about the size of a pea and fibrous.

(1)  
OBSERVATION III.

X, 38 years of age, shirt maker, born at Venissieux, Rhone, was admitted May 1902 to Dr. Mouisset's Ward on account of mitral incompetence.

Previous History.

The health of the patient was good up to the age of 19 years, at that time he suffered from palpitation. Two years later before the conscript medical board the patient's military service was remitted because of his heart disease which, however, did not prevent his working until April 1902.

His parents are dead. The cause of their death is unknown. His brother has been ten years married/

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(1) Pirsche, loc. cit.

married, but has had no children.

Present Condition.

The patient is unusually tall 1m82; his lower limbs are very long relatively to his height. The face and body are glabrous. The breasts are well developed and the pelvis is very broad. The penis is smaller than usual; palpation of the scrotum reveals the presence of two very small and completely insensible testicles. There is no sexual desire.

Psychically the patient is intelligent; he passed through the ordinary primary courses with success.

TABLE SHOWING  
MEASUREMENTS OF THE LIMBS OF THE THREE PATIENTS.

Case	No.1.	No.2.	No.3.
Stature	1m80	1m77	1m82
Humerus	350mm	364	370
Ulna	270	295	282
Radius	260	275	297
Femur	525	522	535
Tibia	440	432	455

Calculating/

Calculating from the femora lengths the statures should be roughly 1,900, 1,880 and 1,940; from the tibia lengths 2000, 1960 and 2074. It is, therefore, obvious that in each case the length of the lower limb is markedly disproportionate to the total stature. This has been seen invariably to be the case in hyperanabolics. X-ray photographs showed the epiphyseal cartilages to be obliterated in all cases.

(1)  
OBSERVATION IV.

X., AGE 27, HEIGHT 1m86.

Previous History

The patient has suffered from many infectious diseases, among them measles, scarlet fever and mumps, which did not affect his growth. At the age of 16 he had an exceedingly severe and prolonged attack of typhoid fever and it was after this that he began to grow unusually rapidly.

Present Condition.

He looks taller than he really is on account of his slender build and thin legs. He is far from being well proportioned: his skeleton has not developed harmoniously./

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(1) Launois and Roy. Société de Biologie.

PLATE XXV.

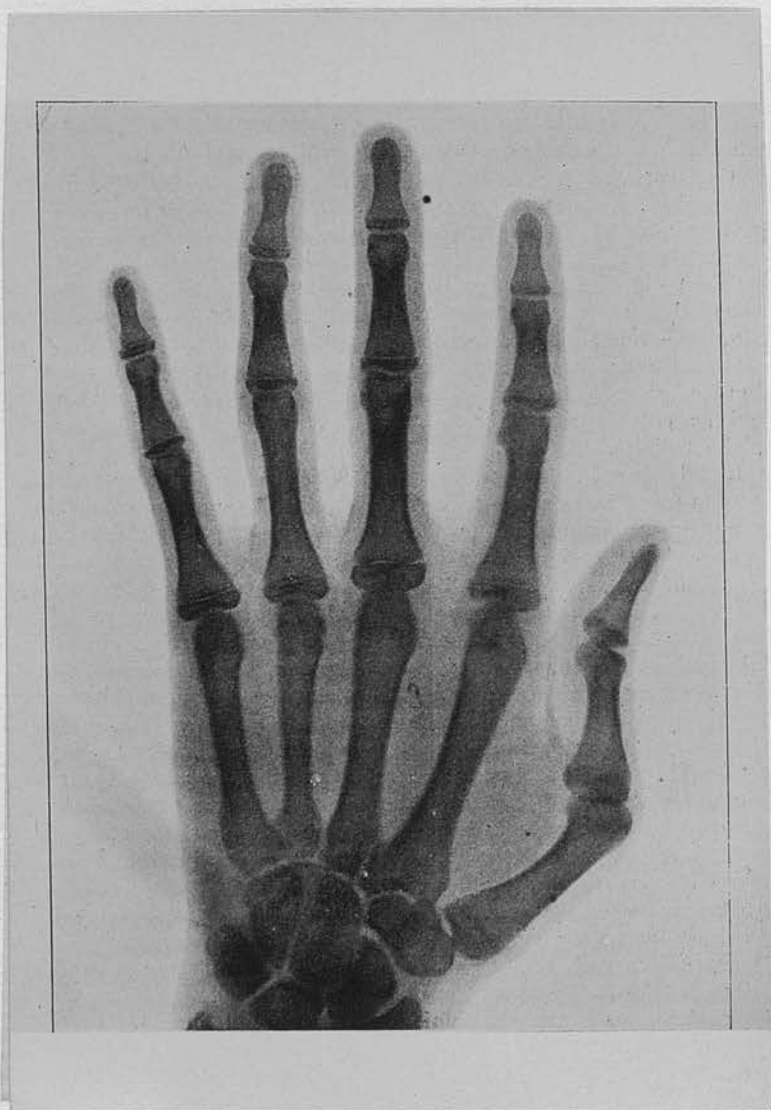


PLATE XXV.

Radiograph of the hand of an eunuchoid showing the persistence of the epiphyseal cartilages at the age of twenty-seven.

---After Launois and Roy.

harmoniously. The shortness of his height seated (Om87) relative to his stature (lm86) or to his span (lm90) shows that his height is especially due to the length of his legs. The height of the great trochanter is lm05; according to Quételet this measurement in a normally proportioned man of 25, lm682 in height should not be more than Om875. The same proportion for a stature of lm86 is Om96, so that there is in this case an excess of 90 millimetres.

The accompanying X-ray photograph shows that the epiphyseal cartilages are not yet obliterated.

In addition it should be noted that the face is glabrous, the chest small, the pelvis large, that the penis and the scrotum are rudimentary and that no testicles can be discovered. No rectal examination was made.

(1)

#### OBSERVATION V.

##### Description of the body of an Eunuchoid Man.

The point which I regard as of especial importance in this case is the age; my reasons for this will become apparent when I come to speak of the other forms/

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(1) Duckworth, "Notes on the Anatomy of an Eunuchoid Man." Jour. of Anatomy and Physiology. Oct 1906 p.30

forms of pathological giantism.

#### X. AGE 87

General External Features:--The body is obese, the hair of the head is white as is to be expected at the advanced age of the subject. The countenance is absolutely glabrous and no appearance of the epidermis gives any indication that the subject has ever shaved. The torso, in its lower parts, is remarkably feminine in appearance, but the breasts are not unusually developed.

The suprapubic fat is so abundant as to produce an eminence which simulates the mons veneris of the adult female. The pubic hair is scanty.

The penis and scrotum are extraordinarily diminutive: the former is not completely covered by the prepuce: it measures only 36mm in the retracted condition.

The scrotum is correspondingly small and the raphe inconspicuous. At first no testicles were detected, but subsequent examination revealed their presence in the scrotum. For details of their conformation v. infra.

The chief point of importance in connection with the limbs is the feminine feature of unusually short/

short forearm, the radio humeral index providing the very small and characteristically feminine value of 67.1.

The thighs are somewhat feminine in appearance, as the adipose deposit has masked the contours of the muscular masses. The following measurements were made:---

Stature	--	--	--	--	--	--	--	1717mm.
Span	--	--	--	--	--	--	--	1792mm.
Arm	--	--	--	--	--	--	--	359mm.
Forearm	--	--	--	--	--	--	--	241mm.
Trochanter to internal malleolus	--	--						458mm.
Tibia	--	--	--	--	--	--	--	440mm.

The spermatic cord is present on each side and is rather larger than usual owing to an abundant fatty deposit. Each cord appears to end blindly in the scrotum, but dissection reveals the presence of a small testicle on each side, the dimensions being approximately 17mm in height 14mm from before backwards and 7mm in width."

In addition, I should like to add, the photograph published by Duckworth shows that the pelvis is exceedingly wide, that the thighs are rather conical and/

and that there is a distinct suggestion of a tendency to a right sided genu valgum. The tibia length of 440 corresponds to a stature of about 2000.

## SECTION II. SOME OBSERVATIONS UPON THE GIANTISM OF UNCOMPLICATED TESTICULAR FAILURE.

It is unnecessary to insist upon the complete accordance of the foregoing clinical observations with the description of the eunuch given in Part I. In one sense these may be regarded as supporting the former and the undoubted femininity of body form which they all show lends support to my hypothesis that the growth of the long bones is dependent upon the existence of a condition of anabolic environment. Duckworth's insistence upon the resemblance which his case showed to the female type is particularly interesting as coming from a wholly independent observer.

The age attained by the old eunuchoid(87) shows conclusively that in that individual there was some mechanism in active operation which limited the amount of nutritive material made available for the body cells in early life, but which, as life progressed permitted an increase of that amount. Had this not been so and had the somatic cells in early life multiplied to such an extent that they required all the food absorbed by the/  
the/

the intestine for their maintenance, death must have supervened from starvation, for first as age increases it is probable that less food is absorbed from the intestine and second it is certain that the absorptive power of the cells diminishes.

Physiologically, then, it is possible to say that the functional removal of the testicles does not in any way interfere with the efficient working of the exogenous metabolism. This is an important consideration.

Further consideration of this group of hyperanabolics is deferred until it is possible to compare the peculiarities of their growth and body form with those of the remaining types of pathological giants.