TWINS AS A NATURAL TEST OF CHRONOGENETICS

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Monozygotic twins are the best witnesses of the existence of a hereditary biological time, because they would not be identical if they had not also inherited the times of appearance and duration of their common hereditary information. The authors gave the name "chronogenetics" to this branch of genetics which concerns the temporal dimension of the gene and the mechanisms of transmission and manifestation of the temporal characteristics. The "Ergon/Chronon System" is suggested as a model to explain chronological heredity in terms of molecular genetics.
An example is offered of a chronogenetic analysis of puberty based on the study of puberty times in 157 female and 154 male twin pairs. This shows the hereditary conditioning of numerous chronogenetic parameters, the extrapolation of conclusions concerning the phenomenon of puberty, and the establishment, in this regard, of a borderline between hereditary and physical times.
A picture is finally drawn exemplifying Normal Hereditary Times (gametic, auxologic, homeostatic, and old-age recession times) and Pathological Hereditary Times (auxologic, cardiovascular, neoplastic, immunitary, metabolic, and antitoxic pathology times).
Provisional chronogenetic developments are indicated, and a possible advancement toward the recycling of the gene is hoped for.

What are twins? In our present intention, they are the witnesses of the biological times that each man lives, and of the hereditary origin of these times.

The evidence given by twins is a natural and absolute proof that heredity controls biological time, because only in this way can MZ twins be identical at different ages. They are the living proof that heredity contains that which permits it to prophecy the maximum time that genic information will last.

MZ twins, with their between-pair variability in the same environment, and the synchronization wich exists in one twin in respect to his cotwin, show, first, the relative independence of biological time from physical time; second, that biological time is distributed in a variability which concerns each single hereditary unit: the gene.

Figs. 1 and 2 show the MZ quadruplets of Wroclaw, Poland, and their developmental curves as compared to those of nonrelated boys from the same age group and environment. The concordance in the developmental times of the quadruplets is very striking.

Therefore, the study of twins allows us to affirm not only the existence of an authentic and basic biological time, but also the existence of a time for each individual gene, to which we gave, in 1964, the name *chronon.*

This name was then also used by Ehret and Trucco (1967) to indicate a circadian clock composed of a polycystronic complex, thus making it apply to a different subject. They

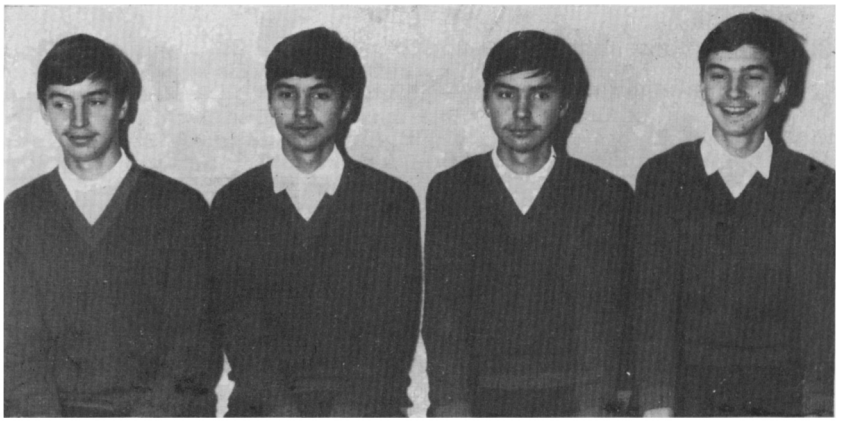

Fig. 1. The Wroclaw quadruplets. (*After Nowakowski 1972*).

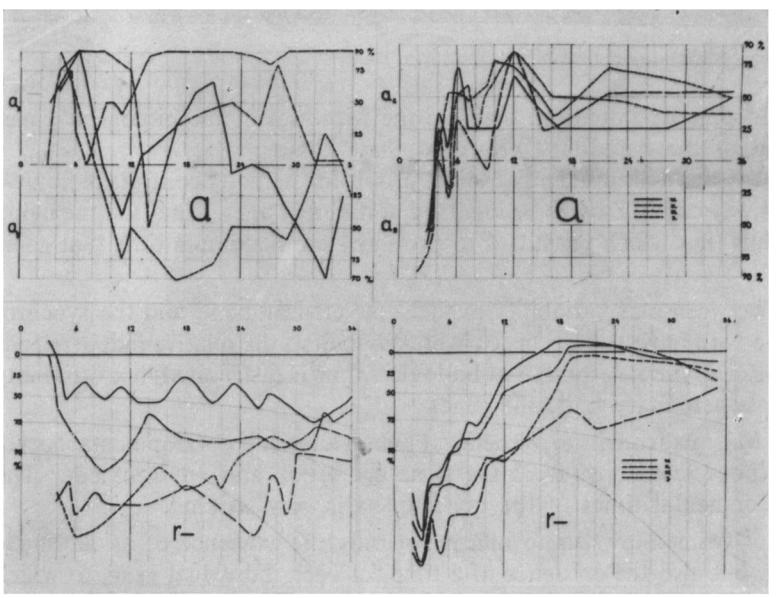

Fig. 2. Developmental curves (according to the Wroclaw method, s. Bartkowiak et al. 1958) of Wroclaw quadruplets (left) as compared to those of four random boys from the same age group and environment. (*After Nowakowski 1972*).

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evidently were not aware of our prior use of the name chronon, nor of its meaning, i.e., the temporal dimension of the gene.

Furthermore, we called this study *chronogenetics*, because it deals with the consideration of time in the hereditary *continuum*, and we included chronogenetics in the subjects to be discussed at the First International Congress of Twin Studies. We believe that, in this way,

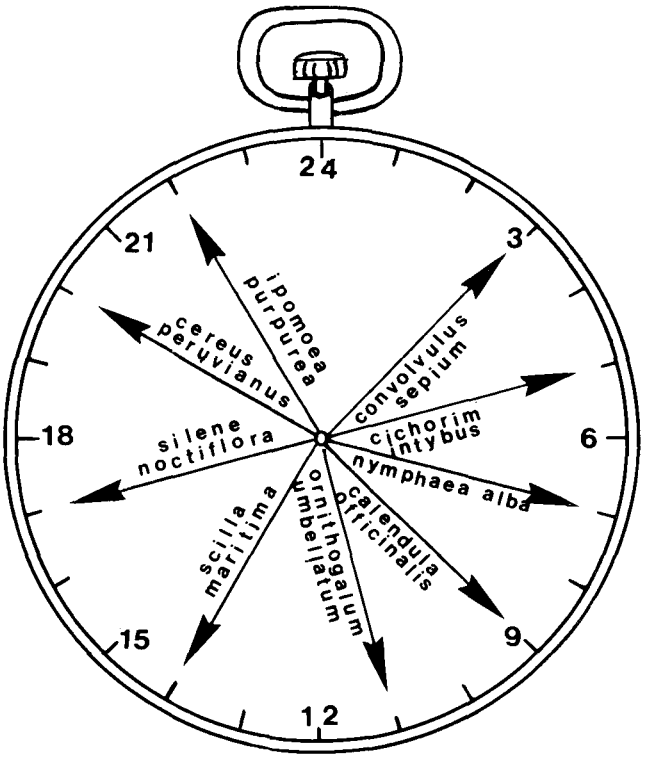

Fig. 3. Linnaeus's «flowers' clock». (Authors' original drawing).

gemellologists may realize that they are the natural investigators of a new branch of human genetics concerning the heredity of biological time.

The existence of particular biological times is clear, and MZ twins prove it strikingly in the human species. However, even beyond this, in the entire field of plant and animal life, the existence of autonomic and genetic time is likewise evident. In fact, each species preserves and transmits certain characteristic times of average lifespan and biological recurrences which these concern. Linnaeus's "flowers' clock" is an ancient phenomenon of plant chronogenetics: flowers of different species respectively and regularly open their petals at different hours of the day. This also shows that the biological time of each species follows an external rhythm, since this is due to a circadian rhythm connected with the sun.

Linnaeus's flowers' clock represents an area of interaction between the biological time determined by environment and the biological time determined by heredity. We stand on the border between chronobiology and chronogenetics. The former concerns the times the phenotype receives from outside, and especially the rhythms. The latter concerns the genotype as a

point of departure for biological time, expressed by specific hours of opening of the petals and the length of time they remain open.

We wish to thank Prof. Reinberg, who in this Round Table will bring us up to date on chronobiology, with special reference to the areas where chronobiology and chronogenetics study the same phenomena, but from different points of view.

The model we suggested as a key to chronogenetics regards not only the chronon, but also and firstly the degree of initial stability of the gene which determines the chronon as lifespan of the gene.

The duration potentiality of the gene in time corresponds to its initial status conditions, which the gene receives from a parental gamete. This stability depends, in its turn, on certain components whose principles we have pointed out, such as *synonymy*, *redundance* and *repair*.

Synonymy is caused by the fact that some triplets can codify a single aminoacid and therefore thay are called " synonyms ". For this reason, there is the possibility of a higher or lower number of H-bonds present in DNA molecules which codify the same information. For example, the aminoacid arginine can be codified by six different synonyms; hence, an information which contains arginine disposes in two cases of nine H-bonds, in three cases of eight H-bonds, and in one case of seven H-bonds.

Watson himself posed the problem of the significance of this variability in the number of H-bonds based on the AT/GC rate, to which he replied by saying that this variability does not necessarily have a phylogenetic meaning. We also believe that H-bonds are a stabilizing factor of the molecule, and therefore a greater number of bonds produces not only a greater stability, but also a greater lifespan of the information. This statement of ours coincides with the results of experiments on DNA denaturation, which show that the DNA is just as stable as it is rich in GC bases, i.e., H-bonds (see Fig. 4).

We have identified the second stability coefficient in the number of repetitions possessed by the gene. The number of efficient repetitions may be different for the same information from individual to individual. The concept of redundance has exact reference to the number of repetitions, and we maintain that stability of information depends significantly upon the number of repetitions, i.e., upon redundance.

Finally, we think that the gene's stability depends on the interaction between the structure of information and the quantity and efficiency of the enzymes employed in the repair of damages the genes might receive from the external or internal environment, such as exonuclease, endonuclease, ligase and DNA polymerase.

Since this deals with not only a single stability coefficient but at least three, we had to consider the result of this functional pluralism which guarantees stability, and we gave the name *ergon* to the group of positive conditions upon which the chronon depends, i.e., synonymy, redundance and repair.

The definition of stability conditions makes it possible to establish in a single model the stability and the average lifespan of the gene. We have called this model *Ergon/Chronon System*, and we maintain that, when the ergon or stability is greater, the chronon or average lifespan is longer, and viceversa.

A synthesis of our idea of the structure of the E/C System is shown in Fig. 5.

We are using the Cartesian coordinates to represent the temporal dimension of a gene: the X on the ordinate represents the value corresponding to the stability of the information of that gene produced by the number of H-bonds resulting from the A/T and G/C relationship in the segment of molecule under consideration; the S on the abscissa marks a segment cor-

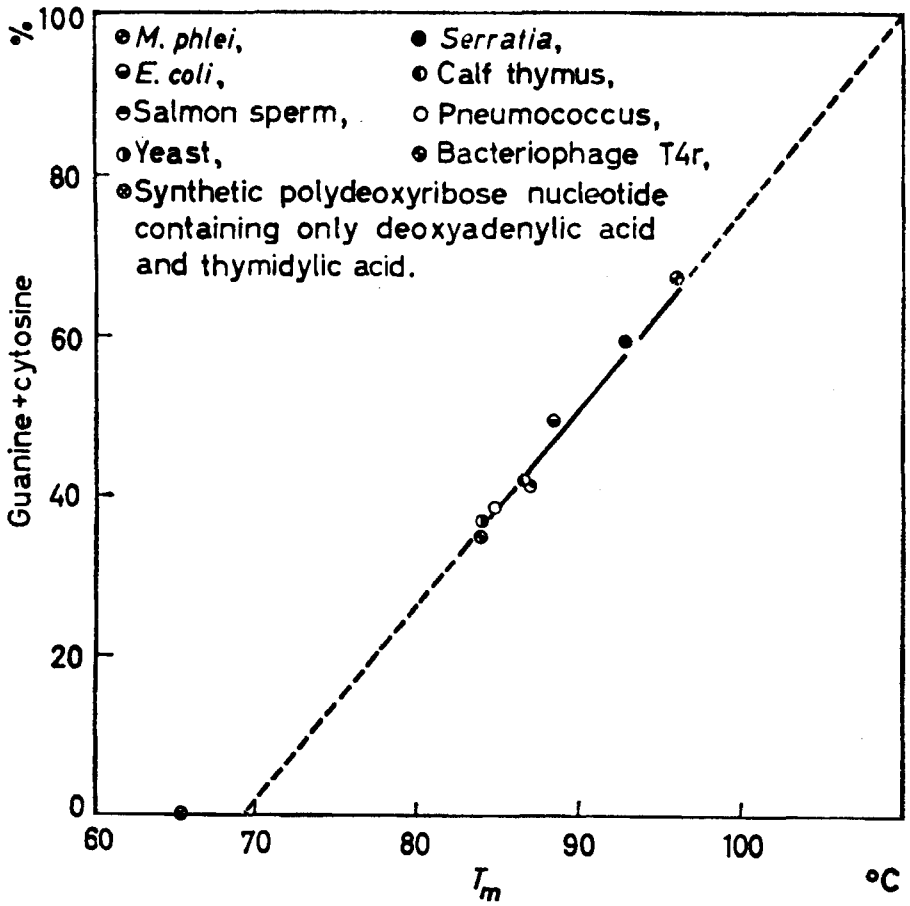

Fig. 4. DNA stability and G-C bases. (*After Marmur and Doty 1959*).

responding to the one on the ordinate, and represents the Synonymy Chronon, i.e., the lifespan of the average information due to this stability factor. The curve that joins these two points encompasses an area which represents the Synonymy, or S Ergon (Fig. 5*a*).

Next (Fig. 5*b*), we mark with the letter R on the abscissa the average lifespan of information caused by the repetitions of the same gene, i.e., the Redundance Chronon, and we draw a second curve that connects point X to point R. The area encompassed between the first curve and the second represents the ergon resulting from the number of repetitions (Redundance, or R Ergon).

Finally (Fig. 5*c*), we mark with an r on the abscissa the degree of efficiency of the repair enzymes for the information under consideration, i.e., the average lifespan of the information obtained from the repair, that is, the Repair Chronon, and we draw a third curve which connects X with point r. The area encompassed between the second curve and the third represents the ergon resulting from the efficiency of repair for the gene under consideration (Repair, or r Ergon).

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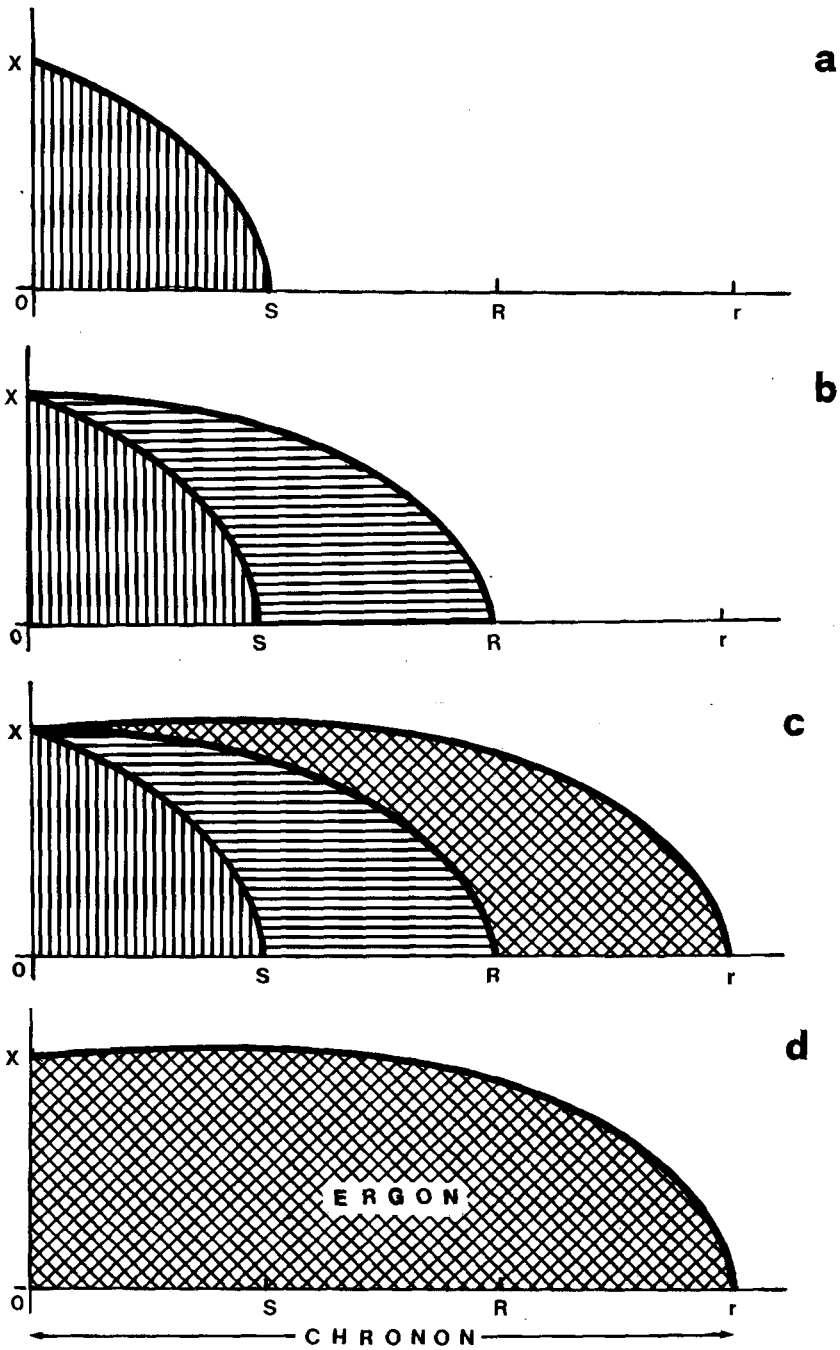

Fig. 5

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Representing in this way the factorial analysis of the ergon, we may conclude by observing that the area encompassed by the most external curve, embracing the lesser areas encompassed by the other curves, represents the entire ergon, while the segment of the abscissa between time 0 and the furthest point of the repair chronon represents the entire chronon, i.e., the average lifespan of the specific information furnished by the gene.

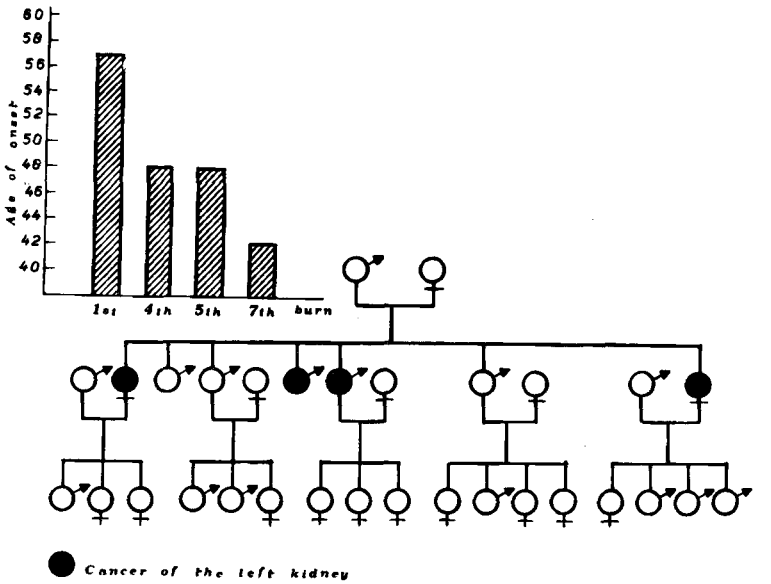

Fig. 6

Let us examine a concrete case. We are offered this occasion by a family described by two groups of French colleagues (Bernades et al. 1972, Valleteau de Moulliac et al. 1974).

This deals with a family case of kidney cancer which strikes four out of a sibship of seven children (Fig. 6): the four affected children died from cancer of the left kidney, whereas the other three are in good health. If we were to interpret this case on the basis of Mendelian models, we could refer to dominant heredity, because the probability of this model is at least five times greater than that of a recessive one. However, we are particularly interested in emphasizing the years of birth of the affected subjects: 1915, 1922, 1922, 1926. Now, let us note their years of death: 1973, 1972, 1971, 1971, and their age at death: 58, 50, 49, and 45.

We do not want to take a position concerning the mechanism responsible for kidney cancer, even though we believe it to be due to a family deficiency of the immune defense system. We limit ourselves to observing that (1) the efficiency of the defense system, whether of an immune nature of or a different kind, depends on a specific genotype; and (2) the efficiency of the specific antitumoral genotype shows itself to be precarious in four children, and this precariousness is not equal in them but in inverse proportion to the order of birth — that is to say, the later the child is conceived, the more deficient the defensive genotype is.

Since the complex of genes is stored in the maternal gonads from the first moment of organogenesis, remaining there up to the moment of readiness of the fertilizable ovum, we could think that the damaged gene had undergone a progressive deterioration, so that the gene transmitted to the first born was the carrier of damage +; the one transmitted to the

fourth, of damage ++; the one transmitted to the fifth, of damage +++; and the one transmitted to the seventh, of damage ++++.

Only in this way, can we explain the appearance of the hereditary disease at an age inversely proportional to the order of birth; i.e., with a quicker linear progression the later the conception took place.

An analogous family case of Fabry's disease was described by Franceschetti and commented on by us (1973) from a chronogenetic point of view. In this case, a female carrier of Fabry's disease had a total of 15 conceptions, 5 of whom had the disease. The progression of onset in time was the following in order of birth: the first affected was 20 years old, the second was 12, the third was 11, the forth was 9 and the fifth was 5.

From the chronogenetic point of view, it is important to note the significance of other observations which could have the same interpretation.

First of all, we mention the clear correlation between the increase in maternal age and the frequency of stillborn and congenitally malformed children that we ourselves have documented (Gedda 1966).

Furthermore, we point out the well-known influence of late maternal age on the etiology of Down's syndrome and all the trisomic anomalies (Tumba 1974) which, others, because of mongolism, extend also to late paternal age (Rundle et al. 1974). The influence of late paternal age was indicated as a cause of Marfan's syndrome (Lynas 1958, Murdock et al. 1972, Smith 1972), of fibrodysplasia ossificans progressiva (Tünte et al. 1947). Recently, Erickson and Cohen (1974), as previously Blank (1960), demonstrated the influence of advanced paternal age on the production of fresh mutations for Apert syndrome, which they refer to the probability of error in cell divisions in the male germ line, which occurs with greater frequency the older the person is. This, however, does not explain the true cause of this phenomenon, since the very high number of male gametes permits a good selection when the mutation is sporadic. In our opinion, the manifestation of damage related to the aging of the father is due to the progressive exhaustion of stability of a specific gene in all the gametes produced. This prevents the selective mechanism from functioning.

For some time, it has been known that men of science are much more frequently first-born. Recently, Belmont and Marolla (1973), of the New York City Department of Mental Hygiene, analyzed the results of four hundred thousand mental tests given in medical examination prior to induction into the army of boys born in Holland in 1947. It showed that first-born boys have a higher average quotient than second-born, and the latter, in *their* turn, higher than third-born. This fact holds true whether there are three or five children in the family. The conclusions are the same for all social levels. Belmont and Marolla insist on giving no explanation for the facts they observed and exclude any hereditary influence. Obviously, interpretation of these data was not easy up to now, but on the basis of chronogenetic principles it becomes possible. The genic ergon weakens as time passes, and, therefore, the genic information for later conceptions is less efficient than that of earlier conceptions. This could also concern the heredity of mental faculties.

We quoted the fundamental parameters of chronogenetics, and we will come back shortly to the other general problems, because now we would like to examplify how the study of twins can be a method of research for the study of chronogenetics. To show this, we will now relate the results of a study on the chronogenetics of female and male puberty that we did on the Register of the Mendel Institute in Rome.

With respect to female puberty, we studied the age of menarche, the length of the period

and the length of intermenstruation in the year of menarche, in 76 MZ and 81 DZ pairs, and in their respective mothers. The results concerning the age of menarche are shown in Table 1.

The figures obtained correspond to the averages in the general population even as to the fact that the age of menarche in the present generation occurs a year earlier than in the previous one. This deals with chronological values (years), which we considered for purposes

TABLE 1
AGE OF MENARCHE
(years)

MZ pairs (N = 71)			DZ pairs (N = 81)		
Twin A	Twin B	Mother (M)	Twin A	Twin B	Mother (M)
12.52 ± 1.28	12.44 ± 1.23	13.06 ± 1.67	12.49 ± 1.95	12.37 ± 1.89	13.33 ± 2.22
	r			*r*	
	A × B = 0.887			A × B = 0.670	
	A × M = 0.463			A × M = 0.351	
	B × M = 0.520			B × M = 0.267	
		H = 79.5 ± 4.6			

of analysis as quantitative characters. The correlation of MZ twins approaches unity (0.887) and is greater than that of DZ twins (0.660). The correlation between each female twin and her mother is about half of the correlation between twins. Holzinger's index reports a hereditary determination of the time of menarche which is close to 80%. These results are exactly what we could expect from Mendelian hereditary characters.

The results concerning the duration of menstruation, or days of flow (Table 2), offer prime chronogenetic data which were completely unexpected, consisting of a longer duration

TABLE 2
DURATION OF MENSTRUATION
(days)

MZ pairs (N = 76)			DZ pairs (N = 81)		
Twin A	Twin B	Mother (M)	Twin A	Twin B	Mother (M)
5.03 ± 2.36	4.91 ± 2.08	5.34 ± 4.75	4.70 ± 1.81	4.69 ± 1.89	4.26 ± 1.59
	r			*r*	
	A × B = 0.845			A × B = 0.668	
	A × M = 0.224			A × M = 0.224	
	B × M = 0.241			B × M = 0.421	
		H = 69.7 ± 4.6			

of flow in MZ twins and their mothers (average 5 days) than in DZ twins and their mothers (average 4.5 days). This disparity has no connection with twinning, since it also refers to mothers, who are not twins; this has a genealogical, familial significance. Here, too, the experimental values lived up to expectations in the hypothesis of Mendelian heredity because the correlation index between MZ is close to unity and higher than that of the DZ; both are higher than those between twins and mothers. The H index approaches 70%.

The data concerning the intermenstrual period (Table 3) were the most difficult to obtain;

TABLE 3

DURATION OF INTERMENSTRUAL PERIOD

(days)

MZ pairs (N = 76)			DZ pairs (N = 81)		
Twin A	Twin B	Mother (M)	Twin A	Twin B	Mother (M)
28.41 ± 6.94	28.18 ± 6.40	28.83 ± 7.85	27.46 ± 7.06	28.49 ± 7.83	27.53 ± 4.09
	r A × B = 0.574			r A × B = 0.264	
	A × M = 0.284			A × M = 0.312	
	B × M = 0.304			B × M = 0.351	
		H = 59.2 ± 5.3			

hence, they are more scattered and further away from the expected values, but nonetheless on the order foreseen, with an H index of about 60%.

What is more, in order to establish a comparison between female and male puberty, we had recourse to a secondary sexual character: the age at which height growth stops (Table 4).

TABLE 4

AGE OF HEIGHT INCREASE ARREST

(years)

Males				Females			
MZ pairs (N = 74)		DZ pairs (N = 80)		MZ pairs (N = 72)		DZ pairs (N = 79)	
Twin A	Twin B	Twin A	Twin B	Twin A	Twin B	Twin A	Twin B
18.85±2.21	19.00±2.49	18.46±1.73	18.92±3.89	18.93±2.19	18.90±2.13	18.47±1.75	18.57±1.96
r A × B = 0.804		r A × B = 0.384		r A × B = 0.919		r A × B = 0.381	
H = 81 ± 3				H = 92 ± 5			

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These data on males and females correspond not only to the average age and the disparity forecast between r values of MZ and DZ twins of the two sexes, but the high value of the H index as well.

From this example of chronogenetic analysis it appears that the following can be concluded:

(1) The examined temporal characters behave like qualitative and quantitative characters with respect to Mendel's laws of heredity; therefore, they are chronogenetic characters.

(2) The chronogenetic characters of male and female puberty prove a hereditary dependence in the following decreasing order: arrest of height growth, age of menarche, period of flow, duration of intermestrual time.

(3) The chronogenetic characters of the period prove the existence of an average value significantly greater in the families of MZ than in those of DZ female twins.

We have also studied our data with the method of canonical analysis which tends to curtail the variability of each parameter in order to evidence the covariance common to the parameters considered. We studied this covariance on three chronogenetic characters of 74 MZ and 80 DZ pairs, all of them male, as well as on three chronogenetic characters of 76 MZ and 81 female DZ pairs.

The results (Table 5) show a very high correlation for the MZ as well as for the DZ male

TABLE 5

ANALYSIS OF CANONICAL CORRELATIONS

Males		Females	
MZ pairs (N = 74)	DZ pairs (N = 80)	MZ pairs (N = 76)	DZ pairs (N = 81)
$r = 0.983$	$r = 0.935$	$r = 0.889$	$r = 0.718$
$H = 86 \pm 8$		$H = 76 \pm 5$	

pairs, with a heredity index of 86%. The female puberty characters also show a very high correlation in both MZ and DZ pairs, with a heredity index of 76%. The extremely high canonical covariance of DZ pairs is surprising.

With regard to this simultaneous activation, we believe that the concordance between MZ and DZ is higher than that of single children, hence it is erroneous to consider the DZ as "fraternal twins".

The research on puberty is an example of chronogenetic analysis utilized to understand man's temporal structure.

Every normal and pathological phenomenon can be studied from the chronogenetic point of view in order that it be known, interpreted, forecast and treated.

Twins represent an invaluable method for chronogenetics, but chronogenetics is not limited to twins because it extends to all sectors of human and medical genetics — much greater, to all sectors of physiology and pathology.

As geneticists, we say there is no study of healthy or ill persons in which a genealogical tree is not made. As chronogeneticists, we say there is no genealogical tree which does not

show the individual year of birth, the year of the appearance of hereditary disease and, if necessary, the year of death.

Looking to the future, we believe that it could be helpful to set up a perspective of biological times, which is not a catalogue but an exemplifying picture of the order in which the subject can be faced.

Biological times can be classified as normal and pathologic times; each one can be divided into groups.

NORMAL TIMES

Gametic Times

These are times which begin in the embryo when cloning of the germ line takes place, guiding it before and after meiosis up to the menopause of the man or woman produced by that embryo. These are individual times measured on an average by the species-specific times which determine, among other things, on the occasion of amphimixis, the potential span of the individual life. They are punctual and lasting times, greatly conditioned, especially for the female gamete, by rhythms of physical time.

Auxologic Times

These are times especially numerous in the first phases of ontogenesis, and represent a continuous chain by means of which the organism reaches the standard of the species and the time of reproduction. Auxologic times are of input, duration and output.

Homeostatic Times

This concerns the times of the mechanisms which have the function of preserving the ontogenetic levels already reached, with respect to change of internal or external environment. Homeostatic times are of input, duration and output; since they can be repeated, they could present some variability in the same individual. The reaction and chronaxy times also belong to this group.

Old-Age Recession Times

These are times which mark the disappearance of phenotypic structures and functions because of the recession of information caused by the exhaustion of the corresponding genic ergon. These recession times are times of definite end of information, and for this reason they are individual times and draw the individual profile of aging.

PATHOLOGIC TIMES

From the chronogenetics point of view, hereditary diseases are caused by greatly anticipated and genetically conditioned recession of specific information. Therefore, hereditary diseases are characterized by punctual times of exhaustion of the E/C System of the corresponding genotypes.

Secondarily, other hereditary times can be singled out marking the steps of disease,

corresponding to the concepts of phenogenesis and pathogenesis. The groups we will indicate are merely example and are understood to describe from the chronogenetic point of view the principal causes of nonaccidental death indicated by the W.H.O.

Auxologic Pathology Times

These are times marked by pathologic recession of information affecting development; they correspond to genotypes responsible for malformations on different levels of pre- and postnatal ontogenesis.

Cardiovascular Pathology Times

These are times marked by the recession of information necessary for the integrity of the vascular wall, which could fail in certain sectors of circulation, such as heart, brain, kidney, or everywhere, as in the case of generalized arteriosclerosis.

Neoplastic Pathology Times

These are times marked by the pathologic recession of information necessary to the selection of anomalous mitosis in differentiated cellular clones.

Immune Pathology Times

These are times of pathologic recession of HLA and analogous information. They cause arrest in the production of antiinfective or antinonself antibody. They characterize the hereditary disposition to contract autoaggressive, infectious, allergic diseases, etc.

Metabolic Pathology Times

These are times marked by the pathologic recession of information necessary to the catabolic processes; from these, come metabolic diseases, such as diabetes, gout, thesaurismoses.

Antitoxic Pathology Times

These are times marked by the pathologic recession of information necessary to defend the organism against exogenous poisons (alcohol, drugs, occupational and food poisoning). This recession is responsible for hereditary diseases such as cirrhosis, nicotine poisoning, idiosyncrasies.

This catalogue of normal and pathologic times is tremendously incomplete, even though it is limited to the human species.

Each time offered by life could be analyzed in accordance with genetic methodology, e.g., through twin tests as we have done for puberty, or else through Mendelian tests. We did this in connection with the age of onset in psoriasis, and Prof. Cavalieri will report on it during this Round Table.

But we believe it useful to know in advance that the values of onset time analyzed through a correlation index between parent and child, brother and mother, uncle and nephew, correspond to expected values for these relationships in Mendelian heredity for an autosomal diallelic genotype.

From another point of view, we maintain that the figures recently published by the American Statisical Bulletin (1974) are very significant. They report the survival rate of people with cancer of the stomach, colon, rectum, lungs and bronchi, prostate, kidney, bladder, and with melanoma. Survival is calculated in years after the time of diagnosis. The tables show a survival variability according to the type of tumor, but also according to the age at which the

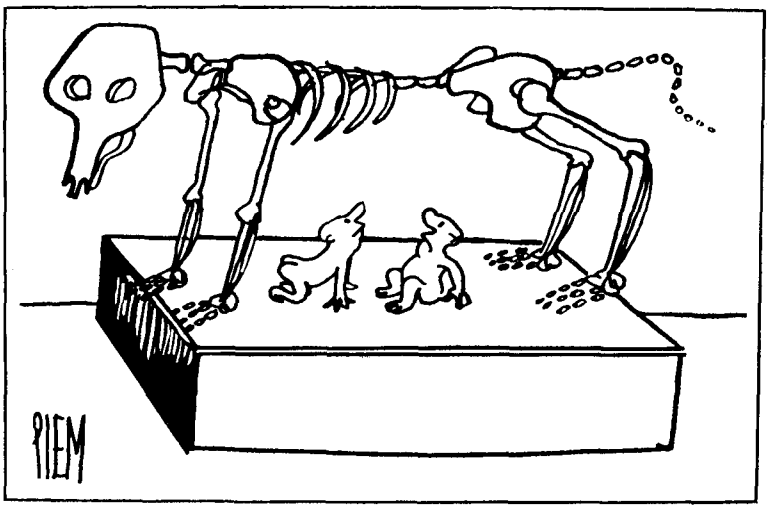

Fig. 7. (*After "Le Figaro"*).

diagnosis was made, i.e., the lifespan is relatively shorter, the greater the age. This agrees with the decay of the ergon of *quoad vitam* genotypes according to the age forecast by our model.

In this regard, it is interesting to note a recent observation made by Aksoy et al. (1974) regarding two cases of acute leukemia in two members of the same family (uncle and nephew) following occupational exposure to benzene. It is striking that even though the length of time of exposure to benzene was different, the time elapsing from the beginning of exposure to the manifestation of the disease was six years for both of them.

Our conception based on the degree of efficiency of the gene is a dynamic conception of the life of hereditary information. In its development, it leads to the facing of many problems of application, which, for the time being, can be considered only from the theoretical point of view, as the mathematicians Rossi and Bellacicco will do in this Round Table. These are problems of monitoring, forecasting, prognosis.

One could also foresee some problems concerning the prevention and treatment of hereditary diseases which consist of the plan of the recycling of deficient genes. We are still far away from this goal, which we can only hope to reach (for the times of senility as for those of individual hereditary diseases). According to the principles of chronogenetics, recycling concerns the ergon of the individual gene. The clinical twin method can be an excellent way to lead us to this goal.

To get back to twins as an ideal test for the study of chronogenetics in man, we would like to show a cartoon with which the newspaper *Figaro* a few months ago represented Italy's economic situation (Fig. 7). Even in Italian, we call it " austerity ". We will not comment

on the good-humored malice of this drawing. Instead, we will supply a caption for the dialogue which could have taken place between Romulus and Remus. It is as if they said, " Enough of this nursing! We can do it ourselves by setting up a new field of genetics: chronogenetics ".

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RIASSUNTO

I Gemelli come Esperimento Naturale di Cronogenetica

I gemelli MZ sono i migliori testimoni dell'esistenza di un tempo biologico ereditario in quanto essi non sarebbero identici se non avessero anche ereditato i tempi di comparsa e di durata della loro comune informazione ereditaria.

Gli autori hanno dato il nome di « cronogenetica » a questo ramo della genetica che riguarda la dimensione temporale del gene ed i meccanismi di trasmissione e manifestazione delle caratteristiche temporali. Il « Sistema Ergon/Chronon » viene suggerito come modello per spiegare l'eredità cronogenetica in termini di genetica molecolare.

Viene offerto un esempio di analisi cronogenetica mediante lo studio dei tempi dello sviluppo puberale in 157 coppie gemellari femminili e 154 maschili, mediante cui si dimostra il condizionamento ereditario di numerosi

parametri cronogenetici, l'estrapolazione di conclusioni riguardanti il fenomeno della pubertà e lo stabilimento a tale proposito di una linea divisoria fra tempi ereditari e tempo fisico.
Viene infine tracciato un quadro in cui si esemplificano tempi ereditari normali (tempi gametici, auxologici, omeostatici e dell'invecchiamento) e tempi ereditari patologici (tempi di patologia auxologica, cardiovascolare, neoplastica, immunitaria, metabolica ed antitossica).
Vengono indicati gli sviluppi provvisori della cronogenetica e la possibilità di progressi riguardanti il riciclaggio dei geni.

RÉSUMÉ

Les Jumeaux comme Expérience Naturelle de Chronogénétique

Les jumeaux MZ sont les meilleurs témoignages de l'existence d'un temps biologique héréditaire, car ils ne seraient pas identiques s'ils n'avaient hérité des temps d'apparition et de durée de leur commune information héréditaire.
Le auteurs ont donné le nom de « chronogénétique » à cette branche de la génétique qui s'intéresse à la dimension temporelle du gène et aux mécanismes de transmission et de manifestation des caractéristiques temporelles. Le « Système Ergon/Chronon » est proposé comme modèle pour expliquer l'hérédité chronogénétique en termes de génétique moléculaire.
On offre un exemple d'analyse chronogénétique au moyen de l'étude des temps du développement pubéral dans 157 couples géméllaires féminins et 154 masculins, par lesquels on démontre le conditionnement héréditaire de nombreux paramètres chronogénétiques, l'extrapolation de conclusions relatives au phénomène de la puberté et à l'établissement à ce propos d'une ligne divisoire entre temps héréditaires et temps physique.
On trace enfin un tableau dans lequel les temps héréditaires normaux (temps gamétiques, auxologiques, homéostatiques et du vieillissement) et les temps héréditaires pathologiques (temps de pathologie auxologique, cardiovasculaire, néoplastique, immunitaire, métabolique et antitoxique) sont révélés par des exemples.
On indique les développements provisoires de la chronogénétique et la possibilité de progrès relatifs au recyclage des gènes.

ZUSAMMENFASSUNG

Zwillinge als natürliches Experiment der Chronogenetik

Die besten Zeugen für die Existenz eines biologischen Erbtempos sind die EZ, denn hätten sie nicht eben die Tempi für das Auftreten und die Dauer der gemeinsamen Erbinformation geerbt, so wären sie nicht identisch.
Dieser Zweig der Genetik, der sich mit der temporalen Dimension des Gens und den Uebertragungs und Manifestationsmechanisme der zeitgebundenen Merkmale befasst, wird von Verf. als « Chronogenetik » bezeichnet. Um die chronogenetische Vererbung mit molekelgenetischen Ausdrücken zu erklären, wird das « Ergon/Chronon-System » als Modell vorgeschlagen.
Als Beispiel wurden 157 weibl. und 154 männl. Zwillingspaare chronogenetisch analysiert, um die Tempi der Puberalentwicklung zu untersuchen. Daraus ergibt sich, dass verschiedene chronogenetische Parameter erbbedingt sind, dass sich die Schlussfolgerungen über das Phänomen dFr Pubertät hinaus extrapolieren lassen und es möglich ist, diesbezüglich eine Trennungslinie zwischen Erbtempo und physischem Tempo zu ziehen.
Schliesslich geben Verfasser eine Uebersicht einerseits über die normalen Erbtempi (bezogen auf Gameten, Wachstum, Homöostase, Altersprozess) und andererseits über die pathologischen Erbtempi (bezogen auf pathologisches Wachstum, Herz-Gefässerkrankungen, Neoplasien, Stoffwechsel- und antitoxische Immunität).
Es folgen Hinweise auf die provisorischen Entwicklungen der Chronogenetik sowie auf die möglichen Fortschritte im Hinblick auf den Wiederzyklierungsprozess der Gene.

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ERRATA CORRIGE

In a previous paper by Gedda and Brenci, "Chronogenetics — Its Foundations, Scope, and Impact" (Acta Genet. Med. Gemellol. 22: 3-17), in the Table on page 7 the columns under "Bloom time" have been inverted: columns (2) and (3) are actually referred to the parental species [(1) and (2)], and column (1) to the hybrid [(3)]. As indicated in the text, in fact, with respect to pure parental varieties [(1) and (2)] hybrids [(3)] exhibited intermediate bloom times.

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