# WORKING PAPER

ACTION CURVES AND CLOCK-
WORK GENIUSES

C. Marchetti

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WP-85-74

IIASA
International Institute
for Applied Systems Analysis

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RESUME

Earlier analyses of the generation and spread of innovation led me to look into the generator and scatterer, man.

Applying the same analytic techniques as are used for examining societal structures, I found that man is highly ordered and regulated. His output therefore can be simply described and, to an extent, predicted. This generalizes the principle that the biological paradigm can be extended to social behavior.

ACTION CURVES AND CLOCKWORK GENIUSES

> Tu ne quaesieris, scire nefas,
> Quem mihi quem tibi
> Finem dii dederint, Leuconoe, nec Babylonios
> Temptaris numeros.
>
> Horace Odes, Book I, Ode xi

Fate and destiny are crosscultural elements in philosophy, religion, and art, perhaps reaching the highest emotional and intellectual intensity in Greek tragedy and their most subtle expression in Calvinist theology.

Man perceives external forces, endowed with an internal logic, that frame his actions, feelings, and thoughts in an unbreakable, if not visible, cage. Surely it would be strange if such a general perception did not correspond to some objective fact.

That the society around us frames our actions is a trivial observation. However, from my socioeconomic analyses (e.g. 1, 2,3) I conclude that this frame is quantitative. The underlying logic is hard. Although expressed at the collective level, it may yet be able to accommodate the individual. As Greek tragedy and Calvinist theology focus on the individual, I therefore confined my analysis to the individual, to determine whether there is a strict logic operating there.

Certainly logic abounds as long as we remain within the biological realm. The more we know about genetics, the more we can observe its pervasive and steely control. It might even clock the day of our death. The evidence is indeed mounting ( 4 ). Intellectual activity is a good example. Although patterns have been sought and found ( 5 ), basically they have not gone beyond the level of qualitative descriptions. Youngsters are naive and oldsters are tired, so that activities such as sports and writing books must go up and down with age.

I sought to harden the analysis. As usual, I started with facts, hard and proven. And, as usual, I searched exclusively for patterns, avoiding as much as possible the fly paper of explanations.

For appropriate documentation, I concentrated on persons whose actions have been appreciated, studied, and classified: artists and scientists provided a good start. I assumed that a piece of art or science is the final expression of a *pulse of action*, which started in some obscure part of the brain and worked its way through all the intermediate steps. This led me to study the time patterns of these pulses. In my heuristic mental image actions are transcodifications of information structures. This relationship is true at the biological level, where information is processed in the DNA, as well as at the personal or social level, where the coding has a different substrate but the same basic processing rules apply ( 6 ).

One of the consequences of this mental image is the assemblage of pulses of action into growth processes. Integrating these over time, I found that the growth function is in fact the temporal organizer of these processes. The curves presuppose a final target (a "niche") and a rate, which in biology is directly proportional to the product of the level reached (i.e. the current size of a population) and the part yet to be bridged (i.e. the unfilled niche) to meet the target. As competition, for example, can keep one from reaching this final target, I chose to call this target a virtual or, better yet, a *perceived target*. This is a constant in the growth equation and remains so throughout the entire growth period.

I have applied these concepts to analyses of a disparate array of socioeconomic structures, classifying the growth of populations such as railway networks (with the inauguration of the first line taken as the birth date) ( 2 ), automobiles ( 3 ), and clusters of innovations ( 1 ). Application to individuals comes automatically, provided that one takes the backward step of assuming that information is processed essentially at the individual level, as in society as a whole. Anyway, the reasoning is heuristic. The results will tell whether we are on the right path.

The analytic results for a selection of outstanding personalities from science, music, and the visual arts are given in Figures 1 to 13. In each case, I took as the population the "brain-children" of these people, plotting its growth and then fitting the data to a logistic curve. I call the resulting chart the *action curve*, analogous to the growth curve of an individual, and refer to the saturation level as the *perceived potential*.

These logistics have only three parameters. Thus the time distribution of the work of a great man can be condensed into three numbers: one defines the perceived potential; the second fixes a rate constant (or, more intuitively, a time constant) that measures the spread over time; and the third is a time cursor that locates the structure within the lifespan of the person. These parameters can be extracted from a segment of the data, making the rest of the data determinate.

It must be obvious that I did not take aim at the holy cow of creativity, only at its mooing. For this reason I call such charts action curves. Because I think this relationship is of general character, I continue to search for appropriate indicators and statistics to prove that it applies also to lesser activities.

These three numbers create possibilities for prying into the life of geniuses, categorizing and classifying them. To illustrate further what I mean by the perceived potential, consider the amount of beans a man carries in his bag and the amount left when he finally dies. Looking at the cases mentioned here and the others excluded to keep the paper relatively brief, I find that the leftover beans are usually five to ten percent of the total. Apparently when Mozart died at 35 years of age, he had already said what he had to say.

My choice of cases may be biased. That is possible, as it was determined by the availability of serious data strings. For example, my personal interest in the visual arts and the abundance of critical information in my personal library has biased me towards painters.

As my investigations are at the beginning, there are many open questions -- e.g., how large is the area of application. My guess is that the observed pattern is, indeed, a general one which can be used to describe human actions. In Figure 14 I show the results of analyzing childbearing, as a counterpart to the look at brain-children. The charts reveal some interesting peculiarities in the social and cultural modulation of fertility.

On other occasions I have examined the generation and spread of innovations in Western societies. After all, man is the prime mover and final recipient of innovation.

## COMMENTS TO THE CHARTS

The charts fit the cumulative number of things produced, independent of their size and the importance attributed to them.

The fitting equation is a three parameter logistic of the type

$$N(t) = \frac{\overline{N}}{1 + \exp - (at+b)}$$

where N is the cumulative number of objects at time t and $\overline{N}$ is the asymptote or saturation level. $\overline{N}$, a and b have to be calculated by fitting the data.

The charts show $F = N(t)/\bar{N}$ in a linearized form:
$\log (F/1-F) = at + b$.

$\bar{N}$ is given in paranthesis; it is called the *perceived potential* in the text. $\Delta T$ gives the temporal spread of production: the time to go from 10% to 90% of $\bar{N}$; it represents a more intuitive way of expressing a. The parameter b is a time cursor locating the pulse into the life of the person.

The year of maximum productivity is usually marked. It corresponds to the point in the curve where .5 $\bar{N}$ is reached. The first data points are usually below the equation line; this I interpret as a *catch up*. The line may be interpreted, implying that the creative impulses existed before they could be technically expressed, as is the case with the fertility of girls of 14 years. But as the dynamic of catching up shows, the impulses are delayed but not suppressed. (Girls have already met their prescribed quota by 18 years of age as do artists very early in their creative period.)

When death is approaching (very often around 90% of $\bar{N}$), usually there is a slight increase in output with respect to the prescription of the equation. See, typically, Mozart. In the case of Shakespeare, the extra play, as I later discovered, was in fact written by somebody else.

Other cases not shown here are still under elaboration. They show that sometimes a double-barrel life, with two pulses, may be possible.

REFERENCES

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(2) Marchetti, C. (1983) *On a Fifty Years Pulsation in Human Affairs: Analysis of Some Physical Indicators.* PP-83-5. International Institute for Applied Systems Analysis, Laxenburg, Austria.

(3) Marchetti, C. (1983) The Automobile in a System Context: The Past 80 Years and the Next 20 Years. *Technological Forecasting and Social Change* 23:3-23.

(4) Winfree, A.T. (1980) *The Geometry of Biological Time.* Springer Verlag, New York.

(5) Simonton, D.K. (1984) *Genius, Creativity and Leadership.* Harvard University Press, Cambridge, Mass.

(6) Marchetti, M. (1983) On the Role of Science in the Post-industrial Society: "Logos - The Empire Builders". *Technological Forecasting and Social Change* 24:197-206.

Note

These references are basically limited to my connected work. Literature on the application of Volterra-Lotka equations is vast and easily retrievable.

Figure 1.

LOTKA (1880 – 1949) (69)

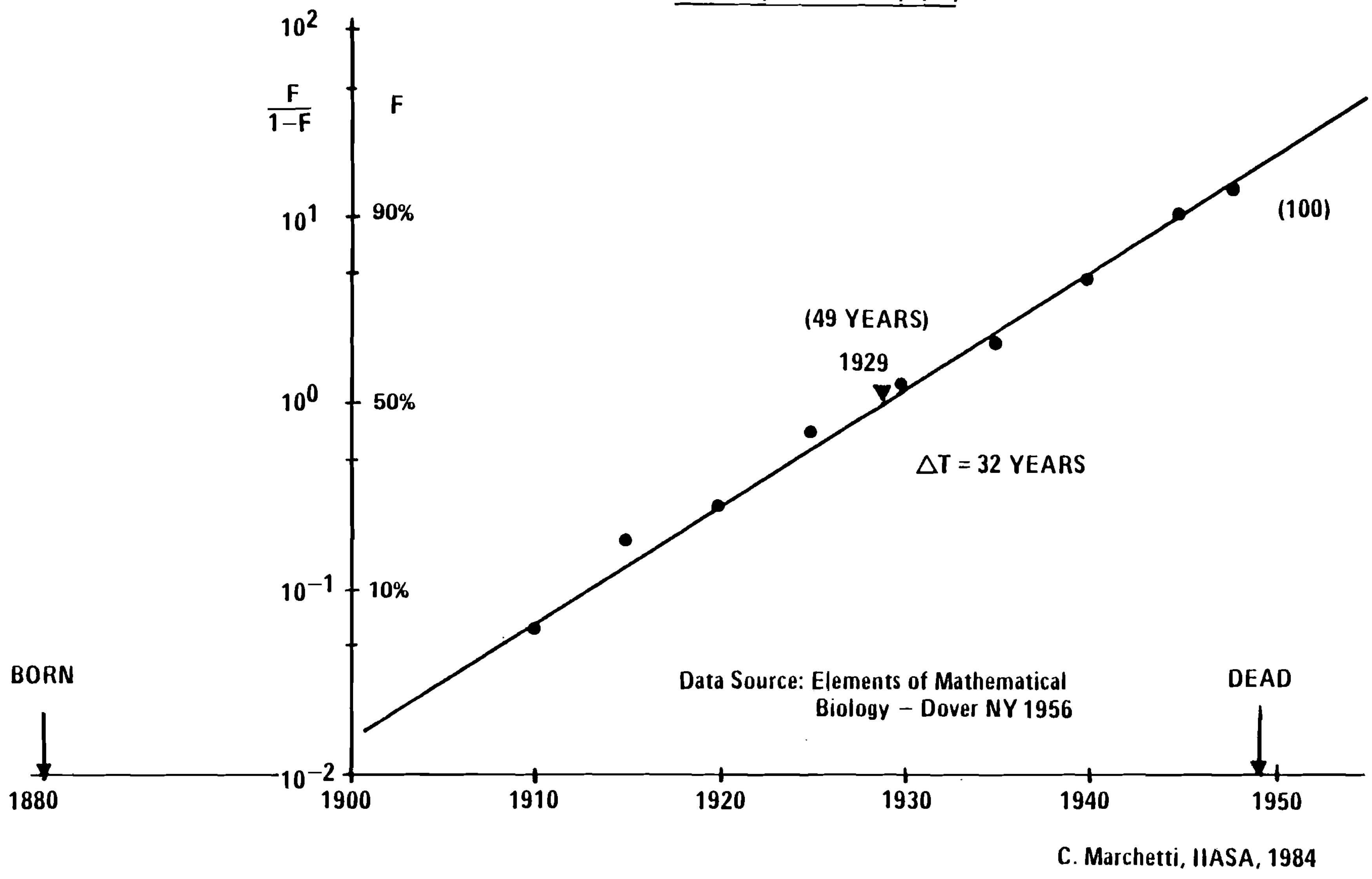

Figure 2.

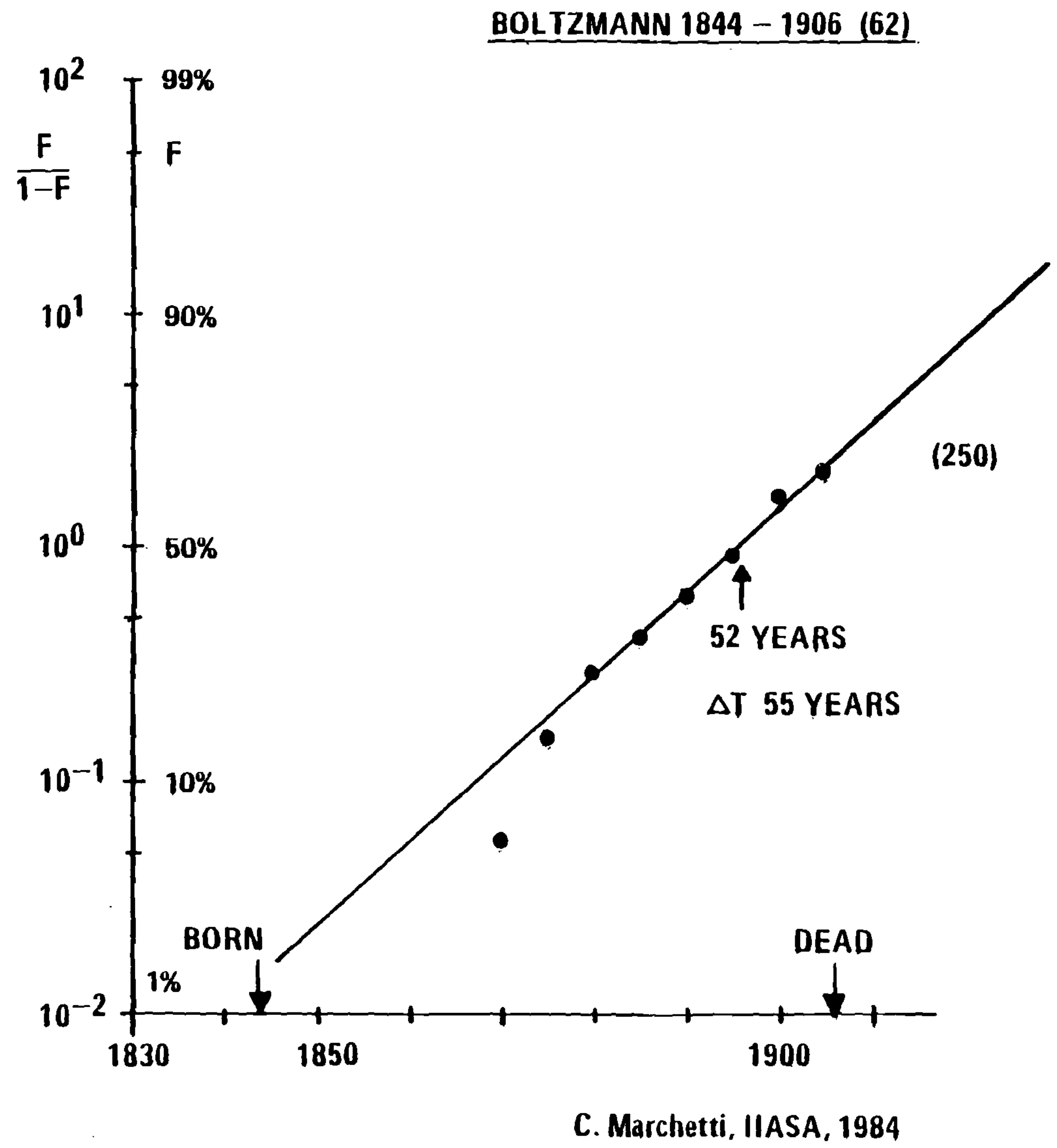
BOLTZMANN 1844 – 1906 (62)
10^2
F/(1−F)
10^1
10^0
10^−1
10^−2
99%
F
90%
50%
10%
1%
BORN
DEAD
(250)
52 YEARS
ΔT 55 YEARS
1830
1850
1900
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Figure 3.

A. VON HUMBOLDT 1769–1859 (90)

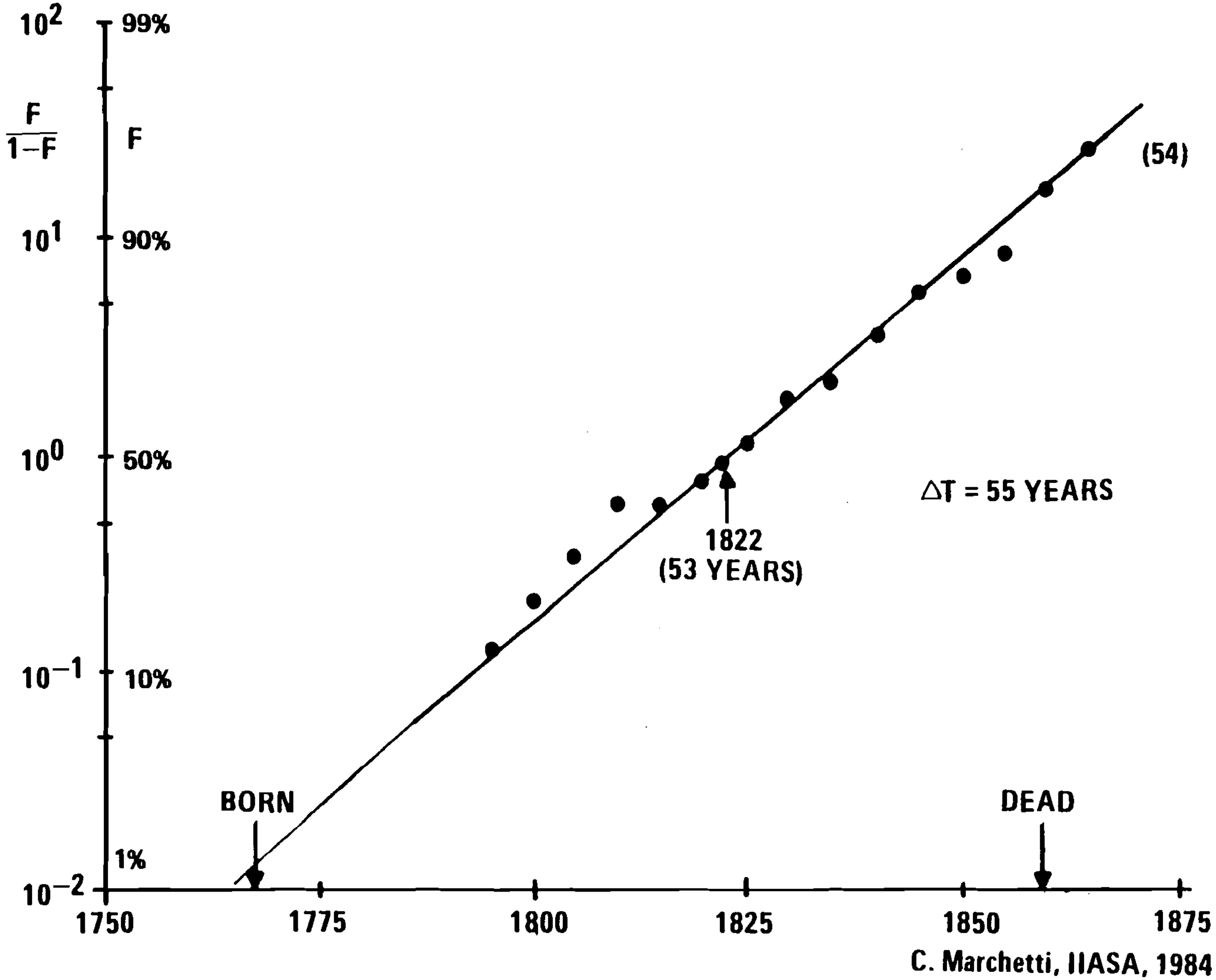

Figure 4.

BECCAFUMI 1486 – 1565 (79)

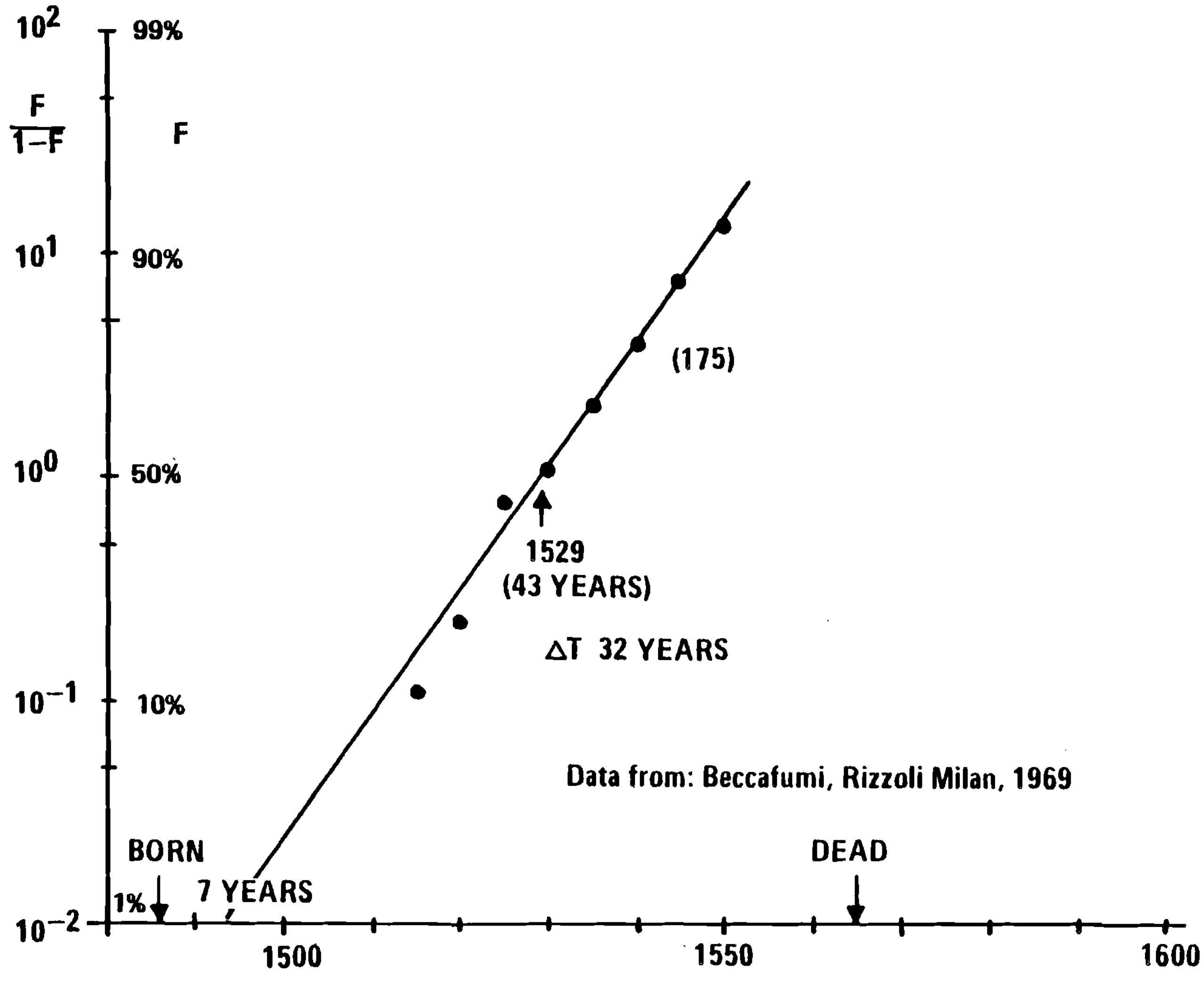


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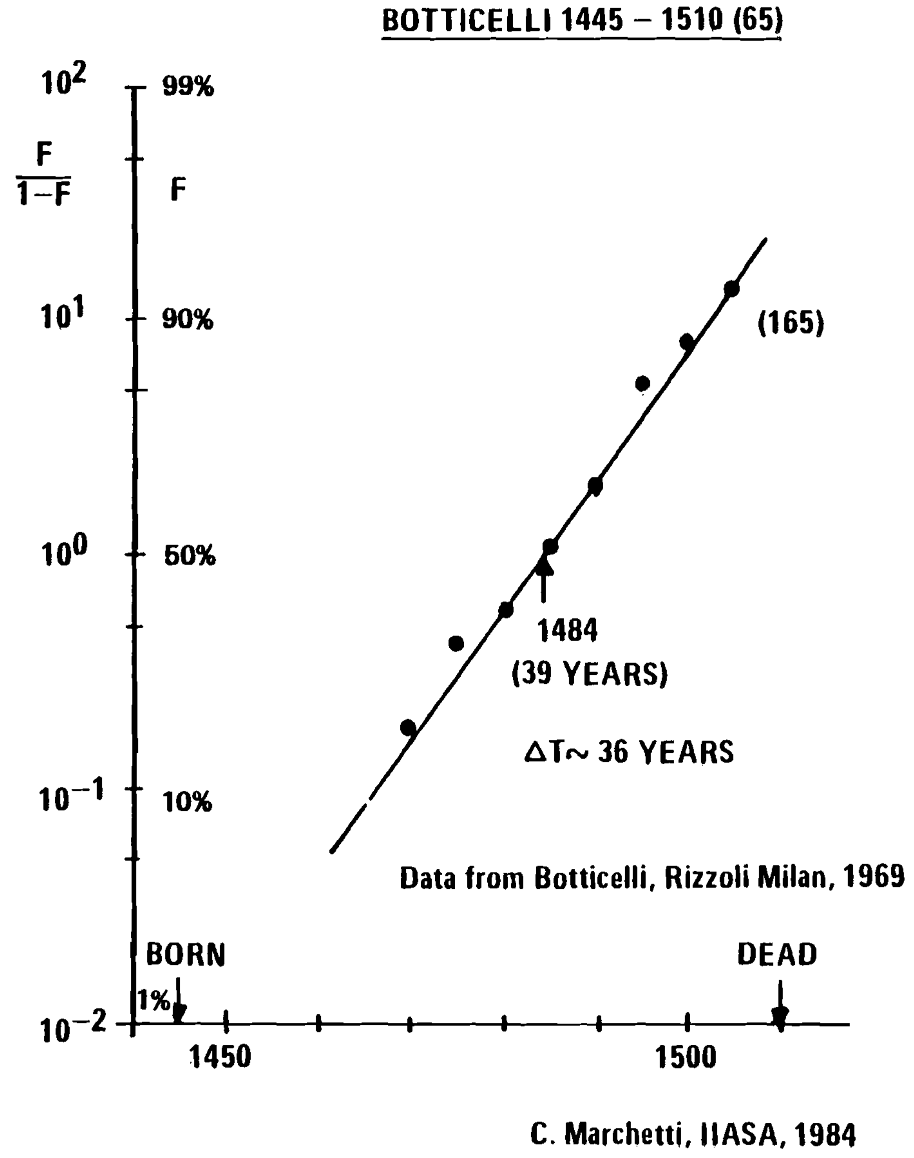
Figure 5.



BOTTICELLI 1445 – 1510 (65)
$10^2$
$\frac{F}{1-F}$
$10^1$
$10^0$
$10^{-1}$
$10^{-2}$
99%
F
90%
50%
10%
1%
(165)
1484
(39 YEARS)
ΔT~ 36 YEARS
Data from Botticelli, Rizzoli Milan, 1969
BORN
DEAD
1450
1500
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Figure 6.

GUIDO RENI (1575 – 1642) (67)

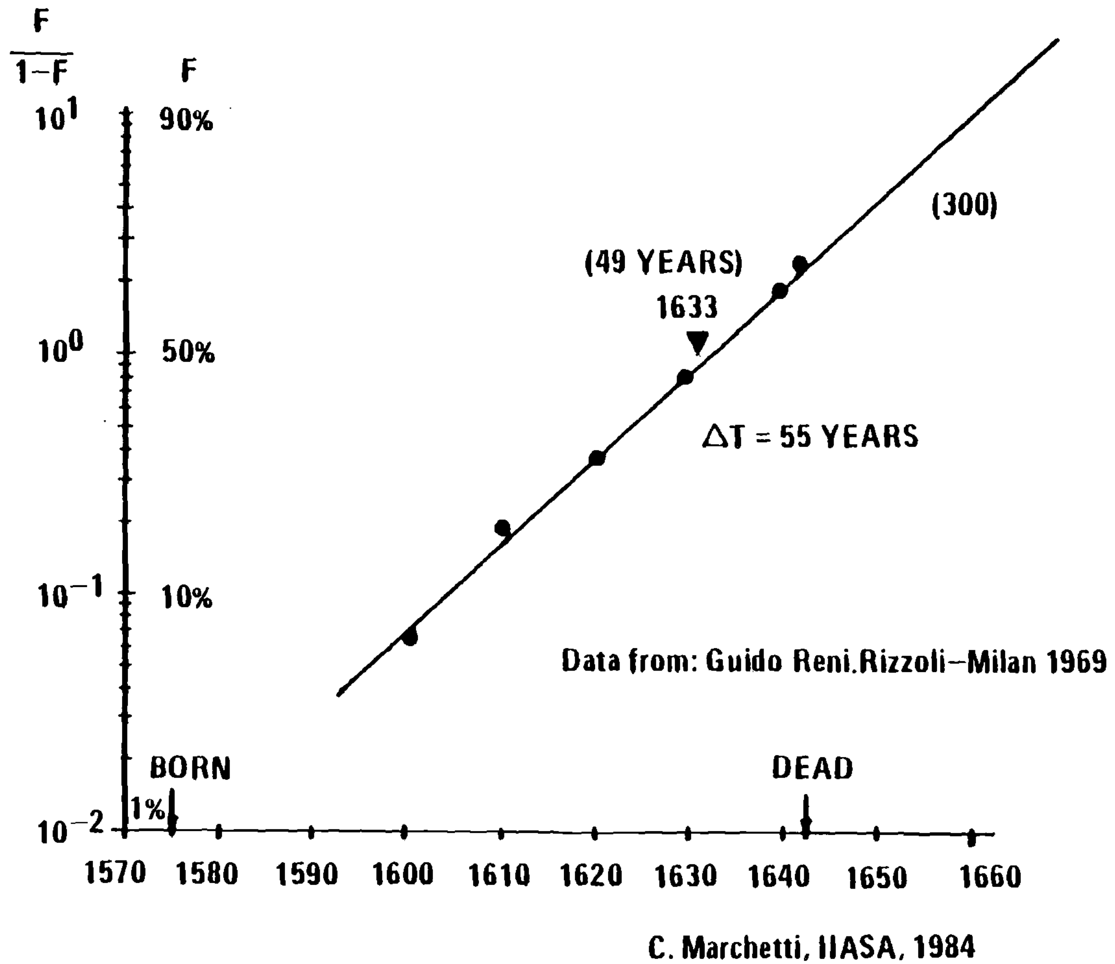


Figure 7.

RIBERA 1593 – 1652 (59)

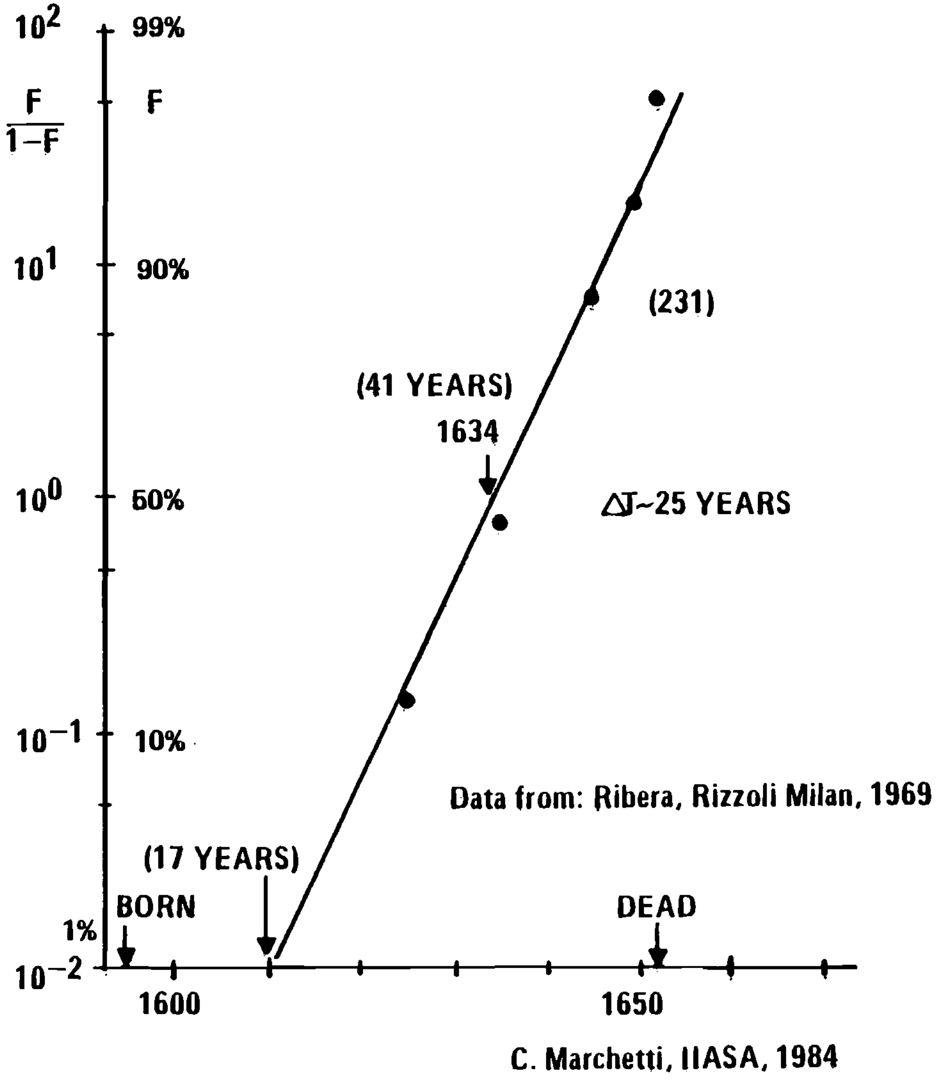


Figure 8.

SEBASTIANO RICCI 1659 – 1734 (75)

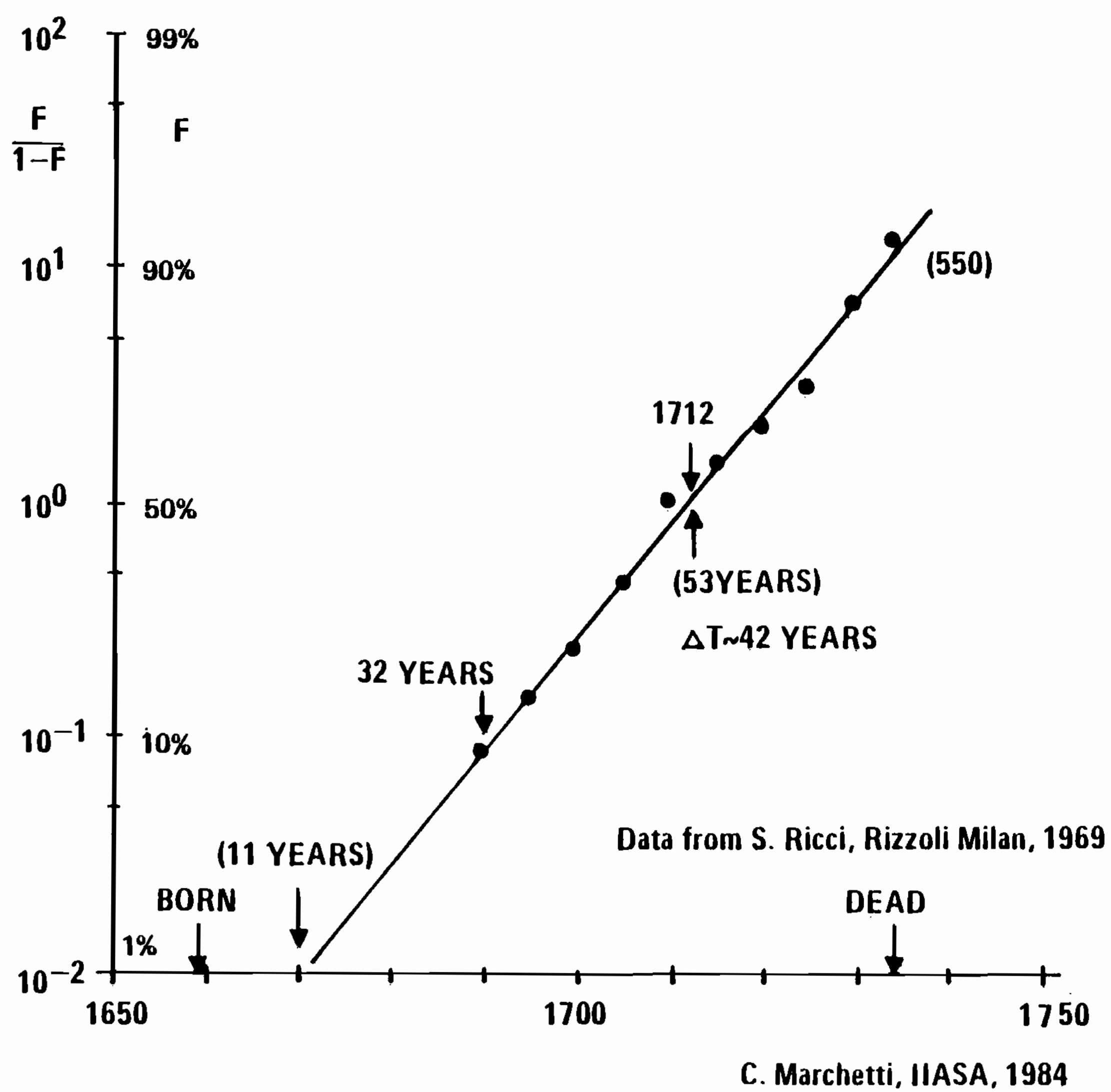
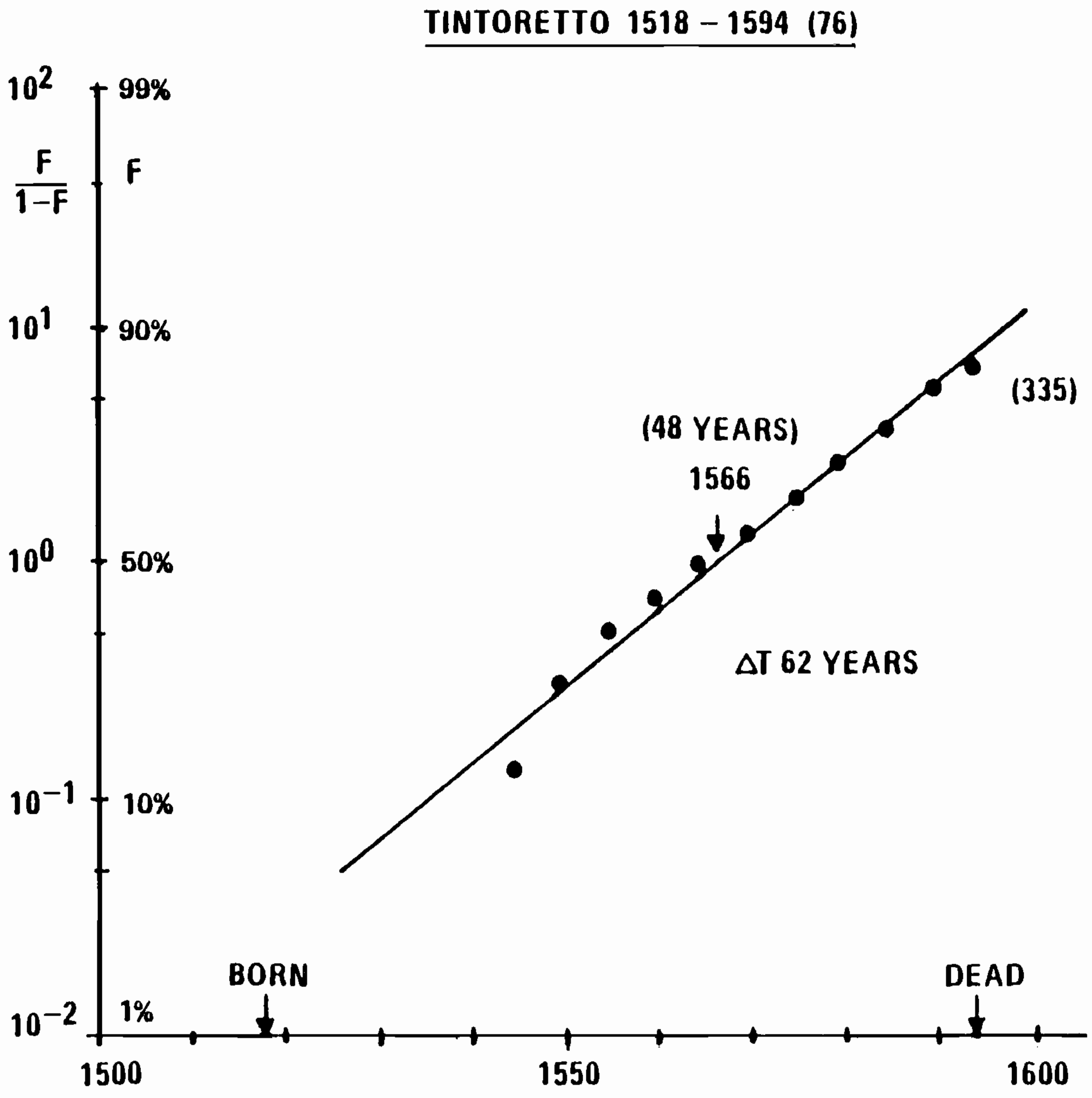


Figure 9.



TINTORETTO 1518 – 1594 (76)
$10^2$
$\frac{F}{1-F}$
$10^1$
$10^0$
$10^{-1}$
$10^{-2}$
99%
F
90%
50%
10%
1%
(335)
(48 YEARS)
1566
ΔT 62 YEARS
BORN
DEAD
1500
1550
1600

Figure 10.

**ZURBARAN 1595 – 1664 (69)**

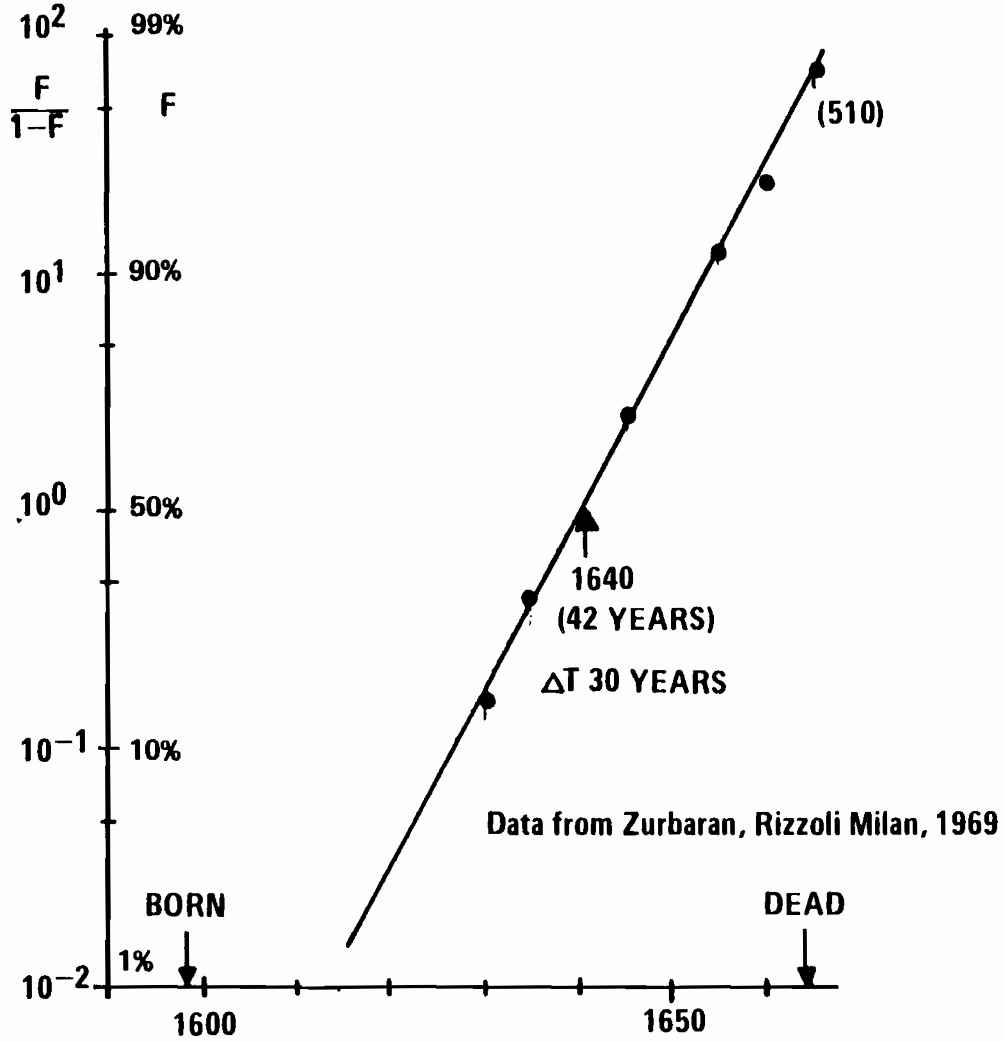



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Figure 11.

BACH 1685–1750 (65)

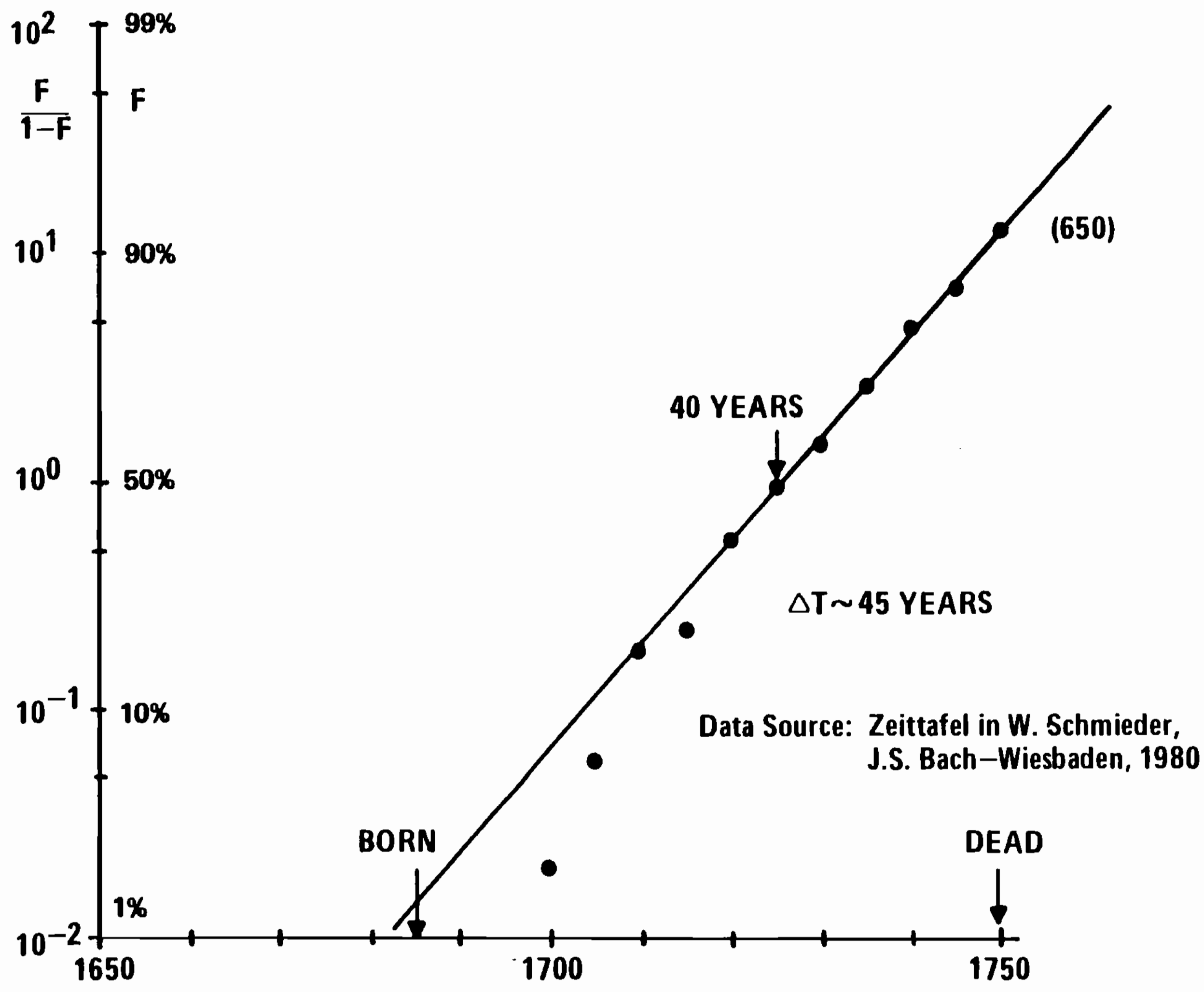


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Figure 12.

W. A. MOZART 1756–1791 (35)

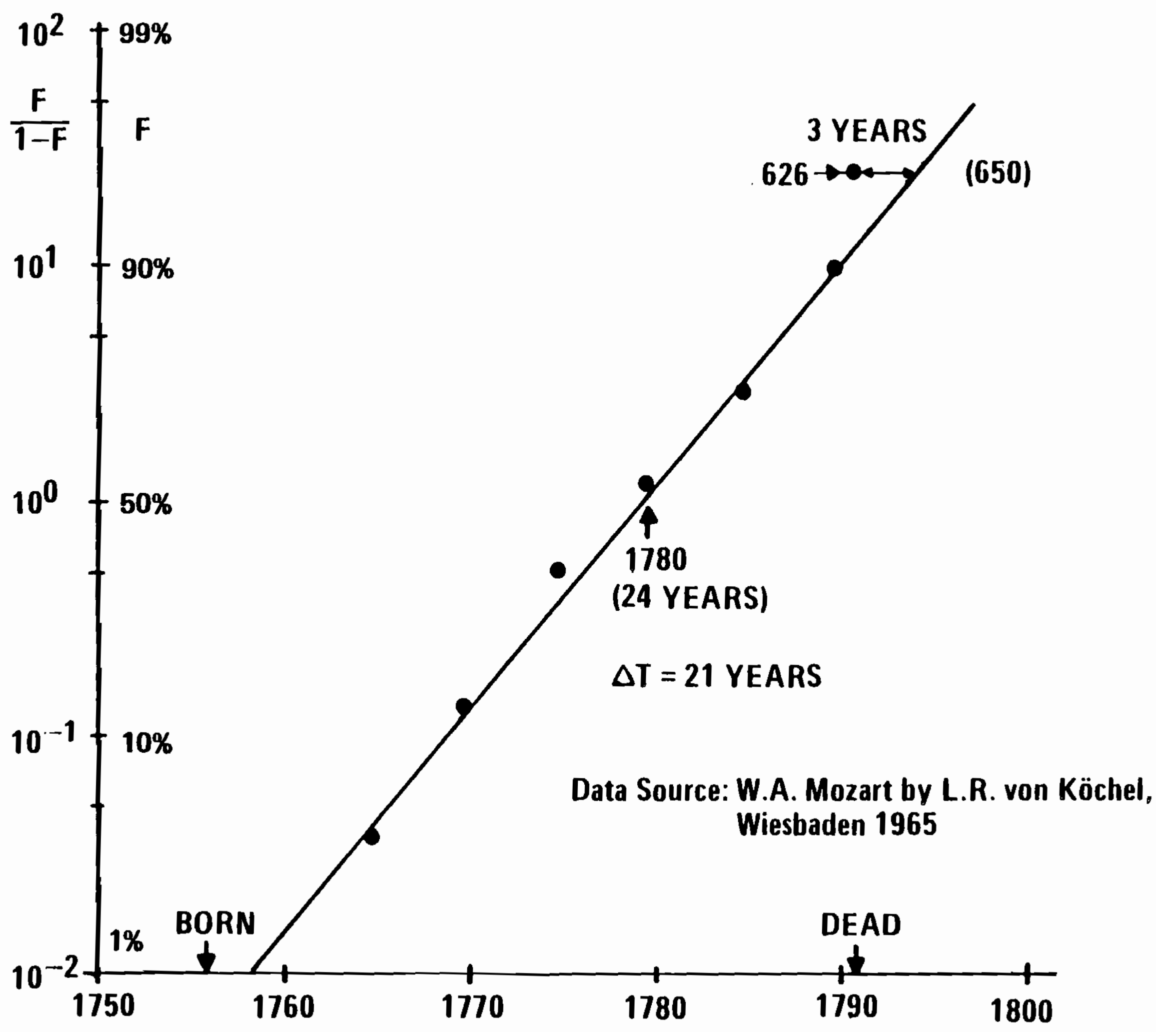


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Figure 13.

SHAKESPEARE (PLAYS) 1564–1616 (51)

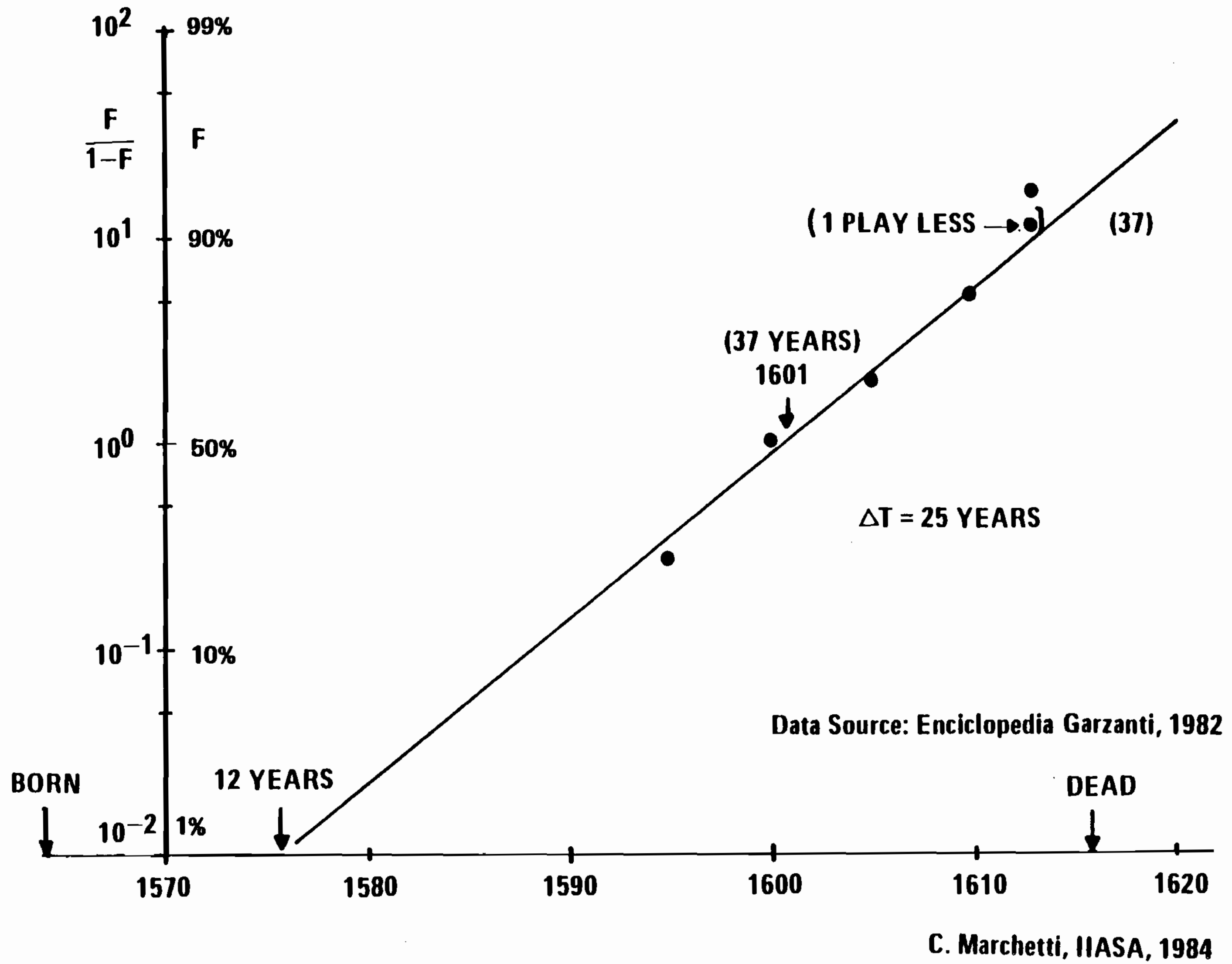

Figure 14.

CUMULATIVE FERTILITY OF AMERICAN WOMEN (1970)