GESTATION TIME AND UTERINE REACTION RATE

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ABSTRACT

Chemical factors affecting the gestation interval are discussed. The human gestation time is also compared with that of representative mammals. It is shown to be anomalously long given the relatively small human birth weight. This anomaly is taken to be evidence of the unique design of the human being in God's image.

INTRODUCTION

The gestation time of an organism is superficially controlled by (1) the birth weight and (2) the organism's complexity or degree of development at birth. But from the view of chemical kinetics, these two factors involve biochemical reactions which occur at certain rates until the required birth weight and complexity are attained. Thus, chemical reaction rate is a fundamental determiner of the gestation interval.

This paper begins with a quantitative discussion of some basic reaction rate theory. The balance of the paper, however, is qualitative. It seeks to show that, from the standpoint of reaction rates alone, man would be expected to have a shorter gestation time than 9 months.

Evidently, man is an unusually complex being whose growth from conception involves more than an increase in physical size. The human being is also developing the unique potential to have fellowship with his Creator. Man in his physical body has fellowship with God. Man's unique interface of his soul and spirit with the mind of God apparently requires a level of complexity other organisms do not possess. In other words, the gestation time of humankind indicates we are made in a special way, "in the image of God."

This study emphasizes the chemistry of uterine growth. Beyond the basic reaction rate theory, the reactions of biological systems are not discussed. Neither are the changes in uterine growth rate with time. The gestation times of some mammals are discussed, but not those of other types of organisms.

A longer study could include quantitative descriptions of the reaction rate theory for biological systems. The growth times for non-mammals seems less relevant since the growth is not *in utero*.

BASIC THEORY OF REACTION RATES

Chemical Reactions in Biological Systems

In any system involving chemical changes, chemical reactions are occurring. For living systems, the sum total of all these reactions is called metabolism. The food ingested by the system is the raw material or reactants. The chemical reactions of metabolism convert the reactants into waste products which are excreted, and energy is extracted to operate the system.

If the system is growing, it is adding mass to itself. The ultimate source of this added tissue is the reactants ingested as food. The chemical reactions of the system convert a percentage of the reactants to products which are added to the body. These products include compounds like proteins, carbohydrates, and fats. These are incorporated into tissues such as muscles, bones, and nerve structure.

Any chemical reaction, whether part of a biological system or not, can be represented as the conversion of reactants into products. A general reaction can be expressed (1) as

$$aA + bB = gG + hH \qquad (1)$$

where A, B = reactants

G, H = products

a, b, g, h = reaction coefficients

Few reactions involve more than two reactants, and many generate no more than two products.

Reaction Rates

The rate of a reaction is the rate at which a reactant is consumed, or the rate at which a product appears (2). In uterine growth, the addition of structured tissue is the primary goal. The critically important conversion of nutrients to tissue is accomplished by many reactions acting together. The overall reaction rate for uterine growth is the rate of consumption of reactants (i. e., nutrients). It is also the rate of appearance of the product (i. e., body tissue).

It is found experimentally that the rate of a reaction can be described by a rate expression. This is an equation which relates the reaction rate to a multiple of powers of reactant or product concentrations. In a simple case the powers might each equal unity.

For uterine growth, we monitor the overall rate of the growth reactions by noting the rate of appearance of products (body tissue). The rate expression would then be

$$r = k[G][H] \qquad (2)$$

where r = reaction rate

k = reaction rate constant for tissue formation

$[G], [H]$ = product concentrations

But this is also the rate at which reactants (nutrients) are converted to body tissue:

$$r = -k'[A][B] \qquad (3)$$

where k' = reaction rate constant for nutrient consumption

$[A], [B]$ = reactant concentrations

The minus sign on the right side of Equation (3) reflects the fact that nutrients are consumed.

Reaction rate depends not only on concentration, but also on temperature. The effect of temperature is considered to reside in the reaction rate constant (3). The temperature dependence of the rate constant can be expressed as

$$k = Z \exp(-E/RT) \qquad (4)$$

where Z = frequency factor

E = activation energy

R = gas constant

T = absolute temperature

The frequency factor Z and the activation energy E are usually found experimentally. For uterine growth in mammalian systems, the environment *in utero* is temperature-controlled. For all practical purposes, the absolute temperature T is constant.

FACTORS AFFECTING THE GESTATION TIME

In an actual biological system, many reactions interact to produce growth. In theory the reactions of uterine growth could be modelled based on the ideas presented above. Practical implementation of such a model would be difficult. However, it is clear that reactant concentration and temperature affect the reaction (i. e., growth) rate. In practical terms this means that the larger the birth weight, the more time is required for the growth reactions to produce a fetus ready for birth--other factors being equal. The rate at which nutrients can be assembled into tissue places a limit on how fast a fetus can develop to its birth weight. Table 1 summarizes the factors which influence the gestation time.

If the growth reactions for all organisms were the same regardless of size at birth, reaction rate theory indicates that gestation time should be proportional to birth weight. As Table 1 shows, this is not the case. Evidently the complexity of an organism increases rapidly with birth weight, and this is also a factor in gestation time. More will be said below about the complexity factor.

The environment of the fetus also affects the gestation interval. For example, the nutritional state of the mother impacts the nutrient (i. e., reactant) concentrations available for the biochemical reactions of growth. This in turn affects the birth weight and gestation time, but only within limits. (Outside these limits, the fetus is not viable and will not survive.)

The growth temperature is another aspect of the uterine environment. As Equation (3) shows, reaction rate constants are sensitive to temperature. For mammals, though, the uterine temperature is virtually constant, and it is similar for most mammals. In reaction systems subject to temperature changes, T is a critical rate determiner. In mammalian systems, however, it is only a minor factor in explaining the differences in gestation time among different organisms.

GESTATION TIMES FOR SOME MAMMALS

Table 2 lists the average gestation times for some representative mammals (4). It is clear that the gestation time is not proportional to birth weight. The gestation times for the whale and mouse have a ratio of 360/19 = 19. But the birth weights for whale and mouse have a ratio of 500/0.002 = 250,000.

This is not what might be expected on the basis of temperature and nutrient requirements, since these do not vary widely. If gestation time and birth weight varied linearly, we might expect the birth weight of a mouse to be 1/19 that of a whale (500 kg/19 = 26 kg)!

Evidently, the complexity of the substrate needed for the functions of life increases with birth weight. Especially in the case of man, the gestation time is disproportionately long, being comparable to the gestation period for larger organisms such as cattle or whales. Figure 1 is a plot of gestation time v. birth weight data from Table 2. The gestation time for man stands noticeably higher than that for organisms of comparable birth weight. Based on the nearness of man's birth weight with that of goats and sheep, we might expect man's gestation time to be about half its actual value.

The age of man at puberty is also anomalously high. Though goats and sheep have birth weights comparable to that of man, man's age at puberty is greater by a factor of almost 20 (8 months = 2/3 yr or 0.667 yr; 13 yr/ 0.667 yr = 19.4). Man's age at puberty onset is more similar to that of the elephant. But the elephant has a birth weight 30 times that of man!

As with man's gestation time, man's age at puberty sets him apart from other organisms. Like other organisms, man is designed to achieve sexual maturity at puberty. But the much greater time preceding puberty reflects the fact that man is also designed to achieve spiritual maturity as well.

By contrast, the gestation period for most primates is less than that for man. The monkey's gestation time is about half of man's. The age at puberty for the monkey is about 2/3 that for man. It seems clear that man is not just another animal.

THE UNUSUAL COMPLEXITY OF MAN

Reaction rate theory indicates that man's gestation time should be about half its actual value. Simple reaction rate theory, however, does not account for man's anomalously high gestation time. Nor should man's age at puberty be so high, if human development followed the norms for other organisms of similar size.

DOES MAN FILL A SPECIAL ROLE?

Does this mean that the human organism has a disproportionately high level of complexity designed to receive the human spirit? Only the human organism is made in God's image. Man's anomalously long gestation time is evidence that man is not just another animal, but is a unique creation made for a special purpose, which Scripture reveals to be fellowship with the Creator.

CONCLUSION

Man's unusually long gestation time is not expected according to basic reaction rate theory. Nor is man's relatively advanced age at puberty expected by comparison with mammals of similar birth weight. The long duration for human growth *in utero* points to the idea that the process of uterine growth assembles an "expert system" designed to learn about the Creator.

Man's anomalously advanced age at puberty corroborates this conclusion. As the human creature matures sexually, he is designed to have the time to mature spiritually as well.

REFERENCES

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TABLE 1
FACTORS AFFECTING THE GESTATION PERIOD

Major Factors

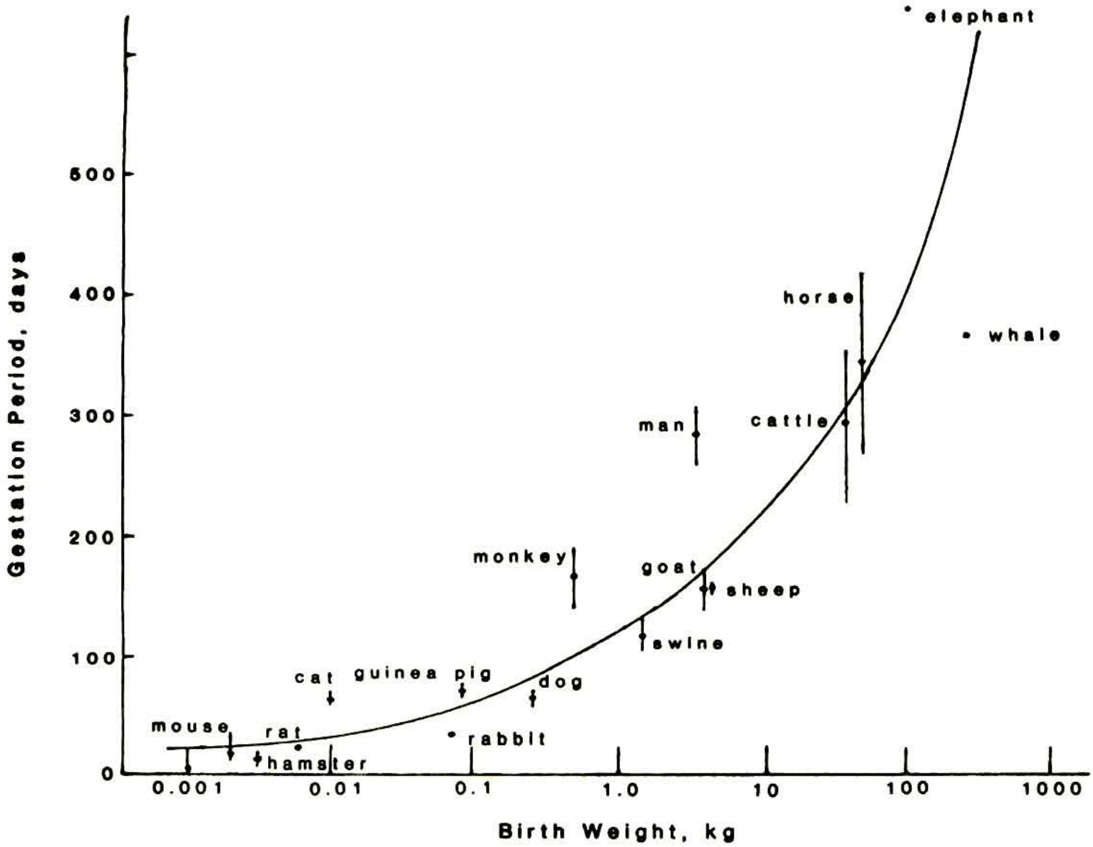
1. Birth weight of the organism
2. Complexity of the organism

Minor Factors

3. Environment of the fetus (e. g., uterine temperature)
4. Nutritional state of the mother

TABLE 2
BIRTH WEIGHT, GESTATION AND PUBERTY (MAMMALS)

Organism	Birth Weight, kg	Gestation, da	Age at Puberty
Mouse	0.002	19	7 wks
Hamster	0.003	16	8 wks
Rat	0.006	21	7 wks
Cat	0.01	63	10 mo
Rabbit	0.07	31	6 mo
Guinea Pig	0.08	68	2 mo
Dog	0.3	63	7 mo
Monkey	0.5	164	4 yr
Swine	1.4	114	7 mo
Man	3.3	277	13 yr
Goat	3.5	151	8 mo
Sheep	4.0	151	8 mo
Cattle	36	284	8 mo
Horse	50	336	1 yr
Elephant	~ 100	624	12 yr
Whale	~ 500	360	3 yr



GESTATION PERIOD v. BIRTH WEIGHT (mammals)

Figure 1