CHANGES IN NUCLEAR SIZE DURING DEVELOPMENT OF THE HUMAN CHORION AND PLACENTA

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Very few reports of karyometric investigations of human chorionic and placental tissues during development are to be found in the literature [8]. The purpose of this study was to remedy this deficiency.

EXPERIMENTAL METHOD

We investigated the chorions from early human embryos and placentas at the 12th, 14th, and 40th weeks of pregnancy. Morphological and histochemical studies were followed by karyometry by the technique described by B. P. Khvatov [5]. By means of the MBI-1 microscope (magnification 15 × 90, immersion) and the Abbe drawing apparatus, 200 cell nuclei from the cytotrophoblast and connective tissue of the villi were drawn at each age. Statistical indices in respect of each variational series were determined and the coefficient of correlation between the number of nuclei of equal size in the cytotrophoblast and connective tissue of the villi was calculated. Since the relationship between the number of nuclei and their size obeys the normal law of distribution, we converted the variational curves into smooth curves by the method of balancing points. To test the significance of the coefficients of correlation we used the formula: $r > (3\text{-}4)m_r$, and to compare the arithmetical mean values:

$$M_1 - M_2 \geqslant 3\sqrt{m_1^2 + m_2^2}$$

EXPERIMENTAL RESULTS

It will be seen in Table 1 and Fig. 1 that the distribution of the cell nuclei of the cytotrophoblast was more compact.

In connection with the morphological and histochemical differentiation of the human chorionic tissues, changes occur in the size of their nuclei. When tissue differentiation has attained a high level (this coincides with the functioning of the mature placenta at the age of 12 weeks), the mean dimensions, especially those of the connective-tissue nuclei, diminish. Under these circumstances the variational curves of size of the cell nuclei of the cytotrophoblast and connective tissue in relation to age are apparently transferred to different coordinates: in the early stages of pregnancy the curve of distribution of connective-tissue cell nuclei is shifted to the right (towards the nuclei of larger diameter) of the variational curve of the sizes of the cytotrophoblast nuclei (Fig. 1, A, B, C), but later the two curves almost coincide (Fig. 1, D, E), and finally the variational curve of the dimensions of the nuclei of the cytotrophoblast cells is shifted towards the larger values compared with the connective-tissue curve (Fig. 1, F, G, H).

The mathematical transformation of these variational curves into smooth (Fig. 2), by means of the method of balancing points, revealed the principles governing the distribution of cell nuclei in the human chorionic and placental tissues.

It will be seen in Table 2 that the functional relationship between the number of cell nuclei in human chorionic and placental tissues and their size is identical, and may be represented as follows:

$$y = 10^a \cdot 10^{-\kappa(x-\varepsilon)^2}$$

TABLE 1. Principal Indices of Variational Series of Nuclear Size in the Cytotrophoblast and Connective Tissue of the Villi of the Chorion and Placenta, Showing the Pattern of Change in Nuclear Size during Human Ontogenesis

Test object	Age of embryo	Tissue	Mod	Med	M	σ	m	Limits of variation of dimensions of most nuclei
Chorion	21 day (1.4 *мм* length)	Cytotrophoblast	15.0	14.5	14.61	±1.80	±0.13	13.0—16.0
		Connective tissue	15.0	15.0	15.52	±2.20	±0.16	13.5—16.5
Chorion	21—22 day (2.3 *мм* length)	Cytotrophoblast	14.0	13.0	13.00	±1.69	±0.12	11.5—14.5
		Connective tissue	14.0	14.0	14.08	±1.76	±0.12	13.0—15.5
Chorion	25 day (3.2 *мм* length)	Cytotrophoblast	14.0	14.0	14.42	±2.00	±0.14	13.0—16.5
		Connective tissue	15.0	15.0	15.40	±1.94	±0.14	13.5—16.5
Chorion	33 day (5.5 *мм* length)	Cytotrophoblast	12.5	13.0	13.13	±1.48	±0.10	12.0—15.0
		Connective tissue	13.5	13.5	13.90	±1.89	±0.13	12.0—15.0
Chorion	36 day (6.5 *мм* length)	Cytotrophoblast	15.5	15.0	15.05	±1.80	±0.13	13.5—17.5
		Connective tissue	15.5	15.0	15.31	±2.43	±0.17	13.0—17.0
Placenta	12 week of pregnancy	Cytotrophoblast	14.5	13.5	13.62	±1.40	±0.10	12.0—15.0
		Connective tissue	12.5	12.0	12.39	±1.33	±0.09	11.5—13.5
Placenta	14 week of pregnancy	Cytotrophoblast	14.0	13.5	13.62	±1.42	±0.10	12.0—15.0
		Connective tissue	13.0	12.5	13.07	±1.56	±0.11	11.5—13.5
Placenta	40 week of pregnancy	Cytotrophoblast	14.5	14.5	14.31	±1.52	±0.11	13.0—15.5
		Connective tissue	13.0	13.0	13.40	±1.45	±0.10	12.0—14.5

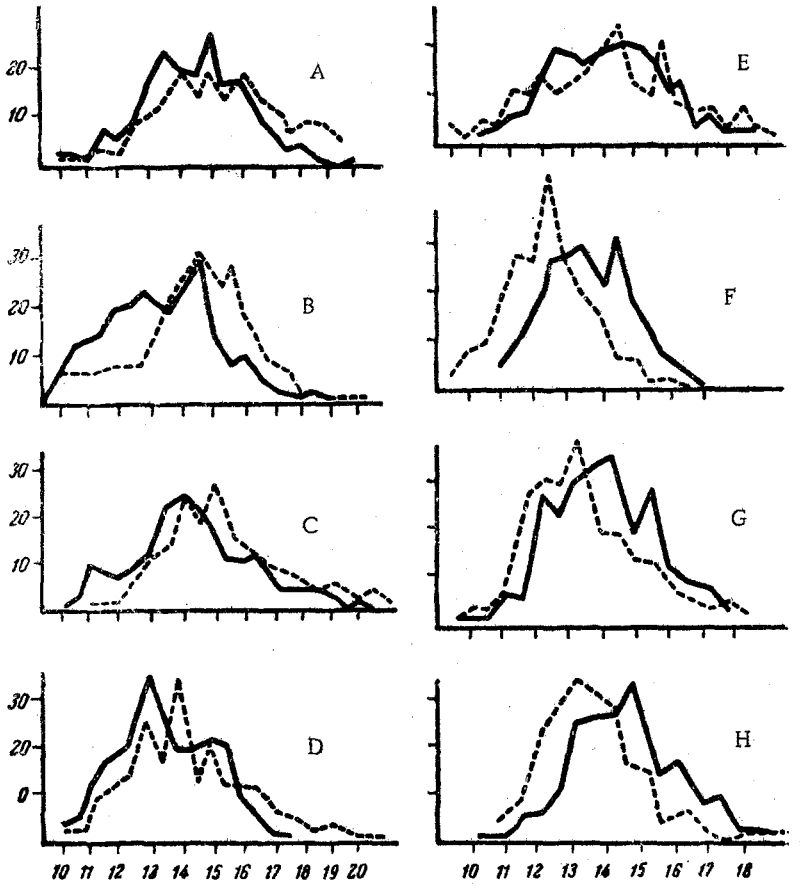

Fig. 1. Variational curves of sizes of cell nuclei of the cytotrophoblast (continuous line) and connective tissue (broken line) of the villi of the human chorion and placenta. A) Chorion of human embryo 1.4 mm in length (21 days); B) 2.3 mm in length (21-22 days); C) 3.2 mm in length (25 days); D) 5.5 mm in length (33 days); E) 6.5 mm in length (36 days); F) placenta at the 12th week of pregnancy; G) at the 14th week; H) at the 40th week of pregnancy.

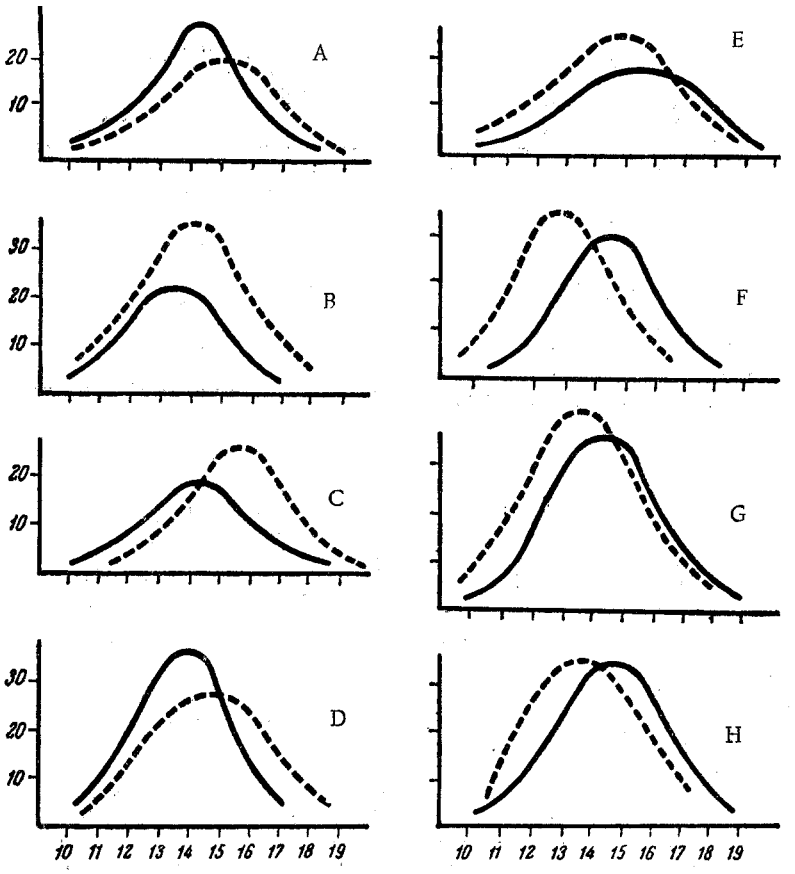

Fig. 2. Smooth theoretical curves of the dimensions of the cell nuclei of the cytotrophoblast (continuous line) and connective tissue (broken line) of the human chorionic villi and placenta. Legend as in Fig. 1.

TABLE 2. Formulae Showing the Functional Relationship between the Number of Cell Nuclei of the Cytotrophoblast and the Connective Tissue of the Villi and Their Size at Different Periods of Human Ontogenesis

Test object	Age of embryo	Cytotrophoblast	Connective tissue
Chorion	21 day (1.4 мм length)	$y = 10^{1.45} \cdot 10^{-0.064(x-14.3)^2}$	$y = 10^{1.35} \cdot 10^{-0.055(x-14.95)^2}$
Chorion	21 22 day (2.3 мм length)	$y = 10^{1.3} \cdot 10^{-0.08(x-12.9)^2}$	$y = 10^{1.52} \cdot 10^{-0.062(x-13.7)^2}$
Chorion	25 day (3.2 мм length)	$y = 10^{1.3} \cdot 10^{-0.057(x-14.7)^2}$	$y = 10^{1.465} \cdot 10^{-0.055(x-16.25)^2}$
Chorion	33 day (5.5 мм length)	$y = 10^{1.53} \cdot 10^{-0.081(x-13.5)^2}$	$y = 10^{1.45} \cdot 10^{-0.06(x-14.0)^2}$
Chorion	36 day (6.5 мм length)	$y = 10^{1.27} \cdot 10^{-0.043(x-15.6)^2}$	$y = 10^{1.38} \cdot 10^{-0.039(x-14.6)^2}$
Placenta	12 week of pregnancy	$y = 10^{1.45} \cdot 10^{-0.095(x-14.2)^2}$	$y = 10^{1.52} \cdot 10^{-0.089(x-12.8)^2}$
Placenta	14 week of pregnancy	$y = 10^{1.51} \cdot 10^{-0.081(x-13.8)^2}$	$y = 10^{1.54} \cdot 10^{-0.075(x-13,1)^2}$
Placenta	40 week of pregnancy	$y = 10^{1.48} \cdot 10^{-0.079(x-14.3)^2}$	$y = 10^{1.49} \cdot 10^{-0.075(x-13.5)^2}$

TABLE 3. Coefficients of Correlation (r) between the Number of Nuclei of the Same Size in the Cells of the Cytotrophoblast and Connective Tissue of the Villi of the Human Chorion and Placenta, and Their Mean Errors (m_r)

Index	Chorion of human embryo					Placenta		
	age							
	21 day (1.4 mm length)	21-22 day (2.3 mm length)	25 day (3.2 mm length)	33 day (5.5 mm length)	36 day (6.5 mm length)	12 week of pregnancy	14 week of pregnancy	40 week of pregnancy
Coefficient of correlation	0.85	0.69	0.97	0.86	0.89	0.62	0.76	0.71
Mean error of coefficient of correlation	± 0.014	± 0.026	± 0.013	± 0.013	± 0.010	± 0.031	± 0.024	± 0.025

The histochemical study of human chorionic tissues, using the same series of preparations [1, 2, 3, 6], revealed a preferential accumulation of polysaccharides, phosphatases, nucleic acids, lipids, and organic iron compounds in the epithelial layer of the villi. These facts were compared with the results of morphological and karyometric investigations of the developing chorion [4]. To determine the degree of correlation between the dimensions of the cell nuclei of the cytotrophoblast and connective tissue of the villi, we determined the coefficients of correlation between the numbers of cell nuclei of the same size in these tissues, and also their mean errors (Table 3).

The results of these investigations suggest that a close correlation exists between the epithelial layer of the villi and their connective-tissue stroma in all the stages of ontogenesis. Together with the previously discovered active participation of the epithelium of the villi in their histochemical differentiation, this is further evidence that this tissue plays a leading role in the histogenesis of the human chorion.

Similar results were obtained in a previous study [7], which revealed the important part played by the epithelium of the internal organs, exceeding that of the corresponding mesenchyme, in early human ontogenesis. Hence, the pattern of correlation between the epithelial and mesenchymal tissues which we have described above is common to both definitive and provisional structures.

SUMMARY

Cell nuclei of epithelial and connective tissues of human chorion and placenta from the 21st day to the end of pregnancy were measured. Variational curves were transformed into smooth and formulae were drawn in relation to the nuclei and their sizes. A direct authentic correlational relationship of high intensity was established between the karyometric index of the cytotrophoblast and connective tissue of the villi. On the basis of these data and also of the previous morphological and histochemical investigations of the villi, it was concluded that a leading functional role is played by the epithelium in the process of intercorrelation with connective tissue in human chorion histogenesis.

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