XXI. THE MITOTIC INDEX OF THE CHICK

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Introduction

Growth and its relation to differentiation has long been one of the perplexing problems of biology. Most scientists believe that the highest rate of growth occurs in the earlier stages of the organism and as differentiation takes place that rate is correspondingly lessened. But the problem is to prove this.

Minot in his book on "Age, Growth and Death" suggested a method. He counted the number of cells in the active process of division out of a total of one thousand. This he called the mitotic index. With this plan in mind I attempted to determine the mitotic indices of the 18-20, 33, 48 and 72 hour chicks. However, I changed the definition of the term mitotic index to mean the number of cells found in the active process of division out of a total of one hundred instead of one thousand, thus making the term mitotic index synonymous with rate and percentage. I might equally well, if not better have called this paper the mitotic ratio of the chick.

Materials and Methods

Prepared serial transverse sections of each of the above named stages were examined with an oil immersion lens and the nuclei counted, one by one, in each section of each chick series. Records were made during the progress of the work of the number of nuclei which were in a process of division. With these figures I was able to determine mathematically the percentage of cell division for the separate parts of the germ layers of each section. I then added up all the dividing and non-dividing cells of these sections. With these totals I figured the rate of cell multiplication of each germ layer and of the chick as a whole. In this paper I shall very briefly discuss the results of each chick stage separately, then draw conclusions from a comparison of all four of them.

18- 20-Hour Chick

The 18-20 hour chick, a stage preceeding the differentiation of organs, shows a very high percentage of cell division having a mitotic index of 4.139. That is out of every one hundred cells an

average of four were observed to be in the process of division. Of the separate germ layers, at this stage the mesoderm shows the highest rate with a mitotic index of 5.0208, the ectoderm follows with 4.5509, while the entoderm shows the lowest rate (2.494). The cells of this chick are characterized by their relatively large nuclei.

33-Hour Chick

In the 33 hour chick where differentiation is taking place there has been a rapid decline in the rate of cell multiplication, the average mitotic index being 2.156 compared with 4.139 in the 18-20 hour stage. Here the ectoderm (2.339) shows the highest rate of growth, the mesoderm (2.072) follows with the entoderm (1.952) showing the lowest rate.

48-Hour Chick

The 48 hour chick shows a higher rate of cell division than the 33 hour stage but less than the 18-20 hour chick, the mitotic index here being 3.121. In this stage the preponderance of the head is a marked feature, the forebrain being bent at right angles to the axis of the embryo. This extraordinary development of the central nervous system together with the resultant extra growth of the ectodermal covering explains the increase in the rate of division of the ectoderm of this chick over that of the 33 hour stage. The mesoderm and entoderm show a much smaller rate of increase. The mitotic index for ectoderm here is 3.896, mesoderm 2.768, and entoderm 2.611.

72-Hour Chick

The 72 hour chick, where differentiation takes place on a larger scale shows the slowest rate of growth of all the chicks studied, the mitotic index being 1.736. The ectoderm here in 2.805, mesoderm .8708 and entoderm .914. Here we notice the parts are growing rather irregularly, some faster, some lower, although on the whole the rate is slower.

General Conclusions

The rate of cell multiplication as shown by my table of totals proves that in all stages of the chicks that I studied, the anterior end in general exceeds the rest of the chick in its rate of cell multiplication, the tail region comes next, while the slowest rate occurs in the central part that is the region of the yolk sac. Because of this higher rate of growth differentiation manifests itself in this head region first with the tail and yolk sac regions following in their respective order.

My tables also show the ectoderm in all the stages studied except the 18-20 hour has the highest percentage of cell multi-

plication with the mesoderm and entoderm following in the order given. A large part of the ectoderm is made up of brain and spinal cord tissue. These columnar cells are tightly pressed together and show a high rate of growth while the rounder mesenchyme cells which make up a large part of the mesoderm are loosely packed and show a slower rate. In the 18-20 hour stage the mesoderm slightly exceeded the ectoderm but this was probably due to the fact that in this stage the mesoderm was just forming. This high rate of growth of the ectoderm, the larger part of which is nervous tissue proves that a higher percentage of cell division takes place in the central dorsal region of the chick than in the lateral ventral parts.

In the early stages of the chick preceeding the differentiation of organs cell division takes place everywhere throughout the tissue, although in places a higher percentage is observed than in others. As development progresses in the later stages definite centers of growth appear. In these centers the cells continue to multiply while in the immediately surrounding parts they cease. Numerous examples of these foci of growth may be cited. For instance, in the brain and spinal cord tissue all the dividing cells are found toward the inside of the tube. These dividing cells are small and round while the surrounding cells which do not multiply are much longer and larger. The dividing nuclei in the oesophagus, stomach, intestine, trachea, etc., are also along the inside of the tube. In the 48 hour chick the walls of the lens sac are practically of even thickness with mitotic figures scattered along anywhere in the region toward the cavity, while in the 72 hour stage the inner layer has greatly thickened and the cavity is almost obliterated. Few mitotic figures can be seen in this thickened and uneven layer, although in the outer layers, which are still undifferentiated, numerous mitotic figures are scattered throughout. Various other examples can be given but these are sufficient to show that in the earlier stages the growth is somewhat diffuse but as development progresses it becomes more focal.

Summarizing, I find that the highest rate of growth is shown in the 18-20 hour stage, next highest in the 48, with 33 and 72 hour stages following in their respective order. As a result of this study one sees that young cells multiply freely and in consequence grow rapidly. When they are older they loose this capacity and their growth is correspondingly lessened. In general, quoting Minot, "We note that wherever a trace of differentiation has occurred the rate of growth is diminished, where that differentiation does show itself, the rate of growth may even increase in order to

acquire a certain special development of a particular part. So that instead of uniformity of values for the mitotic index we get a great variety. But nevertheless there is a general decline."