In frogs from one to four years old, the body weight more than doubles during each active season, although the precise form of the curve representing this body growth is not known.

The growth of the central nervous system is precocious in relation to that of the body, but in the absence of direct observations on the growth of the body, the form of the curve can only be indirectly determined.

During the active season, the percentage of water in the entire frog falls slightly from spring to summer and rises again from summer to autumn. These changes seem to be due to the combined effects of advancing age and varying food supply.

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## An interpretation of growth curves from a dynamical standpoint.

By **S. HATAI.**

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The growth phenomena may be considered as a gradual transformation of growth energy to the work done in forming the mass which composes the body. The present writer wishes to determine "what law, if there is any, governs in any individual the rate of transforming the growth energy into the work done."

In order to solve the above problem, the assumption was made that under normal conditions the growth energy is transformed into the work with least loss of energy. It was shown that in order that this assumption should be true we must have $\delta A = 0$ in the following integral

$$A \text{ (action)} = \int mvds.$$

Applying this principle it was proved that the formula for the growth of brain in weight (and any other data which satisfy the same conditions) must be a function which renders the following integral minimum

$$u = k\int\left(\frac{1}{x} + \frac{1}{a}\right)\sqrt{1 + \left(\frac{dy}{dx}\right)^2}\, dx.$$

The integral is minimized when the function $y$ has the following relations:

$$y = \frac{ca}{k\left(1 - \frac{c^2a^2}{k^2}\right)^{\frac{1}{2}}} \sqrt{\left(x + \frac{a}{1 - \frac{c^2a^2}{k^2}}\right)^2 - \frac{c^2a^4}{k^2\left(1 - \frac{c^2a^2}{k^2}\right)^2}} - \frac{ca^2}{k\left(1 - \frac{c^2a^2}{k^2}\right)^{\frac{3}{2}}}$$

$$\times \log \left\{ \left(x + \frac{a}{1 - \frac{c^2a^2}{k^2}}\right) + \sqrt{\left(x + \frac{a}{1 - \frac{c^2a^2}{k^2}}\right)^2 - \frac{c^2a^4}{k^2\left(1 - \frac{c^2a^2}{k^2}\right)^2}} \right\} + c_2.$$

If our assumptions are correct, the above formula ought to represent adequately our growth curves. It was shown that the above formula can be transformed into the following forms as particular cases:

$$y = a + b \log (x + c),$$
$$\text{and } y = a + bx + c \log x.$$

These are formulas which are already extensively used for graduating observed growth curves. Thus there is no further need to test the adequacy of the formula to represent the growth curves, since numerous applications have been made with satisfaction and already published by various investigators. I therefore put forward the following provisional definition of growth considered as a process: "An organism tends during growth to form greatest amount of mass with least loss of growth capacity."

Further the present investigation furnishes a biological meaning to the logarithmic formulas which have been extensively used without appreciating the full significance of their properties.

The cases of abnormal growth were also discussed but will be treated more fully in a future publication.

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## Experiments to modify the sex ratio in the toad.

By **HELEN DEAN KING.**

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Several series of experiments were made in the spring of 1910 in order to ascertain whether the sex ratio in the toad can be altered by subjecting the eggs to different environmental conditions at or before the fertilization period.

Lots of eggs fertilized in various solutions of alcohol (.13 per cent. to 2 per cent.), as well as those fertilized with sperm from