freshly formed dew. If the dew had been formed for more than a few hours no bows were seen, very probably because the increased size and weight of the drops caused an appreciable departure from perfect sphericity. The idea that it was necessary for the drops to be small was borne out by an observation made at 2 A. M., November 27. At this time a light shower had covered the grass with fairly large drops, which were by no means perfectly round. When the clouds had cleared away and the moonlight was very bright no indication of a bow could be seen.

The dewbows appeared as faintly defined streaks of white light tracing ellipses in the grass. The size and shape of the ellipses depended upon the angle of incidence of the moonbeams and the height of the observer's eye above the ground. The bow moved with the observer and different observers saw different bows.

We can calculate the size and shape a bow should have if it is formed by deviation through an angle β of parallel light rays making an angle α with the horizontal. Take the stance of the observer as the origin and let the $x - y$ plane lie on the ground with the x-axis along the shadow of the observer. The beam AP is reflected to the eye of the observer E after being deviated through the angle β, so that the point P appears to be illuminated more strongly than the surrounding points. The locus of P is found as follows:

EB is a ray of incident light parallel to the ray AP. Draw PD and CD perpendicular to EB. Let h represent the height of the observer's eye above the ground. Then

$$BC = \frac{h}{\tan\alpha} - x;\quad CD = BC\sin\alpha$$

$$= h\cos\alpha - x\sin\alpha;\quad PC = y,$$

whence

$$PD = \sqrt{y^2 + h^2\cos^2\alpha - 2hx\cos\alpha\sin\alpha + x^2\sin^2\alpha};$$

$$PE = \sqrt{x^2 + y^2 + h^2}.$$

Thus

$$\frac{PD}{PE} = \sin\beta = \frac{\sqrt{y^2 + h^2\cos^2\alpha - 2hx\cos\alpha\sin\alpha + x^2\sin^2\alpha}}{\sqrt{x^2 + y^2 + h^2}}$$

from which we obtain

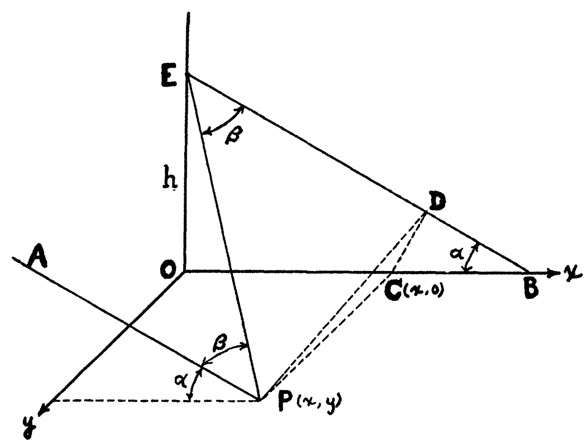
$$\frac{\left(x - \dfrac{h\cos\alpha\sin\alpha}{\sin^2\alpha - \sin^2\beta}\right)^2}{\left(\dfrac{h\sin\beta\cos\beta}{\sin^2\alpha - \sin^2\beta}\right)^2} + \frac{y^2}{\left(\dfrac{h\sin\beta}{\sqrt{\sin^2\alpha - \sin^2\beta}}\right)^2} = 1$$

This equation is seen to represent a circle when the angle α is 90°, an ellipse when α is between β and 90°, a parabola for $\alpha = \beta$, and a hyperbola for α less than β.

All the bows observed were ellipses. It was possible to measure the lengths of the major and minor axes by having an assistant walk around the bow, this assistant, of course, being continually directed by the observer. The track left by the assistant in the dew was an ellipse and its axes could easily be measured. To calculate the lengths of the axes from the equation given above we may take $\beta = 42°$ and $h = 5.4$ ft. To get α the length of the shadow of a tall tower, of known height, was measured immediately after the assistant had traced out the dewbow in the grass. Results of this calculation are compared in the table below with the results of direct measurement for bows seen about 11:30 P. M., November 30 and December 1, 1925.

		Major axis (feet)		Minor axis (feet)	
	α	Obs.	Calc.	Obs.	Calc.
Nov. 30......	69.3°	11 to 14	13.5	10 to 13	11.8
Dec. 1......	59.0°	19	19.9	13	14.3

The agreement is as good as could be expected because the bows were not very sharply defined.



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(*Continued from page 506*)

The acceleration of growth: PROFESSOR THOMAS B. OSBORNE and LAFAYETTE B. MENDEL.

The factors which determine the possibility of growth may be classed, with respect to the organism involved, as internal or external in character. The internal factors include the real impulse to grow, of whatever nature it may be; in part they are inherited, they belong to the permanent biological characteristics of the individual. Heredity, with all that it involves, determines the most potent of these internal, constitutional incentives and conditions of growth. These are the determinants which are largely beyond our immediate control, yet must be reckoned with when defects of growth appear. The external factors, such as air, light, warmth, food, etc., that modify growth, on the other hand, are more amenable to directive regulation. The environment as well as the food of the individual can be modified more or less at will. Here, then, is a possible point of attack.

In the course of the past fifteen or more years we have had an opportunity to secure records of the rate of growth of several thousand rats under controllable conditions with respect to diet and environment. The animals have been bred from laboratory stock without any introduction of "new blood" within the past ten years. The stock diet during this period has presumably remained essentially the same so that changes in the average rate of growth may perhaps be properly attributable to the effects of selective breeding in the attempt to secure vigorous animals for experimental use. A noticeable increase in the average rate of growth has in fact resulted. For example, the average time required by male rats to grow from 60 gms. to 200 gms. body weight has gradually decreased; it was approximately 94 days in 1912; 89 days in 1913; 70 days in 1919; 67 days in 1925; the last rate of gain being somewhat better than that noted in the majority of records currently available. It represents at best the growth advantage secured through attention to inherent or hereditary factors.

From time to time we have observed instances of exceptionally rapid growth under conditions of diet and environment seemingly the same as those to which animals exhibiting the average rate of growth were subjected. This in itself indicates a *possibility* of largely accelerated growth that might be secured more generally if the underlying causes could be correctly ascertained. Chance observations indicated to us some time ago that diet may be concerned therein. Thus when a number of rats were placed upon a special ration that experience had suggested as more nearly "ideal," there resulted what seemed to be a "lesser variability" in the individual rates of growth; and the average for the period already referred to was decreased to 38 days. Subsequent experiments involving among other changes an increase in the protein content of the ration, particularly during the earlier period of growth, and the inclusion of liberal amounts of seemingly heterogeneous sorts of food materials, such as lettuce, liver or yeast, have promoted remarkably rapid gains in numerous instances. An outstanding illustration is afforded by rats—selected, it must be remembered, from our stock colony—that have grown from a body weight of 60 gms. to 200 gms. in less than 25 days, in contrast with approximately 70 days usually required by comparable animals. Records of these unusual accelerations of growth will be exhibited.

It need not be assumed that food itself determines the rate of growth; it merely gives the natural growth impulse fair play in a way that may not always have been recognized hitherto. The maximum size of animals growing at these accelerated rates is in general not unduly large, although frequently it has been decidedly larger than the average. The possibilities here involved raise numerous questions of both theoretical and practical interest. First of all, what is the nature of the chemical substances that may be responsible for the phenomena? Are we dealing with a more adequate supply of some essential that is ordinarily present in suboptimal proportions in the diet? Are there specific stimulants to growth? The effect that growth at highly increased rates may have upon the normal development of individual organs and the correlation of organ systems needs to be ascertained; likewise any influence upon the development of maturity, as represented by the capacity to breed. Indeed, it remains to be determined whether the maximal opportunity for the growth impulse may perchance lead to physiological detriment while chronological advantages are secured.

Emotional stimulation of medulliadrenal secretion: PROFESSOR W. B. CANNON and S. W. BRITTON.

In 1911 Cannon and de La Paz (1) reported that blood taken from the inferior vena cava, central to the openings of the lumbo-adrenal veins, in a cat which had been excited by a barking dog, gave a positive test for the presence of medulliadrenal secretion, whereas the test was negative in blood taken from the same region in the same animal before excitement. Although indirect evidence obtained by other investigators since then has indicated an increased secretion of adrenin in great emotional disturbance, and, although Hartman, McCordock and Loder (2), observing the reaction of the completely denervated iris, have reported some effects explicable as being due to increased secretion during excitement, the observations made in 1911 have not been directly confirmed. The failure of confirmation is mainly ascribable to difficulties in devising suitable methods.

Recently a method has been devised of complete denervation of the heart with survival of the animal (3). The denervated heart is affected by changes in the blood circulating through it. It is accelerated by the presence of secretion from the thyroid gland, from the liver and from the adrenal medulla. Removal of the stellate ganglia in denervating the heart also denervates the thyroid gland. If in addition the nerves to the liver are severed, the only remaining glands with known cardio-accelerating internal secretion are the adrenals. The denervated heart is extraordinarily sensitive to medulliadrenal secretion—it is made to beat faster when adrenin is present in the perfusing fluid in the ratio of one part to more than a billion (4). As a method for testing medulliadrenal secretion the heart separated from the nervous system and undergoing an internal perfusion has a number of advantages over other methods. Chief among them is the possibility of securing a continuous record, which reveals the latent period, the period of greatest response and the gradual subsidence of activity. The method also yields indication of the intensity of effect induced by various circumstances.

By use of the denervated heart as an indicator, we have studied the influence of different conditions on medulliadrenal secretion. Our results may be summarized as follows:

1. Even slight muscular activity, such as that involved in rising from a resting position, or in walking after being recumbent, is associated with an increase of heart rate. This does not occur after one adrenal gland is removed and the other denervated. It is remarkable that even with slight activity of the body there is concurrent discharge from the adrenal medulla.

2. Emotion, as evoked in a cat by the presence of a dog and as indicated by such signs of excitement as erection of hairs, showing of teeth, drawing back of the ears, hissing and snarling, is associated with increase of medulliadrenal secretion. In these reactions there is no movement of the large muscles. The increase of heart rate may not be much greater, however, than that which is seen after moderate activity. Nevertheless there is considerable variation in the response, and when the signs of sympathetic innervation (*e.g.*, erection of the hairs) are extreme, the evidence for coincident increased medulliadrenal secretion is more marked.

3. The denervated heart is extraordinarily accelerated when muscular activity is combined with emotional excitement. Whereas a change from a recumbent position to walking may increase the rate from 10 to 15 beats per minute and emotional excitement without noteworthy muscular activity may increase the rate about 20 beats per minute, the rage and struggle which the animal exhibits when tied to a holder, or the aggressive action with rage which the animal engages in when caged and barked at by a dog may accelerate the heart as much as 70 or 80 beats per minute. These reactions do not occur when the adrenal medulla is not functioning. After excluding medulliadrenal secretion, the increase of heart rate seen in such animals, kept alive and in normal health, was from 5 to 10 beats per minute. The acceleration of the heart, therefore, must have been due to increased secretion of adrenin.

The effects produced by emotional excitement accompanied by struggle are recovered from slowly. In one instance such activity lasting only a minute caused cardiac acceleration which did not subside until twenty-two minutes had passed.

The foregoing results indicate that control of the voluntary elements in an emotional response may remarkably lessen the degree of the bodily disturbance. They also show that there may be prolonged upsetting of the functions of the body as a consequence of emotional excitement.

Calcium metabolism studies; (A) *severe calcium disturbances and severe anemias produced by cultures from oral infections from patients with anemia;* (B) *calcium metabolism disturbances associated with active dental caries of childhood and pregnancy;* (C) *the raising of serum calcium by topical applications of raw and activated cod liver oil* (illustrated): WESTON A. PRICE (introduced by Victor C. Vaughan).

The reddish-blue arcs and reddish-blue glow of the retina: Seeing your own nerve currents through bioluminescence: CHRISTINE LADD-FRANKLIN (introduced by Henry H. Donaldson).

A simple band of bright red light thrown upon a screen in a dark room gives rise to a very curious phenomenon—discovered in the first instance by Purkinje. What you see on the screen is not only the red band, but also, projecting out from it on both sides, big slightly reddish blue arcs—they are not of the color of the visual purple, which is a slightly bluish red. If one considers the shape and the angular size of these arcs, it is perfectly plain that what one sees, as an entopic phenomenon, is certain fibers of the optic nerve which lie on the surface of the retina and which proceed to their exit point, the papilla. But why are they visible? The explanation that has been given of this phenomenon hitherto, by Gertz, by Troland and by others, is that the nerve current by which one sees the red band gives rise to a secondary induced current in adjoining nerve elements. Such a current as this, however, would not be provided with the right "place coefficients"—it would not enable one to see the stimulated fibers in the place where they lie. Various details of the phenomenon—the blue glow (which has been entirely overlooked by most observers), the after image, the absence of the effect in the case of individuals who have myelinated fibers in this region of the retina and other considerations—make it probable that the real cause is a bioluminescence on the part of the stimulated nerve fibers; the important work of Nodon (*Comptes rendus*, 1924) makes it very certain that this is what is actually taking place, and that in consequence all nerves when stimulated shine by their own light—a light which is invisible, of course, when the nerves are not non-myelinated.

"The principle of minimum work II"—"The oxygen exchange in capillaries": CECIL D. MURRAY (introduced by L. J. Henderson).

To what degree should blood be reduced in the tissue capillaries if, at constant metabolic rate, the process of oxygen transport is to be most efficient? If normal arterial blood is to be completely reduced, a capillary volume approaching infinity is theoretically required; if the reduction is infinitesimal, the rate of blood flow must approach infinity. An examination of this antagonism shows that normal operation of the circulation is characterized by a balance between the work of maintaining capillary blood volume and the work required to drive blood through the capillaries—a balance which makes the total work a minimum.

Changes in the blood during exercise (illustrated): L. J. HENDERSON, A. V. BOCK, D. B. DILL, L. M. HURXTHAL and J. S. LAWRENCE.

The control of communicable diseases in the mobilization of armies: VICTOR C. VAUGHAN.

Experimental pellagra in rats: JOSEPH GOLDBERGER and R. C. LILLIE (introduced by Victor C. Vaughan).

Teletactile audition: ROBERT GAULT (introduced by Victor C. Vaughan).