lunar valves and in this position is firmly tied. The clamp on the rubber tube is then completely opened. The filter tube is raised to enclose the heart and its top closed with moist cotton.

For perfusion simply to maintain the heart-beat as long as possible we have had the greatest success with Locke's fluid as given by Baylis,[5] with the difference that it was buffered with 100 mg of sodium bicarbonate and 50 mg of primary sodium phosphate per liter.

We have found that the size and shape of the cannula and the care with which it was tied in the proper position in the aorta were very important in the success of the experiment. The cannula must be sufficiently large to permit the fluid expelled by the beating heart to flow rapidly back through it. The tip of the cannula must be above the semi-lunar valves so that at the beginning of the beat the full pressure of the perfusion fluid is not exerted on the wall of the ventricle. A complete relaxation of the ventricles is necessary to insure a proper perfusion of the coronary vessels. This will not be possible if the cannula projects beyond the semi-lunar valves into the left ventricle and maintains a constant distention of the ventricle. Even when the cannula is correctly inserted a certain amount of fluid accumulates in the ventricles. This may come from leakage past the valves or from the Thebesian vessels. It is for the rapid release of the pressure of this fluid as the heart contracts that it is necessary to make the aperture of the perfusion cannula as large as possible. If, in spite of all precautions, a distention of the ventricle does develop during the experiment it may be relieved by inserting a cannula through the pulmonary vein and the mitral valves into the ventricle. It is obviously necessary to be certain that the tip of the perfusion cannula does not project so far into the aorta that its wall occludes the opening into the coronary arteries.

As the perfusion continues, the pressure in the gasometer is maintained at a constant level by admitting oxygen from the tank as necessary. Oxygen is permitted to bubble slowly through the perfusion fluid by adjusting the level of the funnel of the trap. If the fluid in the flask becomes exhausted it is merely necessary to fill another flask and replace the one originally used.

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SPECIAL ARTICLES

THE PERIHELION OF MERCURY

THE law of Newton states that every particle of matter in the universe attracts every other particle with a force that varies directly as the product of the masses and inversely as the square of the distance. For two bodies this law gives accurate results (a), as they are very far apart and (b), as their dimensions are small in relation to the distance between them but, when two bodies of substantial size are near together and when a small body is near to a large one, there is ground for doubting its precision.

Let the formula for the force of gravitation F, be written,

$$F = G\frac{M_1}{d} \times \frac{M_2}{d}$$

G being the gravitational constant, M_1 and M_2 the individual masses of two bodies and d the distance between their centers. From this it may be inferred that gravitation is the resultant of two forces each varying directly as the mass which produces it and inversely as the distance from the other. These forces are directed toward each other. Each acts at the distance d from the other and their product is the resultant which is called Gravitation.

If the above proposition be true, then the actual attraction between two spheres can not be the same as that which is computed on the supposition that the entire mass of each is concentrated at its center as on the basis of the inverse square.

In Fig. 1, M_1 and M_2 are homogeneous spheres, M_2 being very small, and $M_1M_2 = d$. The inner circle

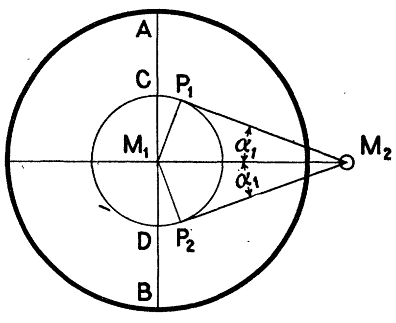

FIG. 1

CP_1P_2 DC is drawn so that $M_1C = 0.4244M_1A$ and it is, therefore, the locus of the centers of gravity of all the halves of the circle AB which is a diametral section of M_1; M_2P_1 and M_2P_2 are tangents to this circle and P_1 and P_2 are the points at which the resultant attractions on M_2 of the upper and lower semi-circles of M_1 may be considered as concentrated. The value of the attraction of each of the semi-circles, if a rep-

[5] Baylis, "Principles of General Physiology," p. 211. London. 1927.

resent its area, is proportional to $a \cos\alpha_1$, where α_1 is the angle $P_1M_2M_1$ and, as the attraction varies inversely with the distance, the attractive force exerted by each semi-circle on M_2 is, if g is a constant and since P_1M_2, the distance at which this force acts is $d \cos\alpha_1$,

$$\frac{\mathrm{ga}\cos\alpha_1}{\mathrm{d}\cos\alpha_1}=\frac{\mathrm{ga}}{\mathrm{d}}$$

The attractive force of the upper semi-circle is exerted on M_2 in the direction M_2P_1 and its component along M_2M_1 is ga $\cos\alpha_1/d$ while, for the entire circle, the attraction is g 2a $\cos\alpha_1/d = g\ A\ \cos\alpha_1/d$. If now, the circle AB is rotated through 180° it will generate the sphere AB and what is true for each of its sections will be true for its mass. The attraction of M_1 for M_2 therefore is, $gM_1\cos\alpha_1/d$ and, in an exactly similar manner, the attraction of M_2 for M_1 is $gM_2\cos\alpha_2/d$. The total force of attraction F, which is that of Gravitation, between the two spheres is, then, the product of the individual forces, thus,

$$\mathrm{F}=\frac{\mathrm{g}\ \mathrm{M}_1\cos\alpha_1}{\mathrm{d}}\times\frac{\mathrm{g}\ \mathrm{M}_2\cos\alpha_2}{\mathrm{d}}=\mathrm{g}^2\frac{\mathrm{M}_1\cos\alpha_1\times\mathrm{M}_2\cos\alpha_2}{\mathrm{d}^2} \qquad (1)$$

and this, when G is written for g^2, is an advanced statement of the law of gravitation.

The relative acceleration f of the spheres M_1 and M_2 therefore is,

$$\mathrm{f}=\mathrm{G}\frac{\mathrm{M}_1\cos\alpha_1+\mathrm{M}_2\cos\alpha_2}{\mathrm{d}^2} \qquad (2)$$

In nearly all cases $\cos\alpha_1$ and $\cos\alpha_2$ are so close to unity that no practical difference between the above formula and that of Newton can be detected. However, the value of $\cos\alpha$ for the Sun, at the distance of Mercury, is such as to point a reason for the observed "advance" of the perihelion of that planet. To this end the acceleration of Mercury has been computed for three positions with the center of gravity of the Sun's semi-circular area at 0.28 of its radius from its center and the following tabulation presents the values of the exponent of d in Newton's law which are necessary to produce the accelerations given by formula (2) above.

Position of Mercury	Necessary exponent of d in Newton's Law
Aphelion	2.00000013
Mean	2.00000019
Perihelion	2.00000031

Allowing for the longer time spent by Mercury in the outer portion of its orbit, the mean value of the exponent of d necessary to conform the law of Newton with formula (2) is 2.000000192 and this is comparable with the value of 2.000000161 which was suggested[1] in order to account for the then known advance of 42″ per century in the position of the perihelion point. Now, if the exponent 2.000000161 accounts for an advance of 42″, then the exponent 2.000000192 represents an advance of 50.″1 per century, which value compares with the recent determination[2] by Morgan of 50.″9.

The quantitative agreement which has been shown between the observed and the computed values for the advance of Mercury's perihelion is of especial interest and the principles on which this finding is based extend into many fields. The placing of the center of gravity of the sun's semi-circular section at the 0.28 point of its radius is merely a recognition that the density of the sun increases toward its center. In a homogeneous sun this ratio would be 0.4244.

A detailed outline of the studies on which the conclusions herein presented are founded is being prepared.

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SOME FACTORS INFLUENCING THE SUSCEPTIBILITY OF ALBINO RATS TO INJECTIONS OF SODIUM AMYTAL[1]

IN an earlier account[2] of the use of sodium amytal (Lilly) as an anesthetic for albino rats a sex difference in the reaction to the drug was noted. The concentration of the solution in which the anesthetic was given was found to have a marked effect upon its efficacy. These two facts have been investigated in an attempt to analyze further the action of the anesthetic.

A record has been kept of the amount of sodium amytal in a 10 per cent. solution required to produce anesthesia in male animals of weights ranging between thirty and four hundred grams. These animals have been anesthetized in experiments of various types during the past year and a half. From these individual records Fig. 1 has been composed. A total of over one thousand observations have been made on animals of varying weights.

In the graph the weight of the animals has been plotted against the milligrams of sodium amytal in a 10 per cent. solution necessary to produce a deep anesthesia from which the animal will recover. This extends the observations on the dosage required for

[1] Simon Newcomb, article, "Gravitation." Encyclopaedia Britannica, 9th Edition.

[2] H. R. Morgan, *Jour. Optical Society of America*, Vol. 20, p. 228.

[1] The sodium amytal used in these experiments was generously furnished by Eli Lilly and Company.

[2] J. S. Nicholas and D. H. Barron, *Jour. of Pharmacol. and Exper. Therapeut.*, 46: pp. 125–130, 1932.