

which leads us to believe that these tissues would also have become disease-producing. Liver, kidney cortex and heart (for one exception, see (D+) heart, Table I) constitute another group, all the tissues of which gave rise to dietary disease in planarian worms, regardless of what vitamin was present or absent, or what type of basal diet was consumed by the animals furnishing the tissues. This last statement requires an important modification. We found that when fresh, green kale served as the source of vitamin C, liver, kidney cortex and heart of the animals so fed were never disease-producing for planarian worms. The nature of this effect of green plant tissue upon the tissues of guinea pigs is under investigation at the present time. In this investigation we are demonstrating, from the condition of the guinea pigs themselves, that the use of vitamin A from certain other sources beside butter does not affect the outcome; neither have other sources of vitamin C beside kale, such as tomato juice, orange juice and ascorbic acid, a protective effect.

The results presented in this paper correlate with those detailed in a recent publication by the authors. (Wulzen and Bahrs.³)

8439 C

Relative Actions of Di-hydro-morphinone Hydrochloride and Morphine Sulphate on the Excised Ureter and Bell's Muscle.*

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It has been shown that morphine sulphate, when added to the bath in which an excised pig's ureter is contracting, increases the general tonus and increases the rate and force of the rhythmical contractions of the tissue.¹ These findings have been supported by those of Ockerblad, Carlson and Simon² on the intact human ureter. Recently Krueger and Howes,³ Gruber and Brundage,⁴ and Mitchell

³ Wulzen, Rosalind, and Bahrs, Alice M., *Physiol. Zool.*, 1935, **8**, 457.

* This research was made possible through a grant from the Therapeutic Research Committee of the Council on Pharmacy and Chemistry of the American Medical Association.

¹ Gruber, *J. Pharm. and Exp. Therap.*, 1928, **33**, 191.

² Ockerblad, Carlson and Simon, *J. Urol.*, 1935, **33**, 356.

³ Krueger and Howes, *J. Pharm. and Exp. Therap.*, 1934, **51**, 139.

⁴ Gruber and Brundage, *J. Pharm. and Exp. Therap.*, 1935, **53**, 120

and Harned⁵ showed that dilaudid hydrochloride is about 10 times more active than morphine sulphate in bringing about an increase in the general tonus of the intact dog's intestine. Experiments on the excised intestine do not give the same results.⁶ On the excised strips of intestine the actions of these 2 drugs were alike.

The experiments here described were done to determine the relative effects of dilaudid hydrochloride and of morphine sulphate on the longitudinal segments of the excised cat's ureters and Bell's muscle.⁷ The method employed was practically the same as that previously described.⁸ Longitudinal segments of the ureters of cats which had just been killed by a fatal blow on the head were used in all instances. The temperature of the bath, the time interval, etc., were the same as those cited before.

A record was always made of the behavior of the tissue, to serve as a control, before the addition of either drug. Thirty experiments were performed on the excised ureters of 10 cats in which the action of each drug was determined. Fourteen experiments were performed on 10 segments of Bell's muscle in which morphine sulphate and dihydromorphinone hydrochloride were each used.

Dilaudid hydrochloride and morphine sulphate in doses of 25, 50, and 100 mg. were added to the 100 cc. of Tyrode-Locke's solution in which the muscle was immersed. In each case both drugs were tested as to their effects on the same tissue. In some cases morphine was tested first, in others the dilaudid was added first. In either case, the tissue was thoroughly washed with Tyrode-Locke's solution between the additions of the 2 drugs.

Our results show that dilaudid is no more effective than morphine, if as much so, in stimulating the excised ureter of the cat. In many instances 50 and 100 mg. of dilaudid hydrochloride when added to the bath, had no effect in establishing rhythmical contractions, whereas the same amount of morphine sulphate, when added to the bath after thorough washing of the tissue, did establish rhythmical contractions.

Similar results were obtained in the experiments in which Bell's muscle was used.

Because of the frequency with which dilaudid failed to establish

⁵ Mitchell and Harned, *J. Pharm. and Exp. Therap.*, 1935, **58**, 331.

⁶ Gruber, Brundage, DeNote, and Heiligmann, *J. Pharm. and Exp. Therap.*, in press.

⁷ Bell, *Medico-Chirurgical Trans.*, London, 1812, **3**, 171.

⁸ Gruber, *J. Pharm. and Exp. Therap.*, in press.

rhythmical contractions in cases in which morphine sulphate did establish them, it appears to us that dilaudid is not as active as is morphine in establishing and stimulating rhythmical contractions in the excised longitudinal segments of the ureter and of Bell's muscle of the cat.

8440 P

Relation Between Basal Metabolism and Minute Volume of Circulation.

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One of the main functions of the circulation is the transportation of oxygen. *A priori*, reasoning would indicate that there is a close correlation between oxygen consumption and rate of oxygen transportation. Grollman¹ expressed this supposed relationship in his "cardiac index" which correlates minute volume at rest with square meters of body surface. He defines "cardiac index" as the minute volume per square meter of body surface. In a large series of determinations on normal individuals, he found that his "cardiac index" was 2.2 liters per square meter of body surface. The standard deviation in this series of determinations was 0.3. Grollman's cardiac index does not take into account the variability in the basal metabolic rate of normals. As we know, this rate varies —15 to +15 in any large series of normal cases. Believing that a better cardiac index could be obtained by taking into consideration the basal metabolic rate, we have constructed a formula which fits the determination somewhat better than the Grollman index. Our formula which was developed from our own data is minute volume = $2.2A \left(\frac{100 + \text{BMR}}{100} \right)$ where A = the body surface in square meters and BMR is the basal metabolic rate expressed in the usual way. In other words, we would define cardiac index as the minute volume per square meter body surface at 0% basal metabolic rate. When this formula is used to calculate the minute volume, it is found that the determined minute volume will differ only very slightly from the calculated minute volume. In our work we did not confine ourselves solely to normal persons. We used not only a

¹ Grollman, *The Cardiac Output of Man in Health and Disease*. Charles S. Thomas, 1932.