

THE MECHANICS OF THE DIGESTIVE TRACT

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The mechanics of the digestive tract by Walter C. Alvarez

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BY

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WITH TWENTY-TWO ILLUSTRATIONS



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THESE PAGES ARE
AFFECTIONATELY DEDICATED
TO
MY FATHER AND MOTHER

PREFACE

IN 1913, while doing some work on the absorption of gases injected into loops of intestine, I noticed differences in irritability in different parts of the bowel; that is, the jejunum reacted actively to distention, while the ileum generally responded but little. It promptly occurred to me that this graded difference in irritability might account for the downward progress of food in the bowel, because it seemed reasonable to suppose that material would have to move from the more irritable and active regions to the less irritable and active ones. While attempting to show these differences in irritability with excised segments of intestine, I found that the rate of rhythmic contraction of the muscle is graded downwards from the pylorus to the ilcoecal sphincter. Remembering how much the heart specialist has profited by the careful study of conduction along a similar rhythmic gradient from the sinus node to the ventricle, I was filled with the hope that a careful analysis of the gradient found in the bowel might throw light on the mechanism of peristalsis and might put more system into the science of gastro-enterology.

As time goes on that hope seems more and more likely to be realized. During 1915, gradients of rhythmicity, irritability and latent period were found in the stomach; and a sort of pacemaker was located on the lesser curvature near the cardia. Later, my assistants and I showed that in addition to the rhythmic gradients in the stomach and intestine, and probably underlying them, there are gradients in metabolism. Ways were found in which these chemical gradients can theoretically be upset; and actually they were found upset in many of the sickly or distempered animals studied.

While this laboratory work was going forward, a careful review was made of our knowledge of peristalsis both in health and disease; and it was found that the idea of a gradient of forces which can be flattened or reversed offers the best, the simplest, and often the only explanation for many of the phenomena observed by the physiologist, the internist, the roentgenologist and the surgeon.

In 1920, at the kind invitation of Dr. J. T. Case, then President of the American Roentgen Ray Society, I prepared a short summary of my views which was presented before the Society's meeting in Minneapolis as the First Caldwell Lecture. This little book has developed as an elaboration and amplification of that lecture. I only hope it will be a help and convenience to those practitioners and roentgenologists who are already finding the gradient theory useful in their work, and who wish to know more about the subject. I have tried to make it sufficiently technical for the research worker in physiology and yet sufficiently readable and practical for the medical student or the physician who is looking for help on a clinical or surgical problem. Such students and practitioners will find summed up in Chapters IV, VIII, IX, X and XI most of the data essential to an understanding of the mechanics of digestion; and with the help of the extensive bibliography and the paragraphs at the end of Chapter XII, they can easily gain access to everything else of value which has been written on the subject. I think the chapter on technic will be helpful to research workers, because the information embodied in it has hitherto been scattered through many articles in different languages.

Although many of the observations upon which the idea rests have been verified repeatedly, and although, as Wallace says, "there is no more convincing proof of the truth of a comprehensive theory than its power of absorbing and find-

ing a place for new facts, and its capability of interpreting phenomena which had been previously looked upon as unaccountable anomalies," I must, in all fairness to my readers, emphasize the fact that much of what is written in Chapters IX and X is purely suggestive. Thus we can easily show that there is a rhythmic gradient down the intestine; we can show that the gradient is upset in a distempered dog; and we can show with excised segments *in vitro* how easy it is to reverse a normal gradient by adding certain poisons like KCN to the Locke's solution. We can speak positively about those things, but we must be careful when we come to say that the reversal found in the sick dog is responsible for the refusal of that dog to eat, and for the inability of his stomach to pass onward the food which has been forced upon him. The observations are highly suggestive; the theory based upon them is proving very useful in explaining the phenomena of indigestion, but we must not lose sight of the fact that it is a theory; that it has weak places, and that much work must yet be done upon it.

As such work will undoubtedly modify or invalidate some of the interpretations which seem logical at this time, it would certainly have been safer and perhaps better if I had left out much of the theorizing which now enters into this little book. By so doing I could undoubtedly have saved myself from future regrets and criticism. I feel, however, with Darwin, that "without speculation there is no good (or) original observation," and that "the observer can generalize his observations incomparably better than any one else." In other words, it would seem that one who has wrestled with a problem day and night for many years, and who has collected all sorts of data bearing upon it, should be most fitted to theorize, to suggest, and to point out the possible applications of his work. He can furnish