ments also indicate that other combinations of anions other than those in which citrate is used also give synergy but more work remains to be done to establish this point. Citrates, of all the salts tried, certainly give the most pronounced synergy.

Studies concerning the causes of the effects mentioned above and a more complete treatment of the subject are in progress, all of which it is hoped may appear in the near future.

[1] Lipman, C. B., *Bot. Gaz., Chicago*, **48**, 1909, (105); *Centralbl. Bakt., Jena*, 36, 1912, (390). Loeb, J., *J. Biol. Chem., New York*, **28**, 1916, (175).

[2] Osterhout, W. J. V., *Science, New York*, N. S., **35**, 1912, (112).

[3] Osterhout, W. J. V., *Bot. Gaz., Chicago*, **60**, 1915, (228).

APPETITES AND AVERSIONS AS CONSTITUENTS OF INSTINCTS

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Communicated by R. Pearl, October 18, 1917

The overt behavior of adult animals occurs largely in chains and cycles, and it has been held[1] that these are merely chain reflexes. Many years of study of the behavior of animals—studies especially of the Blond Ring-Dove (*Turtur risorius*) and other pigeons—have convinced me that, though innate chain reflexes constitute a considerable part of the instinctive equipment of doves, few or none of their instincts are mere chain reflexes. On the contrary, each instinct involves an element of appetite, or of aversion, or both.

An *appetite*, so far as externally observable, is a state of agitation which continues so long as a certain stimulus, the appeted stimulus, is absent. When the appeted stimulus is at length received it releases a consummatory reaction, after which the appetitive behavior ceases and is succeeded by a state of relative rest, a state of satisfaction. The appetitive behavior serves to bring about the appeted situation by trial and error. The appetitive state includes a certain *readiness* to act. When most fully predetermined this has the form of a chain reflex. But in the case of many supposedly innate chain reflexes, the reactions of the beginning or middle part of the series are not innate, or not completely innate, but must be learned by trial. The end action of the series, the consummatory action, is always innate. One evidence of this is the fact that in the first manifestation (also, in some cases, in later performances) of many instincts, the animal begins with an *incipient consummatory action*, although the appeted stimulus, which is the adequate stimulus of the consummatory reaction, has not yet been received.

Thus the young dove when learning to drink makes drinking movements while searching for the water; and when its instinct to fly has ripened, it may make feints of flying, flapping its wings vigorously, and even aiming at an objective point, before it has dared to launch into the air. There are all *gradations* between a true reflex and a mere readiness to act, mere facilitation. In many cases the bird needs to *learn* to obtain the adequate stimulus for a complete consummatory reaction, and thus to satisfy its own appetites.

An *aversion* resembles an appetite in that it is a state of the organism characterized by agitation and persistency with varied effort; it differs from an appetite in that it continues so long as a certain stimulus, referred to as the disturbing stimulus, is *present*, but ceases, being replaced by a state of relative rest, when that stimulus has ceased to act on the sense organs. An aversion is sometimes accompanied by an innately determined reaction adapted to getting rid of the disturbing stimulus, or by two *alternative* reactions which are tried and interchanged repeatedly until the disturbing stimulus is got rid of. An example of aversion is the so-called jealousy of the male dove, which is manifested especially in the early days of the brood cycle. At this time the male has an aversion to seeing his mate in proximity to any other dove. The sight of another dove near his mate is an 'original annoyer.'[2] If he sees another dove near his mate, he may follow either or both of two courses of action; namely, (*a*) attacking the intruder, with real pugnacity; (*b*) driving his mate, gently, not pugnaciously, away from the intruder. The instinctive aversion impels the dove to truly intelligent efforts to get rid of the disturbing situation.

Instinctive activity runs in *cycles*. The type cycle, as it were a composite photograph representing all such cycles, would show four phases as follows.

Phase I. Absence of a certain stimulus. Physiological state of appetite for that stimulus. Restlessness, varied movements, effort, search. Incipient consummatory action.

Phase II. Reception of the appeted stimulus. Consummatory reaction in response to that stimulus. State of satisfaction. No restlessness nor search.

Phase III. Surfeit of the said stimulus, which has now become a disturbing stimulus. State of aversion. Restlessness, trial, effort, directed toward getting rid of the stimulus.

Phase IV. Freedom from the said stimulus. Physiological state of rest. Inactivity of the tendencies which were active in Phases I, II, III.

Some forms of behavior show all four phases clearly. In other cases one or other of the phases is not clearly present. When the bird shows appetitive behavior but fails to obtain the appeted stimulus, the appetite sometimes disappears, due to fatigue or to drainage of energy into other channels. But some instinctive appetites are so persistent that if they do not attain the normal appeted stimulus they make connection with some abnormal stimulus; to this the consummatory reaction takes place, the tension of the appetite is relieved, its energy discharged, and the organism shows satisfaction. This is 'compensation' in the sense in which that word is used in psychiatry. The cycles and phases of cycles are multiplied and overlapped in very complex ways. Smaller cycles are superposed upon larger ones. The time occupied by each varies greatly, from cycles measured in seconds to those that occupy a year or even longer.

The successive phases are not sharply separated, Thus, from the last phase of one cycle in a series to the first phase of the succeeding cycle, there is often a gradual rise of appetite; active search for satisfaction does not commence until a certain intensity of appetite is attained. This is what is known in pedagogical literature as 'warming up.' This gradual rise of the energy of appetite is followed (Phases II–III, or II–IV) by its sudden or gradual discharge. The rise and discharge are named by Ellis,[3] in the case of the sex instinct, 'tumescence' and 'detumescence.' They are important phases in the psychology of art, in which sphere they are named by Hirn[4] 'enhancement' and 'relief.' The discharge (Phase II) is also exemplified in 'catharsis' in art and in psychiatry.

All human behavior runs in cycles which are of the same fundamental character as the cycles of avian behavior. These appear in consciousness as cycles of attention, of feeling, and of valuation. This description is true not only of our behavior toward objects specifically sought by instinct, such as food, mate, and young, but also of our behavior toward the objects of our highest and most sophisticated impulses, such, for example, as a symphony concert. The entire behavior of the human being is, like that of the bird, a vast system of cycles and epicycles, the longest cycle extending through life, the shortest being measured in seconds, each cycle involving the rise and the termination of an appetite. This view helps us to understand the laws of attention; for example, the law that attention cannot be held continuously upon a faint, simple stimulus. For as soon as such a stimulus is brought to maximum clearness, which constitutes the consummatory situation, the appetite for it is quickly discharged and its cycle comes to an end. This familiar fact illustrates the general truth that we, like the birds, have but a very limited power of altering the ebb and flow of our behavior cycles. Cyclical recurrence does not prove that human behavior consists of mere chain reflexes, neither does it prove that the instinctive behavior of birds consists of mere chain reflexes.

Doctor Raymond Pearl read a preliminary draft of this paper and suggested important improvements, for which I express my thanks.

The article of which this is an abstract will appear in the *Biological Bulletin*.

[1] Herrick, C. J., *Introduction to Neurology*, 1915, (61).

[2] Thorndike, E. L., *The Original Nature of Man*.

[3] Ellis, H., *Studies in the Psychology of Sex. III. Analysis of the Sexual Impulse*.

[4] Hirn, Y., *The Origins of Art*.

RAPID RESPIRATION AFTER DEATH

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Communicated by G. H. Parker, October 20, 1917

Various observers[1] have reported that respiration may continue after death but apparently the rapidity of post mortem respiration does not in any of these cases exceed the normal rate. It is therefore of interest to find that the marine alga *Laminaria* in the presence of certain reagents may respire more rapidly after death than in its normal state.

In my experiments the rate of respiration was determined by measuring the output of CO_2 (at 16°C.) by means of suitable indicators added to the solution which had been rendered acid by the respiration of the *Laminaria*. The method has been previously described.[2]

As soon as a determination of the respiration had been made, the solution bathing the tissue was renewed and after exposure for the same length of time the amount of respiration was again determined. In this manner the respiration of the material could be followed and it could be seen whether it was approximately constant before the beginning of an experiment. This constancy was obtained in all the experiments here recorded.

In some cases (acetone 17.4% and alcohol 24.2%) the killing agent extracted from the plant a small amount of pigment which interfered with the color of the indicator.[3] But this difficulty disappeared after the first two periods, as was shown by running pure hydrogen through the solution, after which it returned to the color found in normal sea water plus indicator. This method also showed conclusively that the acid excreted by the plant was CO_2 and not an organic acid.