Contents

I. Introduction
II. Acknowledgments
III. Materials
IV. Physiological states
   1. Rigidity and attachment
      a. Persistence for weeks
   2. Locomotor
      COORDINATION IN THE STARFISH
   3. Resting of "active unoriented" state
   4. Comparison of the physiological states of the different species studied.
V. Responses of a single tube foot
   W. F. HAMILTON 1893 –
   a. Contraction
   b. Direction of extension
      1. Locomotor starfish
      Approved:
      2. Stationary starfish
   c. Rigid starfish
   d. Mechanism
      1. Normal
      2. Isolated tube
   e. Mechanical
      Received in the library December 10, 1930
      N. Howell, Librarian
      a. Conditions
      b. Physiological state
      c. Strength of attachment
      d. Structures involved in attaching
      1. Attaching reactions of isolated tube feet

Contents

I. Introduction

II. Acknowledgments

III. Materials

IV. Physiological states
   1. Rigidity and attachment
      a. Persistence for weeks
   2. Locomotor
   3. Resting or "active unoriented" state
   4. Comparison of the physiological states of the different species studied

V. Responses of a single tube foot
   1. Extension
      a. Conditions of extension
      b. Direction of extension
      1. Locomotor starfish
      2. Stationary starfish
      3. Rigid starfish
   2. Attaching
      a. Conditions
      1. Physiological state
      2. Strength of attachment
      3. Structures involved in attaching
      1. Attaching reactions of isolated tube feet

728925
Contents

I. Introduction
II. Foundation

Materia

IV. Psychological aspects

A. Similarity of effect and attainment
B. Tolerance for need
C. Inoculation
D. Resting on "seating metaphor" base
E. Comparison of the psychological aspect of the different
species reached

V. Response to a single type load

A. Extension

B. Conditions of extension
C. Direction of extension
D. Inoculation analysis
E. Cost-benefit analysis
F. Right answer

VI. Mechanism

A. Motor
B. In Inoculation type test
C. Reasoning continues
D. Psychological aspects of the

VII. Acceptance

A. Conditions
B. Psychological aspects
C. Reflection of approach
D. Efficiency of inoculation
d. Dependence of attaching reaction in isolated tube feet upon physiological state of organism.

e. Attaching by only a part of the ambulacral disk.

3. Releasing of attachment and withdrawal

a. Result of stimulation of side of column.

b. Response to stimulation of the disk.

c. Detaching and withdrawal of isolated tube feet.

d. Detaching and withdrawal as a response to physiological conditions in the nervous system.

4. The step reflex.

a. Intergradations with drawing response.

1. Difference in extension

2. Difference in withdrawing.

b. Description of the step reflex.

c. Significance of extension during back sweep.

d. Analysis of the contact stimulus which initiates the step reflex.

e. Analysis of the factors governing the orientation of the step reflex.

1. Extension determined by "physiological anterior" of animal.

2. Lashing back determined either

a. by location of contact stimulus or

b. the condition of relative excitability of the different parts of the longitudinal musculature.

D. Status of the attaching reflex during the step reflex and its modifications.

g. Relation of the attaching reflex to the amount of resistance to the step.

1. Methods of studying.

2. Numerical expression of this relationship Asterina 2.7


e. Harmony of essential condition to improve form and

f. Requirement of appropriate arrangement and arrangement:

g. Benefit of arrangement or improvement of form:

h. Response to arrangement of the form.

i. Evaluation and improvement of teaching steps also.

j. Determination and arrangement as a component of psychology.

k. Contribution to the various areas.

l. The gap between:  

m. Interaction in psychological knowledge.

n. Difference in experience:

o. Difference in participation:


q. Evaluation of the contact attention with the interaction and

r. Gap.

s. Attraction of material to maintain the enthusiasm of

The next factor

f. Attention to the psychological emphasis of

(Initiation:  

e. Parity of psychological evaluation of

f. Parity of psychological evaluation of the alignment.

The reason of the alignment before and after each factor and the

satisfaction.

The relationship of the alignment factor to the amount of satisfaction

f. Purpose of acquisition.

The important emphasis on the psychological emphasis.

S
3. This is no expression of the relative attaching ability of these animals when not in the locomotor state.

h. Strength of the step reflex (pulling ability)

1. Pulling ability in Pisaster ochraceus
2. Pulling ability in Asterina miniata

1. On a solid substrate with and without additional weight on its dorsal side.
2. On sand with and without load
3. Pulling ability in Pycnopodia helianthoides

1. On said substrate with and without load
2. On sand with and without load.

VI. Coordination of the tube feet.

1. Preliminary description
2. Coordination in the tube feet of the rigid starfish
   a. Retraction
   b. Extension
   c. Nervous mechanism
3. Coordination in the gills
   a. Ciliary currents in gills.
4. Coordination that involves some orientation of the tube feet.
   a. Coordination to attached tube foot and step reflex.
5. Coordination to passive movements of tube feet.
   a. After twisting tube foot.
6. Coordination of the tube feet in active starfish.
   a. Tendency of each arm to migrate in its own direction.

VII. Formation of the unified impulse.

1. General statement of the mechanism of the positive response
2. General description of the negative response.
3. Detailed description of positive and negative responses in Pycnopodia.
4. Orientation as a result of stimulating the dermal net, or a general stimulation of all the tube feet.

5. The significance of the negative behavior of the isolated rays.

VIII. Behavior of the starfish when under the influence of the unified impulse

1. Positive reaction to contact and other stimuli.

2. Negative reaction to contact and other stimuli.

3. Physical as distinguished from physiological orientation.
   a. Direct orientation of the tube feet of the leading ray from unilateral stimulation.
   b. Acceleration of the lateral rays by stimulation or by mechanical factors.
   c. Retardation of the lateral rays by stimulation or by mechanical factors.

IX. General consideration of coordination.

1. General consideration of the factors involved in governing the direction of locomotion in the starfish and their very delicately inter-related balance.

2. Theories of the mechanism of coordination.

3. Orientation of retracted tube feet and the independence of the mechanism of orientation, and that of withdrawal or stepping.

X. The breaking up of the coordinated impulse into areas in which the tube feet are oriented in different directions.

1. The adaptiveness of this response as illustrated in
   a. The righting reaction
   b. The deviation reaction
   c. The locomotor starfish with curved lateral arm.

2. Physiological explanation not to be found in hypothetical "Complex coordination center"
3. Possible physiological explanation in the traction on the tube feet resulting from the movement of the rays over the substrate.

a. Application of this to Mangold's starfish, to the righting starfish and to the deviating starfish.

b. Evidence that the traction of the substrate does orient the tube feet.

1. Direct evidence inconclusive.

2. Evidence from neurotomized animals.

3. Evidence from the behavior of the animal when its parts are placed on separate substrates.

4. Evidence from the deviation reaction.

1. Deviation reaction not interfered with by cutting nervous connections with inter-radial area.

2. Deviation reaction not elicited by prodding inter-radial area.

3. Quantitative aspects of the "deviation push" with different weights on the animal vary with mechanical conditions while quantitative aspects of stimuli required to initiate the negative reaction do not.

4. Operation of a tendency to return to original direction.

XI. Coordination of movements of the tube feet with those of the arm as a whole.

1. Illustrations of the tendency of an arm to set itself more nearly at right angles to its actively oriented tube feet, when such movements involve dorsal and ventral flexion and lateral twisting.

2. Ventral flexion of rigid, of injured, and of nicotinized starfish.
3. Description of various other correlated movements of the tube feet and arms.

4. Description of the formation of the coordinated impulse when the tube feet are free of the substrate.

Although the behavior and physiology of starfish and other echinoderms have been given the attention of many an eminent naturalist, it was hoped that an intensive study of the problem of coordination in the several species available would bring to light the tube feet are prevented attaching by inverting the animal on sand.

5. Correlation of these movements with the righting reaction.

a. Analyses of Jennings seven types of righting reactions.

6. Description of the righting reaction as it occurs when the tube feet are free of the substrate.

XII Interpretation of the righting reaction as a phase of locomotion.

The work was commenced in the autumn of 1917, but in December was interrupted by fourteen months' service in the army. Between February 1918 and June 1919 I have spent most of my free time experimenting upon and observing the activities of starfish. It would be quite impossible to set down my data in full, following each experiment and observation out in detail, for reasons of space alone. By evidence, therefore, has undergone a rather severe selective process. Evidence from the movements of the tube feet and arms.

1. Evidence from the fact that stimulation of the dorsal myodermal sheath is not an essential factor in the righting reaction.

2. Evidence from the persistence of the "unified impulse" in the same direction, to a degree quantitatively comparable to its persistence in ordinary locomotion (Cole).

I wish here to express my thanks to Professor S. J. Holmes under whose direction the following study has been made, for his careful criticisms and his many helpful suggestions. I am greatly indebted to Professor W. K. Fisher, of the Hopkins Marine Station of Stanford University, for his courtesy in putting the facilities of his laboratory at my disposal, and for his help in collecting and keeping alive the material. He was also kind enough to determine the species I worked upon. I wish also to express my thanks to Professor S. S. Maxwell and T. C. Burnett, of the Physiology department of the University of California for their helpful advice.
The idea that any given formative moment of the work of art can be replaced by any amount of information as a point of focus.

The assumption that the emergence of the idea of the momentary loss is the moment of the moment.

The recognition of the contribution of the information to the momentary moment.

Is the moment of the information to the momentary moment.

Information to the momentary moment of the information (197).
INTRODUCTION

Although the behavior and physiology of starfish and other echinoderms have been given the attention of many and eminent naturalists, it was hoped that an intensive study of the problem of coordination in the several species available would bring to light some data, that might prove of interest to the physiologist and general zoologist.

The work was commenced in the autumn of 1917, but in December was interrupted by fourteen month's service in the army. Between February 1919 and June 1920 I have spent most of my free time experimenting upon and observing the activities of starfish. It would be quite impossible to set down my data in full, following each experiment and observation out in detail, for reasons of space alone. My evidence, therefore, has undergone a rather severe selective process.

ACKNOWLEDGEMENTS

I wish here to express my thanks to Professor S. J. Holmes under whose direction the following study has been made, for his careful criticism and his many helpful suggestions. I am greatly indebted to Professor W. K. Fisher, of the Hopkins Marine Station of Stanford University, for his courtesy in putting the facilities of his laboratory at my disposal, and for his help in collecting and keeping alive the material. He was also kind enough to determine the species I worked upon. I wish also to express my thanks to Professor S. S. Maxwell and T. C. Burnett, of the Physiology department of the University of California for their helpful advice.
INTRODUCTION

Attention the committee on physiology of animal and human life have been given to the questions of what may amount to an attempt to define life and death. The question of whether life is an active process of the brain or a passive state of rest has been raised. In the recent decade, some attempts have been made to explore the relationship of the brain to life and death.

The work was announced to the science of 1917, and in the December issue of the Journal of Journeys in the Summer 1920, I was quoted as saying: "It is necessary to define the state of rest and its relation to life and death."

The importance of studying the brain in relation to the activities of life and death is emphasized. The brain is the center of activity, and its function is essential to life. The study of the brain and its activities is therefore important in the understanding of life and death.

I also wish to express my thanks to the committee and to the university, and I am greatly indebted to them for their help in the preparation of this report.
To my wife, for her many cheerful sacrifices and her willing help in numerous ways, is due my fullest gratitude.

MATERIALS.

The following starfish were studied intensively:

*Pisaster ochraceus* (Brandt)

*Echinopodia helianthoides* (Stimpson)

*Asterina miniata* (Brandt)

Supplementary observations were made on the following echinoderms:

*Leptasterias equalis* (Stimpson)

*Pisaster brevispinus* (Stimpson)

*Evasterias troschelii* (Stimpson)

*Strongylocentrotus franciscanus* (Agassiz)

Professor J. K. Fisher writes me as follows "Jennings (1917) worked on *Asterias pertulifera* Xantus. I have the actual specimen sent, for identification to the Museum of Comparative Zoology. Verrill calls the same species *Orthasterias gonalena*." Jennings uses the name *Asterias forrerri* De Loriol.

So far as I am aware, the above seven species are the only Pacific coast starfish, whose physiology has been described.

PHYSIOLOGICAL STATES

*Pisaster ochraceus*, was collected from the wharves in Oakland harbor for study in the zoological laboratory of the University of California. For study in the laboratory of the Hopkins Marine Station they were obtained from the surf beaten rocks in front of the building.

A remarkable difference was evident in the physiology
To the right, for paper work, submit correspondence and reports

deadline.  This is to ensure that they go on time.

Particular

The following articles were submitted for publication:

[Articles listed]

Subsequent to average we note here on the following

[Further articles mentioned]

In the interest of "average" we follow "general" because we feel that in the interest of "average" we follow "general".

"Average" articles are the same as the "average" articles.

This means that we are not the only

[Further notes on submission of articles]

In the interest of "average" we follow "general" to the point

[Further details on submission]

A tentative article and submission to the publication.
of the specimens taken from these two locations, which was not, so far as I was able to determine, due to the salinity of the water in the aquaria, its temperature, freshness, air content or the food needs of the animal, but responses in spite of present stimulations. We shall inquire. 

*Pisaster* taken from the surf-beaten rocks were very inactive, would attach tightly for long periods of time to the substrate, and could not be excited to active locomotion by the most varied, persistent, or continued stimulation. The water in the aquaria was running freely and would keep these animals alive and other animals (starfish, crabs, sea-urchins etc.,) alive and active indefinitely.

The specimens of *Pisaster ochraceus* taken from Oakland harbor presented, when fresh, activity of an almost opposite nature. It was quite as difficult to get them to stop crawling as it was to get those from the surf beaten rocks to start. In some specimens this state of extreme activity never appeared; but in the large majority it appeared when the animals were first put in the aquarium and, continued, interrupted by rest periods of greater or less extent, for from two hours to two months, is wholly different.

The only specimen from the surf-beaten rocks at Pacific Grove which showed this marked locomotor activity was one that had been in the quiet water of the aquarium for nearly three weeks. At the end of this period the animal forsook the tight clinging which had occupied it during its struggle to maintain a foot hold on the rocks and began active migration. I have observed that on a horizontal substrate I have observed.

The specimens occurring on piles in the relatively quiet waters of Oakland harbor do not attach very tightly, though they can do so when disturbed and are not nearly so prone to attach when brought to the aquarium.

I am not inclined to attribute this behavior to "learning"
The scientific paper you chose to present, which we have
on the topic of the water in the

...
(see Sterne 1891) nor even to habit formation (Jennings 1907), but would explain it more simply as a very marked and striking example of "physiological inertia": (Jennings 1907) or the tendency to continue past responses in spite of present stimulations. We shall inquire further into the nature of this tendency. (see also Romanes & Swart (1881), Freyer (1886), Mangold (1908b), Bohn (1908), Cowles (1911), Holmes (1911), Cole (1913a).

To the two physiological states above noted, the one of extreme rigidity and attachment and the other of active locomotion with the arms more or less extended and flexible we may add a third state in which the arms are extended as in the locomotor state but the tube feet are not oriented in any particular direction as they are in the locomotor animal. The tube feet are more or less active and not tightly attached.

Animals in these three states will be referred to as (1) locomotor or crawling starfish, (2) rigid starfish and (3) active but unoriented, or resting starfish respectively. In these different states the animal's behavior is wholly different.

Pycnopodia helianthoides the large 20 rayed "sun star" present these same physiological states in quite as marked a manner as Pisaster. I have never observed Pycnopodia to assume the rigid or attached state when on a horizontal substrate. It will attach quite readily to a vertical substrate, and with such tenacity that it is very difficult to remove it, but on a horizontal substrate I have observed it

In study the factors which govern simple extension of the tube feet it is necessary then to invert the animal on its aboral side, or better yet to suspend it head in the water. Thus are avoided the disturbance of contact stimulation.
(Continued from page 76.) The...
only in the locomotor, or resting (active but unoriented) state.

In Asterina the physiological states are not well differentiated. The animal does not attach tightly though it does become rather rigid and inactive. The locomotor state is clear, although in the unoriented state one often sees the animal make lurches, as if it crawled in this and then in that direction without actually doing so.

The other starfish observed seem to present different physiological states more or less analogous to those described for Pisaster.

In the following pages we shall discuss the responses of the tube feet as individual organs, their coordination among themselves, and the relation of these movements to the coordination of locomotion and righting.

**RESPONSES OF A SINGLE TUBE FOOT**

The tube foot of a normal starfish may exhibit the following responses, which vary, as we shall see, with the physiological state of the animal: (1) extension, (2) attaching, (3) withdrawal, (4) step reflex.

**EXTENSION**

Conditions of extension

(1) Extension of the tube feet is best seen in the active starfish upon the absence of those stimulations which normally cause a withdrawal of the tube foot or complicate its extension by inducing the activities of attaching or "stepping."

To study the factors which govern simple extension of the tube feet it is necessary then to invert the animal on its aboral side, or better yet to suspend it freely in the water. Thus are avoided the disturbance of contact stimulation.
To indicate the situation at present. The position of the forces and the situation in the area is crucial. It is clear that the forces in the area are in a strategic position to influence the outcome of the situation.

In the current situation, the forces have the advantage of controlling the situation. The forces are well-organized and ready to attack.

Facts about the situation:

1. The forces have the advantage of controlling the situation.
2. The forces are well-organized and ready to attack.

In conclusion, the forces are in a position to influence the outcome of the situation.

FOR THE NEXT 24 HOURS:

The forces should maintain their current position and prepare for the next move.

Important notes:

- The forces have the advantage of controlling the situation.
- The forces are well-organized and ready to attack.

In conclusion, the forces are in a position to influence the outcome of the situation.
Direction of extension

The extension is conditioned in direction by the locomotor activity of the animal as a whole. If the starfish is migrating in the direction of a certain arm, for instance, the tube feet will, in the absence of contact stimulation extend themselves in this direction, and remain so extended until stimulated either to retract or execute the step reflex.

In the stationary, non-rigid starfish the tube feet of the outer part of the ray are, in the absence of contact simulation, extended more or less toward the tip of the ray and moving ("feeling") about in that direction. This of course is not constant and is most noticeable in the most active specimens. Starfish that are inactive or in the rigid state do not extend the tube feet as much as do individuals of the active non-locomotor type. The most noticeable difference between the behavior of the tube feet of such a starfish and those of a normally active one is that the former are not directed out from the tips of the rays. They may be waving about approximately at right angles to the ray or even directed somewhat toward the center.

Mechanism

The mechanism of extension, first described by Reamur (1710) in a very interesting paper is well known. It involves a contraction of the ambulacral ampulla and a relaxation of the longitudinal musculature of the tube foot. To ascertain the dependence of this relaxation of the longitudinal musculature on the radial nervous system, tube feet were cut off and tied on to the end of a capillary glass tube. This was connected with a column of sea-water arranged so that the pressure could be
Illegible text due to the quality of the image provided.
increased or decreased by raising or lowering a reservoir, which was connected to the capillary tube by a long rubber tube. If the tube feet were injected with water at a pressure of 10 cm (H₂O) they would slowly extend in the absence of contact stimulation but not to their whole normal length. The extension was much slower than the active extension of a normal tube foot and not so complete. If caused to contract and then injected with a pressure of more than 2 cm (H₂O) the extension was not appreciably accelerated but could be made more complete. Tube feet anaesthetized in MgSO₄ would extend completely under low pressures. This anaesthetization involved also relaxation of the circular muscles so that the tube foot presented a noticeably greater diameter than the normal tube foot. In the extended as well as the contracted tube feet there was a quite constant curvature in the direction of a clear longitudinal line up the shaft of the pedicel which I take to be the pseudohaemal canal (Cuenot 1888) This curvature persists in the anaesthetized (or dead) pedicel and is therefore probably due to mechanical rather than to physiological factors.

Active tube foot preparations were allowed to extend and assume their normal curvature toward the pseudohaemal canal, and then were bent slowly and gently in some other direction. They showed a tendency to remain bent in that direction and then slowly to bend back to the original curvature. An anaesthetized or a dead tube foot does not show this behavior. It is hence physiological in its nature and is perhaps analogous to the behavior of a sea-urchin's spine when bent over to one side (Von Uexküll 1900).

Attaching

Attaching is conditioned by the physiological state of...
the organism. The tube feet of Pisaster in ordinary locomotion do not attach very strongly. When in the rigid appressed state, however, they are so tightly adherent that many may be pulled off before the animal can be removed from the substrate.

**Strength of attachment.**

Mr. Weymouth of the physiological department of Stanford University informs me that he has released the tube feet of such a starfish one by one with a needle until there were just enough tube feet adhering to suspend the animal from the lower surface of a glass plate. The estimated area of the disks of these tube feet multiplied by atmospheric pressure was approximately equal to the weight of the starfish thus showing that these organs are mechanically quite efficient.

**Structures involved in attaching.**

Attaching is a reflex which, though it may be modified by outside factors, involves necessarily only the muscular and nervous structures of the pedicel.

Tube foot preparations were made as above from actively attaching starfish, great care being exercised to quickly and gently. It was found upon placing such a tube foot against a substrate that in about five cases out of ten, it would attach and hold against considerable tension (in one case enough to tear off a part of the disk). This power of attaching was lost after a few trials.

**Dependence of attaching reaction in isolated tube feet upon physiological state of organism.**

Tube foot preparations were also made from starfishes that were not attaching (in active locomotion, feeling about the surface film, etc.) These did not attach.
The interpretation of this phenomenon is rather difficult. It is well known that when an attached starfish is pulled off from its substrate, many of the tube feet will be torn off and may remain attached to the substrate for some time. The experiment shows further that such a tube foot may reattach even tho it be unconnected with the radial nervous system (see also Botazzi 1898 and Russo 1913).

It is well known, also, that some times a a starfish is very prone to attach its tube feet tightly to the substrate while at other times the animal's energy is taken up with locomotion or some other activity that does not entail tight attachment of the tube feet (Jennings 1907). The experiment shows also that there is a difference in the behavior of the isolated tube feet which corresponds to the fluctuation of the attaching reaction of an animal from time to time.

According to Von Uexkull, the contraction of a muscle is due to "Tonus" which is metaphorically referred to as a fluid, that is carried to the muscle through the nerves. Furthermore (1903) by cutting the nerve which has supplied this tonus, the "fluid" may be entrapped in the muscle, and the muscle remain contracted. While this theory has not been very widely accepted, some of its aspects are partly congruent with the behavior of isolated tube feet.

Tube foot preparations, however, that are capable of attachment do not present any differences in appearance from those that are not capable of attachment. Thus they are not influenced by entrapped "tonus" in the sense of Von Uexkull because "tonus" elicits contraction or tension in the muscles it affects and the tube feet under observation did not seem to differ in this respect from tube feet which would not attach to a substrate. In fact they differed from tube feet taken from a starfish in active locomotion only in being in such a state of physiological activity that the
The interaction of the phenomenon is termed "difficulties."

In my opinion, this may be attributed to the fact that the phenomenon is not sufficiently understood. The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

In my opinion, also, there seems to be a relation to the phenomenon in 1868 and 1878.

To some extent, there seems to be a similarity to the phenomenon in 1868.

The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

In the opinion of the phenomenon, there seems to be a relation to the phenomenon in 1868 and 1878.

The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

I believe that the phenomenon is not sufficiently understood. The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

To some extent, there seems to be a similarity to the phenomenon in 1868 and 1878.

The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

In the opinion of the phenomenon, there seems to be a relation to the phenomenon in 1868 and 1878.

The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

I believe that the phenomenon is not sufficiently understood. The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

To some extent, there seems to be a similarity to the phenomenon in 1868 and 1878.

The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

In the opinion of the phenomenon, there seems to be a relation to the phenomenon in 1868 and 1878.

The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

I believe that the phenomenon is not sufficiently understood. The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

To some extent, there seems to be a similarity to the phenomenon in 1868 and 1878.

The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

In the opinion of the phenomenon, there seems to be a relation to the phenomenon in 1868 and 1878.

The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

I believe that the phenomenon is not sufficiently understood. The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

To some extent, there seems to be a similarity to the phenomenon in 1868 and 1878.

The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

In the opinion of the phenomenon, there seems to be a relation to the phenomenon in 1868 and 1878.

The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

I believe that the phenomenon is not sufficiently understood. The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

To some extent, there seems to be a similarity to the phenomenon in 1868 and 1878.

The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

In the opinion of the phenomenon, there seems to be a relation to the phenomenon in 1868 and 1878.

The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

I believe that the phenomenon is not sufficiently understood. The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

To some extent, there seems to be a similarity to the phenomenon in 1868 and 1878.

The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

In the opinion of the phenomenon, there seems to be a relation to the phenomenon in 1868 and 1878.

The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

I believe that the phenomenon is not sufficiently understood. The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

To some extent, there seems to be a similarity to the phenomenon in 1868 and 1878.

The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

In the opinion of the phenomenon, there seems to be a relation to the phenomenon in 1868 and 1878.

The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

I believe that the phenomenon is not sufficiently understood. The phenomenon shows some similarity to the phenomenon in 1868 and 1878.

To some extent, there seems to be a similarity to the phenomenon in 1868 and 1878.

The phenomenon shows some similarity to the phenomenon in 1868 and 1878.
attaching reflex is the one that contact stimulation elicits.

It would seem, then, from the difference in behavior of tube feet taken from animals in different physiological states that this state of specialized irritability is a condition of the ambulacral disk and while engendered, most probably, by influences proceeding from the radial nervous system, is not dependent upon that system for a rather limited continuance.

**Attaching by only a part of the ambulacral disk.**

The attaching reflex does not necessarily involve all of the ambulacral disk. The end of a small rod was placed on various parts of the lower surface of a large actively attaching pedicel. The part in contact with the end of the rod attached with great force, such that an attempt to withdraw the rod resulted in pulling a portion of the disk out of shape. A fine hook was laid flat against the disks of tube feet so that the disk in contact with the instrument was hook-shaped and attached to the hook quite strongly. In fact, any part of various disks was found to attach even to the point of a needle, when this was applied gently enough. These experiments were repeated upon isolated tube foot preparations with the same result.

The disk as an attaching mechanism, then, does not act as a whole (Preyer 1896), but rather the incupping occurs toward the center of any properly stimulated area.

**Withdrawal**

Releasing and withdrawal as a result of stimulation of side of column.

Release of attachment and withdrawal are two responses
To many people, sound* and silence are essential components of the
sound and image of society. Acoustics of sound and silence are among the
most important factors in the coordination of the society. Silence is not
always negative, as it can also be a powerful tool for communication.


type for a better future communication.


type for a better future communication.


type for a better future communication.


type for a better future communication.


type for a better future communication.


type for a better future communication.


type for a better future communication.


type for a better future communication.


type for a better future communication.


type for a better future communication.


type for a better future communication.


type for a better future communication.


type for a better future communication.


type for a better future communication.


type for a better future communication.


type for a better future communication.


type for a better future communication.
that are closely analogous. If a starfish is tightly attached to the side of the aquarium, to get it off without injury to the tube feet, one has but to stimulate the sides of the tube feet sharply with the edge of some flat instrument that will slip under the starfish. This stimulation causes the release of the stimulated tube feet and sometimes the release of neighboring tube feet.

If a starfish be inverted or suspended, when not exhibiting a locomotor tendency, and the side of an extended tube foot be touched even very lightly, there is an immediate collapse and withdrawal of the tube foot. Careful observation of the phenomenon leads one to think that it is a result, first of the relaxation of the ampulla and second of a contraction of the longitudinal musculature of the tube foot.

Withdrawal as a response to stimulation of the disk.

If the tube feet show a tendency neither to locomotion nor to attachment, this same withdrawal reaction follows the stimulation of the disk.

Usually, however, there is a tendency toward attachment which does not necessarily interfere with the presence of the withdrawing reaction. This conclusion was reached from a study of the reactions of tube feet to very light suspended objects. A small piece of thin celluloid, suspended by a thread, was brought in contact with extended (non-locomotor) tube feet. The first response, usually was found to be attachment. After this, depending on conditions which will be...
discussed in connection with the step reflex, a slight extension sometimes occurred due probably to an increased tension of the ampullar muscles. Next, in sequence in the non-locomotor tube feet was the retraction of the tube foot and a consequent moving of the piece of celluloid toward the ray. This does not involve release of the substrate by the disc as does the withdrawing on stimulation of the side of the column and is probably the response of the tube feet that is involved when the animal shrinks down on the substrate after having been disturbed.

Detaching and withdrawal of isolated tube feet.

An isolated tube foot preparation does not show typical withdrawal reactions, because of course, the reciprocal action of the ampullae is absent. Harsh stimulation of the column of the attached tube foot preparation was found to cause release.

Shortening by a slow contraction of the longitudinal musculature was found to follow severe stimulation of any part of the tube foot, even against a strong water pressure.

Response to internal changes

Release and withdrawal of attached tube feet may occur as a response to a change of internal physiological conditions. Thus an animal all of whose feet were tightly attached, one minute, may the next minute be seen in active locomotion about the aquarium. The factors governing this response will be taken up elsewhere.

The Step Reflex

Intergradation with withdrawing response.

The step reflex is I think, merely a modification of the

The first description that I can find of the 'step-reflex' is that given by Reamur (1719). After describing the morphological connection of the ampullae ('tiny pearl like' balls) and the 'legs' (tube feet) he goes on to say 'But one brings out the whole ingenious mechanism of it when one presses the finger on one of the 'balls.' It is seen to empty and at the same
in connection with the present action.

In the case of the present action, the question is whether the evidence adduced at the trial was sufficient to establish the facts set up in the claim for relief. It is not necessary to determine the exact nature of the evidence, but it is sufficient to say that the evidence was sufficient to support the finding of the court that the defendant was guilty of the offense charged.
time, the 'leg' which corresponds to it becomes inflated and elongated. Finally it is seen that on cessation of the pressure the balls refill and the legs become empty and shorten themselves, and it is nothing more than this that the starfish does in extending its legs to press upon the balls, as one may do at any time with his finger. It is easy to imagine a thousand ways in which the starfish can do this. The compressed balls discharge their water into the legs which they inflate and thus extend, but when the starfish ceases to press on the balls, the natural elasticity of the legs, which is considerable causes them to shorten. These legs, thus elongated the animal uses in locomotion by extending them out toward the body to which the animal wishes to move and attaching to it at a very acute angle. The strength with which the leg remains affixed to this body while trying to make a right angle with this same surface obliges the animal to approach.

Of the withdrawing reflex as a response to contact stimulation of the disk. The intergrading steps depend upon the presence to a greater or less degree of a locomotor tendency. This expresses itself, in the inverted or suspended starfish, as already shown by an orientation of the extended tube feet in the direction of the physiological anterior. If the locomotor impulse is not very strong, the only modification perhaps that will be observable in the withdrawing reaction, will be an exaggeration of the tendency to extend after the contact stimulation and before the withdrawal.

With the increase of the locomotor impulse comes a change in the behavior of the tube foot which integrates both with the withdrawing response and the step reflex. This change is a further increase in the above noted tendency to extend, caused no doubt by an increase in the tension of the ampullar muscles. This complicates the withdrawing action, and then results, for reasons which we will take up later a more rapid contraction of the muscles on one side of the pedicel than on the other. This gives rise to a lateral movement of the tube foot which increases in extent with the increase of the locomotor impulse, from a slight bending (fig. 3) of the tube foot to one side, to an active lashing back (fig. 4) of the disk with sufficient force to throw a grain of sand some few centimeters.
To the British^70^71/j^71 The fogg^72^73 The primary interest as a response to a request for information on the progress of a project. The atmosphere of the project continues to evolve and change as new information is gathered. The project is not yet complete, but it is moving forward. The completion of the project is expected to be significant in the future.

After the completion of the project, the team will analyze the data collected in the project. The analysis will be used to make decisions about the future of the project. The team will also use the data to make recommendations to the stakeholders. The recommendations will be reviewed and discussed with the stakeholders. The recommendations will be implemented as needed. The completion of the project will provide valuable insights into the future of the project. The insights will be used to make decisions about the future of the project.

The completion of the project will provide valuable insights into the future of the project. The insights will be used to make decisions about the future of the project. The completion of the project will provide valuable insights into the future of the project. The insights will be used to make decisions about the future of the project.
Description of the step reflex.

Under ordinary circumstances of locomotion, this lateral movement is followed by retraction and the retraction by re-extension in the direction of locomotion. This involves contact with the substrate and the stimulations which give rise to the repetition of the lashing back, the retraction and the re-extension. These movements which involve, as shown in detail later, attachment to the substrate, are those of ordinary locomotion. Each tube foot, acting independently as to time but in harmony with its fellows as to direction, repeats these movements as long as contact stimuli result from extension and the locomotor impulse remain unimpaired.

Physiological description of the step reflex involves a tendency to describe an arc, as it does would attachment about so very slight (See also Magats 1908). It is this tendency to describe an arc, to keep fully extended as the disc is pushed back, that keeps the animal well off the substrate during locomotion.

A further analysis of the step reflex raises the question?
The step reflex, as set off by the disc reflex in one of gentle contact on the disc contact in the absence of harsh stimulation at the disc results in a single withdrawal. In the absence of contact stimulation, there is no approach toward the step reflex. I have seen a sample of nematocyst in its left in shallow water, remaining with a view of the S. S. W. (Verrett 1885) lose feet extended in locomotion (the direction changing from time to time) for half an hour, with none of the tube feet planting the disc. Occasionally, however, a slight object, such as a piece of sand, was placed on the tub feet and the step reflex immediately set in all of the tube feet. A result the significance of extension during backsweep.

Jennings (1920, p. 99) describes the step reflex in terms of the behavior of a tube foot on a solid flat substrate. Thin clear glass was used as the substrate, but it could not be seen at all, under water, but a light object the tube feet could be clearly followed by observation. In which the pedicels were executing the move in figure 1.9.7. Jennings diagram of tube foot step.

Physiologically the animal performs the sets describing an arc, as it does when the stimulating object is very light (see also Mangold 1908). It is this tendency to describe an arc, to keep fully extended as the disc is pushed back, that keeps the animal well off the substrate during locomotion.

A further analysis of the step reflex raises the question...
(1) What is the stimulus which sets it off? (2) What factors govern its orientation? (3) What is the status of the attaching reflex in the various stages of its accomplishment. (4) What is the relative strength of the step reflex in different species.

The stimulus

The stimulus which sets off the step reflex is one of gentle contact on the disc. Contact on the column or harsh stimulation of the disc results in a simple withdrawal. In the absence of contact stimulation, there is no approach toward the step reflex. I have seen a large Pycnopodia on its back in shallow water, remain with a large part of its 22,000 (Verrill 1914) tube feet extended in one direction (the direction changing from time to time) for half an hour, with none of the tube feet executing the step reflex. When, however, a light object, such as a piece of celluloid was placed on the tube feet the step reflex immediately started in all of the tube feet receiving the contact stimulation. As a result the piece of celluloid was quickly "walked" to the temporary posterior of the starfish. The same was repeated with a very thin clear glass watch-crystal. The glass could not be seen at all, under water, but its course across the tube feet could be clearly followed by observing the area in which the pedicels were executing the step-reflex.

When a starfish in active locomotion is brought above the surface of the water the step reflex was seen to occur without further stimulus. An active specimen of Pycnopodia with the ventral side exposed to the air, presents the likeness of some strange sort of military activity. With machinery like regularity the 22,000 bright yellow tube feet...
The following text is not clearly legible due to the quality of the image. It appears to be a page from a document, but the content cannot be accurately transcribed.
extend themselves out toward the temporary anterior and then lash back vigorously in the opposite direction, exactly parallel with each other.

The true significance of this is seen if the tube feet of a part of such a starfish be submerged. Then only those tube feet that touch the surface film of the water, or those entirely exposed to the air execute the step reflex. The submerged tube feet remain pointed in the direction of the temporary anterior until some contact stimulation, from the surface film or from some solid object initiates the step reflex.

What factors govern the orientation of the step reflex?

The first phase of the reaction, the extension of the tube foot is a function of the physiological orientation of the starfish. This will be analysed further elsewhere. Now if the lashing back is to be effective in locomotion, it must take place (as it does) in the opposite direction from the extension. This, however, merely shows that the response is adaptive and is not a physiological explanation. A physiological explanation may be looked for in the location of the contact stimulation on the disc of the tube foot or in the condition of tension in the musculature of the column. The tube foot as it extends may be seen often to touch the substrate first with the point of the tube foot or it may be expected that excitation to contract caused by the contact stimulus might spread to the side of the column 1-3 and cause its contraction more quickly than to the side 2-4. Furthermore a contact stimulus at the place 2 does not elicit the step...
any form of instruction and teaching: the curriculum's emphasis on practical instruction and hands-on learning. The program offers a variety of courses in fields such as engineering, computer science, and business administration, providing students with the skills and knowledge they need to succeed in their chosen careers. The curriculum is designed to be flexible, allowing students to tailor their programs to their individual interests and career goals.
reflex with as much readiness and regularity (Pisaster) as a similar stimulus at the place 1. It must be remembered however that in normal locomotion the disc is often placed flat on the substrate, and that when the tube feet are exposed to the air the surface tension film may be expected to contract with equal pressure on all sides of the disc, and thus to stimulate them all equally. We have to count then upon the greater excitability of the muscles on the side 1-3 in the post-contact phase of the step reflex. This is comparable to the increased tension of the muscles on the side 2-4 in the pre-contact stage of the step reflex. The oscillations of the tube feet may be explained in terms of von Uexküll’s law of “tonus” or may be left unexplained. The fact is, of course, that they move back and forth in the step-reflex with considerable regularity and precise orientation. The factors that control the orientation of the animal will be taken up in connection with an analysis of coordination among the tube feet.

Status of the attaching reflex during the step reflex.

The strength of attachment during the step reflex differs as we shall see with the different species and with the amount of resistance there is to the accomplishment of the step.

In general we may assume from observation: on ordinary locomotion that the tendency to attach is strongest, during the progress of the step reflex, just after the contact. The tube foot usually remains attached during the first half of the backward oscillation, but the likelihood of release (or slipping) is found gradually to increase during the last phase of the step reflex.

A large grain of sand was placed on one of the ambulacral discs of an active Pseudopodia. The step reflex which resulted was so violent that the grain of sand was thrown as from a
miniature catapult, a distance of four or five cm. On repeating this, the elevation or "angle of fire" was seen to be such as would entail release of the grain from the disc during the third quarter of the arc that the disc describes in lashing back. Usually, however, in Pisaster, Asterina etc., the violence of the lashing back is not so great, and the release is not very sudden or prompt so that such a catapulting action is not often seen in these forms.

**Relation of the attaching reflex to the amount of resistance to the step.**

The relation of the attaching reflex to the amount of resistance to the step was obtained in the following manner: One of the rays of an Asterina was tied by a long thread to a spring recorder which was calibrated to grams and set to write on a slowly moving drum. When the animal pulled against the spring, the strength of the pull was recorded as the height of the curve above the base line. Now when the animal had pulled the spring up to various heights, the glass plate on which it was walking was suddenly slid forward in the direction of locomotion. This resulted in an increased tension on the starfish which was recorded on the drum until this tension became sufficient to cause the animal to release hold on the substrate. The curves got by this method were somewhat as follows:

![Diagram](https://via.placeholder.com/150)

1-4 is the force given by the starfish as it walks against the resistance of the spring. At 2 the glass plate was slid.
In the continuation of the treatment of the relation of 3SJ to the other theoretical aspects of the subject, it is important to emphasize the following points:

1. The relation of the treatment of 3SJ to the other aspects of the subject is not a mere repetition of what has been said before. It is a development of the ideas presented earlier, and it is essential to understand this development in order to appreciate the full significance of 3SJ.

2. The treatment of 3SJ is not isolated from the other aspects of the subject. It is a part of a larger whole, and it is necessary to see how 3SJ fits into this whole.

3. The treatment of 3SJ is not a complete solution of all the problems involved. It is part of a continuous process of exploration and discovery, and it is important to be aware of this.

In conclusion, the treatment of 3SJ is an important aspect of the subject, and it is essential to understand the relationship between 3SJ and the other aspects of the subject in order to appreciate the full significance of 3SJ.
forward and the curve 2-3 measures the amount of increased pull that
the starfish was able to resist before releasing (at 3).

The values for 12 observation on Asterina are as follows:

<table>
<thead>
<tr>
<th>Strength of pull (2 on fig.)</th>
<th>Release at (3 on fig.)</th>
<th>Strength of pull (3 in fig.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 g</td>
<td>15 g</td>
<td>3/2</td>
</tr>
<tr>
<td>3</td>
<td>127</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>321</td>
<td>1.8</td>
</tr>
<tr>
<td>9</td>
<td>624</td>
<td>2.6</td>
</tr>
<tr>
<td>12</td>
<td>936</td>
<td>2</td>
</tr>
<tr>
<td>18</td>
<td>745</td>
<td></td>
</tr>
</tbody>
</table>

Here the average 18 qu 18 av is 2.06. The 57 54 av is 2.06 the 13 as
strong to hold 18, it is to pull.

The difference in the value of 66 the figure is due to specific difference 33 between the two starfish. It is not in any 2.5
correlation. Disregarding the high values of the first three observations
due observably to the fact that certain of the tube feet were "re-
fractory", that is, had not become coordinated in the step reflex and
were simply attaching, we find that the strength of attachment of a
tube foot is on the average 2.7 times the amount of pulling the tube
foot is doing at that time (amount of resistance to the step). That is
to say, the tube feet are attached strongly enough to resist a pull
about 2.7 times as great as that to which they actually are subjecting
themselves; a factor of safety against skidding on the smoothest surface
of 2.7. The value of friction in the above experiment was tested with
the starfish inverted and found to be negligible (about 3 g). Using the
animal for, whether the relation (quotient 3/2) between the two variables
is constant, logarithmic or of some other nature can be told only after much statistical compilation of data. In Asterina it seems to
be fairly constant within the limits studied.

In Pyconopodia the relationship is even more constant, though it has a wholly different value as seen from the following table:

<table>
<thead>
<tr>
<th>Strength of pull (2 in fig.)</th>
<th>Release at (3 in fig.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>18</td>
<td>33</td>
</tr>
<tr>
<td>24</td>
<td>60</td>
</tr>
<tr>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>36</td>
<td>72</td>
</tr>
</tbody>
</table>

Here the average quotient is 2.06. The tube foot is 2.06 times as strong to hold as it is to pull.

The difference in the value of the figure is due to specific differences between the two starfish. It is not in any way correlated with ability of the tube feet to attach when not in the locomotor state. An attached stationary Asterina is very easily removed from the substrate and only once have I seen a tube foot torn off in the process. On the other hand Pyconopodia the attachment of whose tube feet during the step reflex is much less than that of Asterina, would when in the stationary clinging state hold with such tenacity to the substrate, that it was only with much patience and the loss of many of the animals tube feet that I could pull it loose. When the starfish was once released from the substrate, if the tendency to attach continued, as it often did, I was confronted with the equally difficult and much more unpleasant task of releasing the animal from my own hands. I have spent the best part of an hour disentangling the twenty-two arms of an eighteen inch Pyconopodia from myself and the side of the aquarium.
Strength of the step reflex (Pulling ability)

Not only does the ratio of strength of attachment to strength of pull vary between different species, but also the pulling ability considered alone. For instance, a small specimen of Pisaster about 12 cm in diameter was attached one noon to the recording spring and induced to pull against it. During the whole afternoon the tension varied between 40 g and 60 g. The drum was removed and the animal left tugging at the thread all night. The next morning it was pulling in the same direction but had advanced slightly. The tension during that whole day varied from 95 to 190 g. There was much activity of the tube feet when the animal was going forward or being pulled back by the spring. When the animal was holding stationary tube feet were seen to be arrested in the various phases of the step reflex so that only a portion of them were extended forward at such an angle that they could pull the animal forward. Toward evening the pulling increased and somewhere between seven and nine p.m. reached a peak of
225 g. This came from a sudden increase of pulling as shown by the curve and resulted in the arm breaking off where it was tied. The animal had thus pulled steadily at a tension of from 60 to 225 g for a period of over 33 hours. Another specimen 18 cm in diameter pulled 300 g when it was released for fear of breaking the apparatus.

Correlated with the fact that *Asterina* never attaches as tightly as does *Pisaster* is the fact that it never pulls as hard. A 10 cm *Asterina*, registered pulls of 60, 77, 69, and 46 g. in four successive trials. A smaller (8 cm) but more active *Asterina* pulled 99 g. The peak of the curve would be reached after a gradual ascent of about 20 minutes. The decline would last from one to two hours. Both the decline in the height of the curve and the fact that the pull did not last long, comparatively, are perhaps, evidences of fatigue.

To test the role of the attaching reflex in this response, the animal was put on sand and set to pulling in the same way. The best pull it could record was 7½ g. A 40 g. (weight in water) Syracuse dish was laid on top of the animal. This increased its pulling ability to 15 g. The adding of weight to *Asterina* or *Pisaster* when pulling on a solid substrate made no appreciable difference in their pulling ability.

The case of *Pycnopodia* is different as we shall see later.

---

Scheinmetz (1896) states that with respect to food taking, starfish may be divided into two types, those that swallow their food whole such as *Astraeaster* and those that pull open the bivalves on which they feed and digest them by extruding their stomach and applying it to the soft parts of the mollusc. (*Asterias*) Although *Pycnopodia* is grouped in the *Forcipulata* with *Asterias* and has tube feet, in contradistinction to those of *Astraeaster*, capable of tight attachment, it swallows its foot whole, ejecting the indigested parts. Correlated perhaps with the fact that the animal does not pull open its bivalve prey, as do most of the other *Forcipulata*, is the fact that under other conditions as well, the tube feet, though they can tightly attach, do not ordinarily do so when pulling, and consequently the animal can not pull very hard.
is different as we shall see later. The animal studied in this respect was about 50 cm in diameter, with, according to Verrill's estimate about 22,000 tube feet, each of which was extremely active. In water the animal weighed only 50 g. but in air the weight was estimated to be well over 1000 g. Such a starfish when set to pulling against the recording lever pulled 54, 45, 30, 60 g. in four trials (on different days). The time relations were similar to those of Asterina's pulling reaction (less than half an hour of increasing tension and up to two hours of declining tension).

The remarkable fact that this large and active starfish should not pull nearly as hard as an 8 cm Asterina, or less than one fourth as hard as a 12 cm Pisaster, was thought perhaps to be due to failure of the attaching reaction during the step-reflex, to keep the same relationship with the resistance to the step (pull) for these higher values, which it has shown according to the above table for lower levels. Some tube feet were seen to slip on the glass as they performed the step reflex. Other tube feet were seen to be in the "refractory state" that is to be attached tightly and to be showing no sign of the step reflex. This made it impossible to get direct evidence as to the status of the attaching reflex in the locomotor tube feet, as the "refractory" tube feet caused the release to be abnormally high.

Besides direct observation of slipping tube feet, indirect evidence that the lack of pull was due to failure of the attaching reflex in the active tube feet, was furnished by loading "balasting" the animal with 80 gm (weight under water) of Syracuse dishes placed on its dorsal side. When so weighted down, the value of the 54 g. pull was increased to 69 g. and the value of the 60 gm pull was increased to 75. The increased pulling ability was undoubtedly due to increased friction between the tube feet
and the glass. It also involved the wrenching loose of a number of refractory tube feet.

On sand it was found that the animal could pull 15 gm without load) and the load of 80 gm could pull about 32 gm.

COORDINATION OF THE TUBE FEET

Preliminary description.

When starfish were suspended and the tube feet at the end of one of the rays brought in contact with some solid object, those that touched it first were usually observed to attach. Then the neighboring tube feet oriented and extended themselves in the same direction as the attached tube feet. If opportunity offered these other tube feet attached as did the first tube feet.

If now these tube feet are stimulated sharply they retract and the neighboring tube feet also retract (Romans and Swert 1881, Preyer 1886, etc.). The wave of retraction passes down the stimulated arm, and out the other arms along the line of the ambulacral nervous system. This is in accordance with the older observers, especially Preyer (1886). They also showed that if the nervous system was cut at some point the above coordination would extend as far as the cut and no farther.

Further than the fact that it rests in the ambulacral nervous system, the mechanism of this coordination is very obscure. Physiologically, it is a fact attested so far as I am aware by all of the workers on this phase of echinoderm physiology. One tube foot seems to "imitate" in its activity the behavior of its neighbors. In the following analysis of coordination in the tube feet we shall inquire into its
EXPERIMENTAL FORMATION

The best growth of corn is obtained by the use of a generous amount of fertilizers. This is especially important in areas where the soil is poor in nutrients. Corn requires a lot of water, and it is important to ensure that the plants are well-watered throughout the growing season. In addition, corn is susceptible to a variety of pests and diseases, so it is important to monitor the field regularly and take appropriate action to prevent damage.

In order to achieve optimal yields, it is essential to use proper pest control measures. This includes the use of insecticides, fungicides, and other chemicals as needed. Regular monitoring of the crops will help to identify any problems early on, allowing for prompt action to be taken.

Corn is a valuable crop, and its successful cultivation requires careful planning and attention to detail. With the proper care and maintenance, corn can be a highly profitable crop for farmers and an essential part of the global food supply.
characteristics in the rigid starfish, and compare it with
the coordination manifested by the gills. We will also inquire
into coordination in tube feet of active but non-oriented starfish,
the building up of this coordination into the unified impulse,
the behavior of the starfish under the influence of the unified
impulse and the breaking down of this unified impulse under
various normal and abnormal conditions.

**Coordination in the tube-feet of the rigid starfish**

When rigid specimens of *Pisaster* were suspended or inverted
the tube feet, after their temporary retraction from the stimulation of loosening, were found to extend more or less at right
angles to the body of the ray. There were subsequent movements of the ray which will be considered later. Some of the tube feet
were then stimulated to retract. There was a wave of retraction
passing along the lines of the tube feet. This lessened in intensity as it proceeded from its source, so that it did not always reach the farthest tube feet. Later the tube feet would again extend the wave of extension passing back in the reverse order so that the tube feet stimulated to retract and those nearest them will be the last to reextend.

To account for this coordination in retraction and extension
it is not necessary to hypothesise very complex conditions in the nervous system at the base of the pedicels. Histologically, according to
Ludwig and Hamburger (1899), Meyer (1916) etc., the ambulaoral nervous system seems to be merely a condensation of the nerve net that extends over the outside of the myodermal sheath. So far as I am aware there is no morphological evidence of synapses in the nervous system of starfishes, though of course the evidence on this question is far from complete. A simple, nerve net will account for the above behavior.
The cooperation and support of the United Nations and other international organizations are crucial in the process of achieving peace and sustainable development. It is essential to foster a culture of dialogue and respect for diverse perspectives. Through collaborative efforts, we can address global challenges and work towards a more equitable and just world.

In conclusion, the implementation of peace processes requires a comprehensive approach that involves not only political agreements but also social and economic development. By focusing on these areas, we can create a foundation for lasting peace and prosperity for all.
It has been seen that an isolated tube foot will not contract or extend quite normally. Certain conditions then may be said to exist in the nerve net at the base of the stimulated tube foot, which affect the muscles of the pedicel and ampulla and cause the normal withdrawal (or extension) of the tube foot. Now in accord with the well known laws of transmission of excitation in a nerve net (Parker 1914) these conditions may spread in any direction (within the ambulacral nervous system) and cause the retraction or extension of other tube feet. We shall see, elsewhere that no such simple condition will account for the physiological orientation of the tube feet and their coordination in locomotion.

Coordination in gills.

The physiology of movement in the gills is quite similar to that of the tube feet in the rigid starfish. Although there is lateral movement in each there is no orientation of these lateral movements in any particular direction in the gills. A stimulus which will cause the contraction of one group of the (dorsal) gills, will be communicated to others near these and cause their retraction (Jennings 1907). In this region the nerve net is quite diffuse, so that the spread of the contraction may be in any direction. The wave of re-extension usually takes opposite direction from that of contraction. It is centripetal rather than centrifugal. If the wave of retraction is sufficiently strong it may be communicated to the tube feet and involve their retraction as well. The retraction of the tube feet does not involve the retraction of the (ambulacral) gills (De Moor & Chapeaux 1891) an evidence of polarity in the nerve net which suggests something in the nature of a synapse. That part of the nerve net which extends up the sides of the long ambulacral gills in Pisaster also shows evidences of polarization similar to the
polarity of sea anemone tentacle (Psiliser 1918) in that when stimulated at the base or middle, the musculature, especially the circular musculature, below (proximal to) the locus of stimulation contracts while that above (distal) does not contract. If stimulated at the tip the whole tentacle contracts, the circular musculature responding to a lesser stimulation than the longitudinal. If cut off at the base with scissors, the edges of both the stump and the ablated piece adhere together along the line of the cut by means, seemingly, of a sticky substance on or near the cut edges, so that the wound does not open an aperture to the exterior. The stumps of course shrivel down in strong contraction. They are found, three days later a little short but with the end healed over normally. The excised gills show no sign of contraction, and the cut end being sealed over as described above, the gill remains distended by its enclosed water like a miniature "sausage balloon" with a truncated end. The contraction of the gill musculature is not sufficient to collapse the gill against the resistance of the closed end. If this end be teased open gently and then the tip be stimulated collapse ensues immediately.

Ciliary currents in gills.

One of the gills, when thus removed was seen to enrobe several clumps of amoebocytes or wandering cells. These made it convenient to see the ciliary respiratory current which continued uninterruptedly after the gill had been removed. The amoebocytes moved up one side to the tip of the excised gill and down the other side to the base. It took three or four seconds to complete the circuit.

Coordination that involves some orientation of the tube feet.

Having studied the coordination of the non-locomotor tube feet and compared that with coordination of the gills we shall...
The article emphasizes the importance of early detection and intervention, particularly in the field of mental health. It argues that by identifying and addressing these issues at a young age, we can prevent or mitigate the long-term effects of mental health problems. The article also discusses the role of education and awareness campaigns in reducing stigma and improving access to mental health services. It concludes with a call to action for policymakers, educators, and the general public to work together to improve mental health outcomes for children and adolescents.
now take up coordination in the behavior of the tube feet during their transition stages between the locomotor and the non-locomotor state.

If a rigid starfish be suspended and some of the extended tube feet be brought in contact with a solid object, as we have already seen, they will attach. This is usually followed by increased activity of the neighboring tube feet and if the starfish is not too rigid, by their active bending toward the stimulated area. It is in this phase of their behavior, that the beginning of the step reflex can be elicited by proper stimulation.

**Coordination to passive movements of tube feet.**

If on such a starfish a long tube foot be brought in contact with a small object, such as a pencil point the disc will attach. If now, the pencil point be moved, with the tube foot still adhering so that the direction in which the tube foot is now pulled out is different from that in which it originally extended itself, other tube feet will then coordinate themselves, not in the direction of the original extension of the stimulated tube foot but rather in the direction to which it had been passively moved. This tendency to coordinate thus, while very marked in some animals, is of course apt not to show itself in starfish that are very inactive or very rigid, and is apt also not to appear at all, if there is a strongly marked coordinated impulse in some other direction. Out of thirty trials on starfish in various physiological states there was well marked and active coordination to passive movement in fifteen.

This coordination could also be brought about when the tube feet was twisted by turning the pencil a few times in the hand before pulling the tube foot over in its new direction.
In a letter bearing on employment and some of the exchange

It is a letter written to Mr. Smith, a worker who has been out of work for some time. The letter is about the possibility of obtaining employment in another area. Mr. Smith has been looking for work for a while, and the writer offers some advice on how to find employment and suggests some steps that Mr. Smith might take to improve his chances of finding work.

The letter also mentions the writer's own experience in finding employment and how he was able to find a job after some time of searching. The writer advises Mr. Smith to be persistent and to keep trying, and to seek out new opportunities.

The letter concludes with some words of encouragement and wishes Mr. Smith good luck in his search for employment.
observed no difference in the accuracy or promptness of the coordination. I have even untwisted the tube foot again, in its new position, without either disturbing the attachment of the tube foot or the coordination of its fellows. Needless to say these manipulations had to be done with extreme care to avoid stimulations which might cause retraction.

**Coordination of the tube feet in the active starfish.**

Thus far we have been discussing coordination in the tube feet of rigid non-locomotor animals. But when a very large number of tube feet are seen in the suspended specimen, pointing in one direction in a coordinated manner, one is apt to be dealing with a starfish in the active rather than in the rigid state.

If we suspend a starfish that is active, but not definitely oriented and locomoting in any one direction, we find that the tube feet at the tips and for a centimeter or more toward the disk are oriented and actively feeling out toward the tip. Proper stimulation of the tube feet at the ends of these rays will elicit the step reflex in the direction of the tip of the ray. This would indicate that each ray has a tendency to migrate in the direction it points.

**Tendency of each ray to migrate toward its tip.**

That each ray does tend to migrate away from the disk was demonstrated by attaching five glass tubes or shell vials, large enough to accommodate the ray, to five floats and presenting these simultaneously to the tips of each of the five rays, in such a way that they could each walk onto one of the glass tubes and in so doing pull it back over the ray. When the rays got to the end of the tubes they were seen either to keep on in the same direction or reverse and back out, or part way out. It was really quite amusing to watch this suspended animal industriously...
Corporation of the United States in the United States

The fact is we have been called upon to explain the process. The law is very simple. Instead of choosing one or the other alternative, we have a very simple matter to decide. In order to do so, it is necessary to consider which alternative will be best for the United States in the United States.
trying to walk in five different directions at once.

**Autotomy**

Another indication of this tendency is the fact that in stale water or under the influence of chloroform (Moore 1916) a starfish is extremely susceptible to autotomy. *Pisaster* seems much more susceptible to this reaction if the nervous system has been injured in some part. As I have observed it, the reaction consists in an exaggerated tendency in the tips of the several rays to migrate in their own direction and a failure of this tendency to effect an orientation of the tube feet of the rest of the animal in the way that will be seen below to be usual in the normal starfish. This is due to a pathological sluggishness in the action of the central part of the ambulacral nervous system, as seen from the fact that the tube feet in that region are comparatively inactive. The rays of a *Pisaster* undergoing autotomy present an elongated appearance. The tube feet at the tip pull actively, each in the direction of its own ray, so that after stretching somewhat the ray gives way, usually at or near the base.

**FORMATION OF THE UNIFIED IMPULSE**

From such a picture as the above it may seem as far call to the unified behavior of the actively walking starfish. In the latter each tube foot is put out in a single definite direction and locomotion proceeds in a beautifully unified and coordinated manner. The difference is just this, that in the unified locomotor starfish, one, or more often two adjacent rays become for some reason more active than the others and the coordinated state which is present at their tips spreads maintaining its own direction and gaining impetus, over the other rays.

It will be our purpose now to inquire into the factors which give precedence to the activity of some ray or rays in the
REGULAR EXAMINATION Income Taxation

Regulation of Income Taxation

Section 1: The Income Taxation Act

(a) Income Taxation Act (1918) (Amended 1936)

The Act provides for the assessment of income tax and the collection of tax. It also contains provisions for the enforcement of the Act and the administration of income tax.

(b) Income Taxation Act (1936)

The 1936 Act amended the 1918 Act to provide for the assessment of income tax and the collection of tax on income derived from the following sources:

(i) Salaries and Wages

(ii) Profits and Gains from Business

(iii) Interest

(iv) Dividends

(v) Royalties

(vi) Other Income

The Act also contains provisions for the assessment of income tax on property and the collection of tax on income derived from property.

Section 2: Assessment of Income Tax

The assessment of income tax is based on the income derived from the various sources mentioned above. The assessor is required to assess the income of each taxpayer and to determine the amount of tax payable on that income.

Section 3: Collection of Income Tax

The tax is collected by the government through the office of the offices of the Assessing Officer. The tax is due on the 31st day of March in the year following the year in which the income is derived.

Section 4: Enforcement of the Act

The Act contains provisions for the enforcement of the Act and the administration of income tax. The Commissioner of Income Tax is responsible for the enforcement of the Act and the administration of income tax.

Section 5: Appeal

Any person aggrieved by an assessment of income tax may appeal to the Income Tax Appellate Tribunal. The Tribunal is composed of three members, one of whom is a chartered accountant.

Section 6: Registration

Every person who is liable to pay income tax is required to register himself with the offices of the Assessing Officer.

Section 7: Penalty

Any person who fails to pay income tax on time is liable to pay a penalty equal to the amount of tax due.

Section 8: Returns

Every person liable to pay income tax is required to file a return of income with the offices of the Assessing Officer by the 31st day of March in the year following the year in which the income is derived.

Section 9: Records

Every person liable to pay income tax is required to keep proper records of his income and expenses.

Section 10: Powers of Inspection

The Commissioner of Income Tax is empowered to inspect the books and records of any person liable to pay income tax.

Section 11: Special Provisions

The Act contains special provisions for the assessment of income tax on income derived from certain sources.

Section 12: Offences

Any person who contravenes any provision of the Act is liable to be punished as provided by the Act.

Section 13: Interpretation

In case of any dispute as to the meaning of any provision of the Act, the onus of proving the meaning of such provision is on the party seeking to rely on such provision.

Section 14: Repeal

The Income Taxation Act (1918) is hereby repealed and the provisions of the Act contained herein shall come into force on the 1st day of January, 1937.

This Act shall come into force on the 1st day of January, 1937.
formation of the "unified impulse".

The responses of a starfish to stimuli, in so far as they involve locomotion, may be divided into two categories, positive responses, in which the resulting locomotion is toward the stimulus, and negative responses, in which the direction of locomotion is away from the stimulus. Gentle contact at the tip of the ray will usually elicit a positive response while a negative response usually results from severe prodding or pinching.

**General statement of the mechanism of the positive response.**

The mechanism of the positive responses, as I see it, is as follows: A gentle contact stimulation of the tube feet at the end of a ray causes these tube feet to extend in the direction of the stimulus as we have already seen. Other tube feet behind this coordinate in this action, and receiving the contact stimulation of the substrate, execute the step reflex. The impulse to coordinate with the active tube feet at the tip of the stimulated ray thus spreads to the rest of the starfish, involving after a time every tube foot in the body in coordinated locomotion.

**General description of the negative response.**

The negative response is brought about on exactly the same principle. The prodding or pinching of a certain ray results in the retraction or inactivation of the tube feet in that region and to the spread of this impulse, to certain of the other tube feet. The extent of the spread is of course determined by the strength of the stimulus.

Assuming first that the stimulation is severe enough to cause all the tube feet to retract or become inactive, the first tube feet to resume their normal function are those farthest away from the source of stimulation. In this experiment the tube feet farthest away are those of the opposite ray tips. These tube feet are oriented in the direction of their
General Introduction of the Negative Response

The negative response is the opposite of a positive one. Some principles of the negative response are frequently used in the selection of a negative response. If the negative response is selected, it is usually the opposite of the positive response. The negative response is also the antithesis of the positive response.

Assuming that the positive response is a source of information, the negative response is a source of attenuation. Some of the negative response is to cause attenuation to occur. The negative response is often used to reduce the effect of the positive response. The negative response is a useful tool in the modification of the negative impact on the positive response.
which is in fact away from the source of stimulation. In so doing they come in contact with the substrate and execute the step reflex. From this point on, the coordination completes itself in the same manner as outlined for the positive response.

In case the stimulation is not sufficient to cause the retraction or inactivation of all the tube feet, it will spread among the tube feet, to a certain extent so that the farthest tube feet are the most active and therefore will dominate in the coordination.

**Detailed description of positive and negative response in Phoronopodia.**

*Phoronopodia* on account of its large size and great activity is very favorable for a study of the mechanism of coordination in positive and negative responses. The active but not oriented animal can be represented as above, with the tube feet at the tip of each ray orinfated in the direction of the ray, and ready to give the step reflex upon proper stimulation. Now much observation has convinced me that a positive stimulation at a will result in the increase of coordinated activity in the region of . the spread of this coordinated activity in the way...
In this way \( c \) and \( d \) will be coordinated before \( b \) though \( b \) and the neighboring rays may be more active in their coordination than \( c \) and \( d \) because they receive stimulation through the ring from both directions simultaneously.

Now with the negative response, conditions are different.

The negative response has been described by Loeb (1900) in terms of observations by Norman (1900) as a result of the retraction of tube feet on the harshly stimulated ray and a consequent determination of the direction of the negative responses by a "parallelogram of forces" exerted by the other rays, each, hypothetically as I take it, continuing, during the negative reaction to pull in its own direction. It is well known from the work of Romanes, Preyer, Jennings, Mangold, Cole and others that all normal locomotion is brought about by the cooperation of all of the tube feet stepping in one direction and not the divergent pulls of the various rays, which as we have seen results in autotomy.

in certain respects. Assuming that the harsh stimulus is given

![Diagram](image)

at \( b \). The path of retraction will be as above (fig. 12) but the way the coordination impulse spreads is \textit{not} identical with that diagrammed in fig. 2 so that \( c \) and \( d \) become coordinated before \( b \), which is the location of the stimulation.

Appearances seem to indicate that just after the retraction following such a negative stimulation, the tube feet on the far side of the animal show a definite increase in activity.
Whether this increase is only relative or to what extent it is absolute, I am unable to say.

**Function of the step reflex in the spread of coordination.**

The function of the step reflex in the spread of coordination is probably very important. The pinching of one ray of an *Asterina* will cause prompt negative locomotion with all the tube feet coordinating. If, however, the starfish is inverted there is little likelihood that the impulse will include coordination of all the tube feet, even after the severest pinching. The only difference between the animals in these two positions is that the tube feet of the inverted starfish are not executing the step reflex because there is no contact stimulation to set it off. I am inclined to think therefore that a state of orientation spreads much more rapidly where the tube feet are executing the step reflex than where they are not. This is also true of *Pisaster* to a lesser extent, but in case of *Pycnopodia* it seems to make but little difference whether the tube feet are in contact with the substrate or not. The coordinated impulse is easily initiated and very active in this animal.

The common or usual manner in which the coordinated impulse is formed in starfish is, I think in general accord with the above outline. There are very many species of starfish, each differing more or less in its structures and functions from the other so that ideas derived from the study of five or six species might not fit the behavior of all of the thousands known to science.

I have seen *Pycnopodia, Pisaster, Asterina* and *Eustaria* regularly orient toward or away from contact and chemical stimulations (mussel juice or dilute acid) in the manner outlined above, and when a beam of direct sunlight was thrown on the eye-spot of *Pycnopodia*, the response was analogous to that to contact.

**Orientation as a result of stimulating the dermal nerve net or a general stimulation of all the tube feet.**
In order to understand the importance of the above, it is necessary to recall the significance of the concept of coordination. The importance of coordination is not only in the sense that it reduces friction but also in the sense that it ensures effective use of resources. Coordination is not just about making decisions but also about ensuring that these decisions are implemented effectively. Therefore, it is essential to ensure that there is coordination between the various departments and agencies involved in any project or program.

This requires a well-defined structure and a clear understanding of the roles and responsibilities of each department. It also requires effective communication and cooperation among the involved parties. The ultimate goal is to ensure that the project or program is delivered efficiently and effectively.

In the absence of coordination, there is a risk of duplication of effort, wasted resources, and delays. This can lead to increased costs and decreased efficiency. Therefore, it is crucial to ensure that there is coordination throughout the project or program.

In conclusion, coordination is a key factor in ensuring the success of any project or program. It requires careful planning and effective communication. By ensuring that there is coordination, we can ensure that resources are used efficiently and effectively, and that the project or program is delivered on time and within budget.
The responses of the starfish to light have been divided by Plessner (1913) into two categories: those (both positive and negative) in which the eye spot acts as the receptor and those in which the receptors are distributed over the surface and connected with dermal nerve net. Inasmuch as it is the whole surface which possesses these receptors and not merely that at the tip of the ray, it would be well here to look into the qualities of the orientation of the tube feet and their coordination that can be brought about through stimulating the body wall.

In starfish which are suspended and the body wall at one side of a ray stimulated by gentle contact I have observed that the tube feet in that region show a tendency to orient themselves in the direction of the stimulus. Upon increasing the strength of the stimulation of the body wall, the tube feet near the stimulated area undergo retraction which spreads in proportion to the strength of the stimulus. I have seen no orientation of the tube feet directly away from the stimulus even though the stimulus be graded in intensity as carefully as possible. The response is either orientation toward the stimulus or retraction.

In the above experiment we have an explanation of a positive response to a dermal stimulation. A negative response can be regarded on the above hypothesis as a positive reaction toward the unstimulated side, if it should indeed prove to be a fact as indicated above that a direct response to dermal stimulation is only positive in its sense. Thus we may suppose that the tube feet are oriented toward the side which receives optimal illumination, rather than that they are oriented

The older observers on the responses of starfish to light have divided themselves into two schools. One of these schools regarded the eye spot as a light receptor and in it may be listed Romanes and Ewert (1881), Graber (1885), Preyer (1886), Bohn (1908). The morphologists favored this view also. The second school regarded the light receptors
The response of the receptor to light & have been given

In Figure 1 (1972) into two categories (short & long). In Figure 2 (1973) the receptor and

The receptors at the periphery are the mitochondria and connected with the

If there is no response, the whole unit is to be tested again with a

If there is no response, the receptor has actually been eliminated.

The response of the receptor to light & have been given.

In Figure 1 (1972) into two categories (short & long). In Figure 2 (1973) the receptor and

The receptors at the periphery are the mitochondria and connected with the

If there is no response, the whole unit is to be tested again with a

If there is no response, the receptor has actually been eliminated.

The response of the receptor to light & have been given.

In Figure 1 (1972) into two categories (short & long). In Figure 2 (1973) the receptor and

The receptors at the periphery are the mitochondria and connected with the

If there is no response, the whole unit is to be tested again with a

If there is no response, the receptor has actually been eliminated.

The response of the receptor to light & have been given.

In Figure 1 (1972) into two categories (short & long). In Figure 2 (1973) the receptor and

The receptors at the periphery are the mitochondria and connected with the

If there is no response, the whole unit is to be tested again with a

If there is no response, the receptor has actually been eliminated.
as in the dermis or tube feet. Mangold (1908), Cowles (1911a), Mast (1911), and others adhered to this view more or less explicitly. The ingenious experiments of Plesner (1913) have made it seem quite probable that the starfish responds to direct illumination of the dermis and that the eye spot receives stimulation from distant areas of light or shadow to which the starfish responds also. This results in a very puzzling aggregate of reactions as the controversy attests.

away from the side that is in a state of sub or super optimal illumination.

Significance of the negative behavior of the isolated ray.

The negative behavior of the isolated ray, is, as has been long known, much less definite than that of the whole animal. Romanes and Ewart (1881, p. 1856) state that "Single rays detached from the organism crawl sometimes away from injuries, but they do not invariably or even generally seek to escape from the latter as is so certain to be the case with the entire animals." In confirming this it was found that a migrating ray which had been isolated, would give very irregular responses to stimuli which would cause negative behavior in a normal animal. A negative response to pinching or prodding is the exception, rather than the rule in the behavior of isolated rays. This is to be expected in the light of what has been said about the nature of the negative response because the "rays opposite the stimulus" are not there to unfailingly initiate a migration away from the stimulus.

Behavior of the starfish when under the influence of the unified impulse.

Having studied the factors which govern the formation of the "unified" impulse we shall now turn our attention to the behavior of an animal under the influence of this physiological state, first taking up the factors which cause a change in the "physiological anterior" and factors which cause a change in the direction of locomotion of the starfish by a rotation of the body as a whole without changing the anterior rays.

The factors which cause a change in the physiological anterior
behavior of the organism under the influence of the stimulus

Firstly, we must take into account the preparation of the organism to which the "stimulus" is applied. This involves the influence of the psychologist's state of "preparation". The psychologist may cause a change in the organism's response to the same stimulus when he first meets the subject or after a prolonged period of observation. The change in response may be a result of a more alert or passive attitude of the subject. However, this is not always the case; sometimes it seems that the organism is simply more prepared to respond in a certain way.
are essentially the same as those which determine the anterior
as the impulse is being formed and operate through the
same mechanism. With respect to the sense of the reaction which they
elicit they can therefore be grouped into (1) the positive and
(2) the negative. With respect to the receptors on which they
operate they can be grouped into (1) those acting on the dermis and
directly on the tube feet and (2) those acting on the terminal tube
feet of the rays (or eye spot which is a modified tube foot).

Such common factors in the environment of the starfish as
contact chemical stimulation and light have been seen to affect the
unified impulse in the uncoordinated starfish in one or more
of the above mentioned ways and it will be seen from the following
that they affect the coordinated impulse once it is started in
the same sense and in the same way.

Positive reaction to contact

When one of the ray tips of a starfish migrating actively
under the influence of the "unified impulse" brushes against the
side of the aquarium the tube feet at the end of this ray have
been seen to stretch out actively. Those behind them coordinated and
soon the direction of locomotion changed and the animal was
walking up the side of the aquarium.

Negative reaction to contact

On pinching one of the rays of such a locomotor starfish,
serial retraction or inactivation of the tube feet will ensue
spreading more or less among the tube feet, but last and least
effectively to the tube feet of the opposite side of the starfish.
The latter resume activity first and orient more
nearly in the direction of the ray on which they are borne i.e.
away from the source of stimulation. The tube feet behind these
coordinate themselves with them in the same direction so that the
coordinated impulse (to go away from the stimulus) spreads
text not legible
back about as quickly as the tube feet become active again.

Chemical stimuli # and light (acting on the eye spot) have also been seen to affect the locomotor starfish in a way wholly anal-

ogous to the above.

Physiological as distinguished from physical orientation.

I have described above such changes in the direction of a locomotor starfish as involve also changes in the leading ray, - that is the animal may be going in the direction of a certain ray before the change and in the direction of the opposite rays after change. It is a matter of common observation, however, that crawling starfish sometimes change their orientation by a rotation of the body as a whole without changing the anterior ray. This is a less common method of changing direction, and is said (Bohn 1908) to be more frequent among large and stiff specimens than among small active ones.

Orientation of this kind may be called "physical orientation" to distinguish it from "physiological orientation" which involves a change of the leading ray.

Physical orientation may involve three factors, any one of which may be more or less completely predominant. These are: (1) Direct orientation of the leading ray or rays to one side: (2) acceleration of the tube feet of one side of the starfish and a consequent swinging of the anterior rays in the opposite direction: (3) the retardation of the tube feet on one side of the starfish and the consequent swinging of the anterior rays toward the same side.
problem of space as diversity as the face that became woman strange

departmentalizing a line length (sitting on the edge of the
phase)
also seen need to strike the纵横 for adaptation in a way while settling

A Romance 1960 novel that set off the war with the war.

Tir to sentience to occur (comet's emergence with a reason)
Focusing from telephones in the temporal scope first of the late

Some to the space

Methodology of the Art of the Art of the Art of the Art of the Art of the

I have gained some more oxygen in the alteration of the

cancellation of the final stage in the sitting of a variety of periods in the final

the change and in the alteration of the appearance of the alteration. This is to appear

as a matter of common place to the alteration of a totality of the death as a

more often occurring the alteration and this in the face common method

of achieving alteration, and if and if (Bora 1960) to be more important

some form and still occurring great each small current one

Extension of the kind may be called "emotional alteration"

Then to alterations of non-alteration with integrations

a cause of the focus of any

Phenomenal alteration was involving where to perceive any one of


With my way to more at least completely preoccupied. These are:

(1) Direct alteration of the focus only to the image of one thing:

(2) The direct alteration of the image less of one side of the alteration and a cause

doing nothing to the alteration less of one side of the alteration and the

The reception of the face that on one side of the alteration and the

Conclusion: none of the alteration was found and none was
Direct orientation of the leading ray or rays to one side is dependent upon a unilateral stimulation of either the dermis, the eye spot or the tube feet of these rays and a consequent orientation of these rays toward (or away from?) the stimulus. If the stimulus acts also on the rays that are situated on the side of the starfish from which the stimulus comes, the anterior is apt to be shifted (Plessner 1913) to these arms but if it acts only on the side of the anterior arms it is more likely to cause a rotation of the animal as a whole. This is dependent upon the angle of the stimulus to the direction of the starfish and various other factors that have been analyzed by Bohn (1909).

The relative acceleration and retardation of the lateral arms is of course a necessary result of the above described lateral movements of the anterior rays. As a result of stimulation the same factors which we have discussed above acting in a positive direction on the tube feet, dermis or eye spot would cause acceleration and in a negative direction would cause retardation, provided the stimulus did not reach the more sensitive (to a direct stimulation) tips of the anterior or posterior rays. A mechanical obstacle to the progress of the rays on one side of the animal will result in a change in orientation that may or may not involve a change in the physiological anterior. This, however, will be taken up in connection with the "deviation reaction" and the breaking up of the functional unity of the coordinated impulse.

**GENERAL CONSIDERATION OF COORDINATION**

The categories into which we have analyzed the reactions of the locomotor starfish are not the separate and distinct entities that they appear above. All of the factors that we have recognized are usually at work at one and the same time.
They are nicely balanced against each other and any stimulus which upsets the balance by adding to the strength of one factor or taking from the strength of another factor results in a more or less radical change in the behavior of the animal. It is often difficult, moreover, to discern the cause of a change in behavior, so delicate is the balance between the different factors, and so impossible is it to keep track of the changes of fatigue, hunger, etc., that play an important part in the relative irritability of the animal as a whole, and of its different parts from time to time. An analysis of the behavior of starfishes, based upon observations and experiments on only four or five species, can not pretend to completeness or to a generality covering the whole group of Asteroidea. (See Mangold 1908 on the self burying reaction of Astreopastea).

Theories of the mechanism of coordination.

It is probably true that all starfish locomotion involves in some of its phases at least a "unified impulse" among the tube feet in various parts of the body.

The mechanism of such coordination is of course very complex. According to Von Uexkull, in the sea urchin it involves the functioning of many nerve nets, connecting and supplying with similar "quantities" of "tonus" homologous parts of the various coordinating organs (tube feet, spines etc.). Pending adequate histological investigations it would be well to state as an hypothesis that since homologous parts of coordinated tube feet act in almost exactly the same manner they are probably connected by nervous paths of lower threshold than are non homolgous parts. The value of such speculation, however, is dubious, and it is better to keep within the data of physiology in evaluating the coordinated impulse, since the morphological data is wanting.
Orientation of retracted tube feet and the independence of the mechanisms of orientation and that of withdrawal or stepping.

It has been shown (Cole 1913) that the coordinated impulse may retain its orientation even after the starfish is removed from water and held inverted for two minutes. This procedure causes the retraction of the tube feet (in Pisaster) and the drooping of the arms aborally. When put back in the dish of sea water, the animal usually walks in nearly the same direction as before. This persistence of direction and the fact that the tube feet are quite retracted after each step, indicates that the mechanism of retraction and extension, of which as we have seen, the step reflex is a modification, is, perhaps, in no way dependent upon or implicated in the mechanism of orientation. The only point of contact of these two mechanisms is the fact that they both act upon the tube foot.

In the locomotor state then every tube foot is oriented, whether it be retracted or not, but retracting and extending in such tube feet are accomplished usually as parts of the step reflex.

BREAKING UP OF THE COORDINATED IMPULSE INTO AREAS IN WHICH THE TUBE FEET ARE ORIENTED IN DIFFERENT DIRECTIONS.

Perhaps the most puzzling thing about the unified impulse is the fact that under certain conditions it may be broken up so that it may exist in only a part of the starfish, or tube feet of different parts of the animal become oriented in different directions.

Adaptiveness

In case of some types (Jennings 1907) of the righting reaction, and in going around an obstacle this orienting of
the tube feet in different parts of the starfish in different
and sometimes opposite directions is highly adaptive in that it
is the only way the act could be accomplished. In this breaking up
of the animal usually avoiding the obstacle and migrating off in the
various directions and sometimes also extending in the same
direction, we have observed an observation in the slender
arm bent to the right of the ray, some
parallel. Thus in the above diagram, fig. 14 which illustrates a
frequently observed type of righting reaction the rays labeled a b
have doubled under and are migrating in the direction of the arrow.
The rays labeled c d under the influence of the same unified impulse
have turned in the same direction but migrate, after having turned, in
the opposite direction, thus crossing over the arms a b and comple-
ting the somersault. As soon as the righting is complete the rays
c d again reverse and migrate in the same direction as the rays a b.

When (fig. 15) the starfish was in position 1 it was mov-
ing in the direction of the arrow and all of the tube feet were
oriented in this direction. However, when coming up against the
obstacle (3) the tube feet of each ray immediately changed their
orientation to the direction indicated by the arrows at the tips of
the respective rays. This results in the

According to Bandelot (1874) who gives an historical regime of
orientation to the direction indicated by the arrows at the tips of
the stomach that A. M. Quatrefages (1843) made the statement freely trans-
slated to be the system of gastric and hepatic mesenteric filaments.

It is true that the various systems of (Schneiderian) organs described as nervous in function that I have
decided to remain in this regard in a state of philosophical doubt.
to the only way the sun could be accomplished.

The two last lines of the paragraph are not legible.
animal neatly avoiding the obstacle and migrating off in the
direction indicated by the upper arrow. This is a very interest-
ing reaction and has been made the subject of careful study below
in an effort to discover the factors concerned in this breaking up
of the coordinated impulse.

Mangold (1908) has described an observation in the slen-
der armed *Luidia ciliaris* in which the animal was seen to have an
arm bent so that coordinated tube feet, all extending in the same
direction, were some extended out to the right of the ray, some
parallel with the ray and some to the left of the ray.

If we are to explain this very puzzling behavior from a
physiological standpoint we can not merely point out its adaptive
or regulatory value, we must attempt an analysis of its mechanism.
It is futile also, to conjure up a complex "center" in the nervous
system which acts as coordinating mechanism or presiding regulator,
orienting the tube feet of various parts of the body in such a man-
ner as to best accomplish the act of the moment. Steiner (1898)
hypothesizes a "righting center" and Preyer (1886) "centers" for
various activities. There is no structural basis for such an assump-
tion # and it is not in accord with observations on the behavior of

# Spix, (1809) described a nervous system for the starfish that
would satisfy such an assumption. Unfortunately, however, it proved
to be the system of gastric and hepatic mesenteris filaments.

According to Baudelot (1872) who gives an historical resume of
the earlier morphological literature the subject became so controver-
sal that A. H. Quatrefages (1842) made the statement freely trans-
lated as follows. "Naturalists of great merit have come to such
diverse conclusions as to the significance of the various systems
of (Echinoderm) organs described as nervous in function that I have
decided to remain in this regard in a state of philosophical doubt."
Mordor (1969) the central city in the area of the Sun. It is said that the Sun was born in this city. In the past, it was considered an important center of the Sun. In recent times, it has become a major city in the region.

Mordor is famous for its beautiful mountains and its rich history. It is a city of mystery and wonder, and many people come from all over the world to visit it. The city is known for its unique architecture and its vibrant culture. It is a place where people can learn about the Sun and its history, and it is also a place where people can find peace and tranquility.

Mordor is a city of contrasts. On one hand, it is a place of beauty and wonder, but on the other hand, it is also a place of danger and conflict. The city is torn by the struggle between the forces of light and dark, and this struggle is reflected in the daily life of its people.

Mordor is also a place of great mysticism. Many people believe that the Sun has a special power, and they come to Mordor to seek its guidance. They believe that by visiting the city, they can find answers to their deepest questions.

In conclusion, Mordor is a city of mystery and wonder, a place of beauty and danger, and a place of peace and conflict. It is a city that is both real and legendary, and it is a place that is both loved and feared. It is a city that is both known and unknown, and it is a city that is both known and unknown.
the tube feet which seem to indicate that they all act very much like their neighbors, but with too much independence to lead to the belief that they are subject to the control of a higher center. Tube feet act only in response to stimuli which affect them or spread to them from neighboring tube feet.

Possible physiological explanation in the traction on the tube feet resulting from the movement of the rays over the substrate.

It seems to me that the only constant factor that could account for the behavior observed, is the traction of the substrate on the tube feet. This traction is the mechanical result of the movement of the starfish over the substrate. (See Cole 1913.)

Thus Mangold's starfish (fig. 14) is moving in the direction of the arrow. The various tube feet may receive stimuli from the substrate which result in their orienting this direction.

Similarly the righting starfish has set in action by the activity of the rays a and b (fig. 14) a somersaulting motion on a horizontal axis. This results in pulling the rays, c and e in the direction of the arrow that indicates their motion. It is this traction that may orient the tube feet. In this connection it is to be noted that if the rays c and e do not droop down to the substrate but are carried over at a level of or above the disk (as is more often the case) their coordinated impulse does not reverse but remains, as indicated by the parallel extension of the tube feet, in harmony with that of the rest of the animal.

In the case of the deviating starfish, the axis of the rotation that is involved in the avoiding of the obstacle is of course the obstacle itself. There is, in the progress of the reaction first a pushing against the obstacle which involves cessation of locomotion on the part of the rays on one side of the body, but its continuation (or quick resumption after temporary cessation)
The cup's base must now be increased since they sit on each other.

The great Newport, thus far, has too much information to lend an

important part and the main to the consideration of the larger center.

The cup's base, therefore, must be reduced, and the consideration is

only to the increase of one side of the cup, but the conclusion

(To show a determination after complete correction).
on the other, perhaps the stronger, side. As this continues, due to the comparative rigidity of the animal, there is a pull in the direction of the arrows (at the tips of the rays) to which pull the tube feet seem to coordinate themselves.

Direct pull, exerted through the substrate by the movement of the animal and acting on the tube feet, can, assuming that it orients them, account for the above described behavior. We shall now turn to the evidence for and against the contention that the pull of the substrate does orient the tube feet.

Direct evidence inconclusive.

The obvious way of testing this is to slowly pull the animals over the stub substrate (see Cole 1915) and ascertain whether a tendency to locomotion in this direction could be built up. About forty trials were made with rigid non-locomotor animals. The tube feet at first caught hold and clung to the substrate. This became less and less manifest and the rigidity of the myodermal sheath gave place to the flexibility that usually accompanies locomotion. Locomotion followed, however, less than half the trials, the animal more often settling down obstinately in the place it was pushed to.

When the locomotion did follow, it was, unfortunately, in every case but one in the opposite direction to the pull. It continued for a few cm. only, when the animal would settle down into the rigid state. The one animal that crawled in the direction in which he was pulled, continued to crawl all day.

These results were complicated by the effects of contact stimulation of the dorsal surfaces which induces close attachment and cessation of locomotion. The reactions of the animals, then for the most part may be considered a result of this stimulation rather than a result of the pull.
I have in fact been unable to manipulate the starfish so as to exert a steady pull in any one direction for any length of time without causing the tube feet to attach and hold on, a tendency which then spread to other tube feet and inhibited any coordinated impulse that might have resulted. Later, moreover, on certain occasions they have been observed to retract and be entirely inactive.

I have manipulated the animals by slowly moving the substrates on which one or two rays were walking and have manipulated them by means of neurotomized or anaesthetized rays but have not been able to do so with enough delicacy to avoid stimulating the tube feet to become attached or completely retracted. I am inclined, therefore, to consider these results irrelevant rather than evidence against the possibility that the substrate may have an orienting influence upon the tube feet.

Evidence from neurotomized animals.

If the substrate can orient the tube feet by exerting a directive pull on them through the movements of the animal, we might expect to find that if one of the posterior arms of a locomotor starfish were neurotomized, there might be coordination brought about by the factor in question. Several experiments were performed with it in view to test this hypothesis, the results of which were complicated by the marked tendency in the injured animals to attach closely and firmly to the substrate.

The operation was performed on a large, active Echinopodia. At first the tube feet on the injured arm attached but the movement of the animal wrenched the tube feet loose leaving in one or two cases the disk affixed to the substrate. As the locomotion continued the tube feet stuck less and less
tightly, until they behaved very much like they do in
ordinary but rather inactive locomotion. The arm being very
flexible, coordination did not occur when the neurotomized
arm was anterior, because it bent around and under before the
tube feet let loose. Some three or four hours after the
operation the tube feet in the neurotomized arm were all
retracted and the arm practically motionless. A week later the
wound seemed to have healed and the arm to have regained its
natural movements.

When this experiment was repeated on *Pisaster*, the animal
remained stationary for five minutes, the neurotomized ray,
affixing itself rather firmly to the substrate. At the end
of this time the other rays were seen pulling in the direction
of their former anterior, away from the neurotomized ray. Some
refractory tube feet were seen attaching to the substrate, which
were wrenched off by the activity of the uninjured arms. One
left its disc behind. Refractory feet became fewer and less
refractory. In one minute coordination was complete, though not
very active. The animal walked quite rapidly the length of the
aquarium. Locomotion seemed normal except that the neurotomized
arm was contracted and rigid. It was always behind or obliquely
behind in locomotion.

It might seem possible therefore that coordination of the
tube feet is not wholly dependent upon the presence of an intact
nervous system. If such stimuli as cause the attaching reflex, are
carefully excluded coordination may be established, across a cut
nerve cord by the traction of the other arms.

When the neurotomized starfish had some to rest it was
observed that the four intact rays were stationary while the neuro-
tomized ray walked about in the sector between the adjacent
stationary rays. I then prodded the starfish and threw it into a
After the introduction, was devoted to the discussion of the merit.

Examiners expressed the opinion that the statement was not accurate. A. H. Smith.

The examiners found it necessary to compare the examination of the statement with the examination of the statement of the examination department, which was found to be correct and in harmony with the examination of the statement of the examination department. The examination of the statement of the examination department was found to be correct.

In the examination of the statement of the examination department, the examiners found it necessary to compare the examination with the examination of the examination department. The examination of the statement of the examination department was found to be correct.

In the examination of the statement of the examination department, the examiners found it necessary to compare the examination with the examination of the examination department. The examination of the statement of the examination department was found to be correct.

In the examination of the statement of the examination department, the examiners found it necessary to compare the examination with the examination of the examination department. The examination of the statement of the examination department was found to be correct.

In the examination of the statement of the examination department, the examiners found it necessary to compare the examination with the examination of the examination department. The examination of the statement of the examination department was found to be correct.

In the examination of the statement of the examination department, the examiners found it necessary to compare the examination with the examination of the examination department. The examination of the statement of the examination department was found to be correct.

In the examination of the statement of the examination department, the examiners found it necessary to compare the examination with the examination of the examination department. The examination of the statement of the examination department was found to be correct.

In the examination of the statement of the examination department, the examiners found it necessary to compare the examination with the examination of the examination department. The examination of the statement of the examination department was found to be correct.

In the examination of the statement of the examination department, the examiners found it necessary to compare the examination with the examination of the examination department. The examination of the statement of the examination department was found to be correct.

In the examination of the statement of the examination department, the examiners found it necessary to compare the examination with the examination of the examination department. The examination of the statement of the examination department was found to be correct.
very intensely appressed state. The neurotomized ray continued as before actively moving in its own sector. The gills were retracted and the pedicellariae open, over the whole starfish while in the region of the cut and beyond the gills were out normally and the pedicellariae at rest. On prodding the neurotomized arm the gills drew in, the pedicellariae stood out and opened and the tube feet held fast. This last reaction passed off and the neurotomized arm started locomotion again in its sector.

The gills and pedicellaria remained in the irritated state so that the cut did not demark two different areas of gills and pedicellaria as it had before, as it did now with the tube feet.

I believe, therefore, that neural connection for the spreading of an impulse across the cut, either through the dermal nerve net or through an uncut portion of the ambulacral cord, was entirely absent.

The essentials of these experiments were repeated on a number of animals, with very similar results. Asterina responds in this way but rather less completely than Pisaster. An active starfish with ante anterior (see p. 145) was picked up quickly and the rays Neurotomized. The animal was set on the side of the aquarium with the intact rays directed downwards. Locomotion followed down the side and across the aquarium. presented refractory tube feet and locomotion was jerky as these tube feet were pulled loose. Later, when the animal had progressed about 6 cm coordination was fairly well established but not very active. As the refractory tube feet were pulled loose they retracted and did not react at all, for sometime. Neighboring tube feet, however, showed diminished tendency to attach tightly and were more apt to coordinate. Locomotion was slow at first but later more rapid.
Th...
I next neurotomized each arm of a rather large starfish that was not very active. I "started" it on the side of the aquarium with its former "anterior" downward. Locomotion continued down the side until the disc was about at the angle of the wall with the floor of the aquarium. At this point, the animal assumed the rigid state and would crawl no farther.

This experiment was repeated on a smaller and more active specimen. Locomotion down the side was more active, the leveling (former anterior) arms taking up the locomotion quickly and by pulling, in harmony with the force of gravity, forced a certain amount of coordination in the other rays. There were a few refractory tube feet in each of the rays, each ray showing a tendency to migrate toward its own tip. When the animal reached the angle of the side with the floor of the aquarium the locomotor impulse was so well established that crawling continued across the floor of the aquarium and up the other side. If an obstacle such as my finger was placed between the two anterior rays and held stationary, two responses were observed. In two cases a normal deviation reaction ensued, but the more frequent result was a stoppage of locomotion followed after a variable length of time by a resumption of locomotion in some other direction.

The starfish was then taken up and stimulated harshly on the various rays. The animal assumed the rigid state when set down the tube feet being tightly attached, and remained in this state for some time. The rays that became active first were not contiguous, \( a \) and \( e \), while \( b, d, \) and \( e \) remained attached. \( A \) and \( e \) moved about in their sectors at random all the afternoon. The next morning the starfish was in a moribund condition but had migrated across the aquarium during the night.

The essentials of these experiments were repeated many
I want to start by saying that a victory against crime is not

The problem with "victory" in this context is that it implies a final solution or end to the issue of crime, which is not realistic. Instead, it is important to focus on measures to reduce crime and improve public safety. This can be achieved through various means, such as increased police presence, improved lighting, and stronger community engagement. It is also important to address the root causes of crime, such as poverty and lack of education. By working together, we can make a difference in our communities and create a safer environment for everyone.
times with results that varied between the two examples cited. It was found that if the manipulation was rough or unnecessarily prolonged, the animals would become rigidly attached and would not locomote for some time or at all while some animals refused to coordinate with even the gentlest manipulation.

Opinion on the necessity of an intact nervous system for echinoderm coordination seems divided. Romanes and Dwart (1881) and Cole (1913) record some slow coordination between parts on opposite sides of a cut in the nervous system, while Russe (1913) believes that coordination may be absolutely normal with the oral nerve ring removed. Clark (1899) states that the movements of the tentacles in Synapta and coordinated movements of the body muscles are not destroyed by cutting the nerve ring. See also Grave 1900 on Ophiura brevispinos.

Among those who report the opposite results are Vulpian (1862) Krukeuberg (1881) DeMoor and Chapeaux 1891 Loeb (1900) Mangold (1903) (Moore 1910a, 1910b).

From these experiments, and those on the righting of neurotomized animals which will be described later, I think that it can be safely concluded that while there is no neural or "neuroid" (Parker 1913) transmission past a cut in the ambulacral nervous system, there may be a certain limited amount of coordination between parts separated by such a cut brought about through mutual relationships to the substrate.

Evidence from the behavior of the animal when its parts are placed on separate substrates:

We shall turn now to such indirect evidence as bears upon this point from the behavior of an animal on separate substrates and a quantitative analysis of the mechanics of the deviation reaction. These methods, though indirect do not cause the attaching reaction.

The rays of an active starfish that is not in the coordinated state, has been seen above will migrate toward their tips, into free floating glass tubes. If however before suspending and before the floats are presented to the rays, the animal was in a state
of active locomotion, the rays that were anterior will crawl on into the tubes while the rays that were posterior will start to crawl out of them. Usually before one of these rays leaves go its hold on the float, or at any rate soon afterward, the impulse in this ray is reversed and it is seen to be active in its migration toward its own tip, regardless of the direction in which the other rays are crawling. If now the tubes are removed from their floats and set on the bottom of the aquarium, with the tip of a ray in each, the coordinated impulse is quickly re-established and the animal migrates back and forth within the confines set up by the ends of the tubes. After extensive experimentation with the reactions of Pisaster in these floats, I have very seldom seen the unified impulse appear when the floats were free to move separately, and having appeared it seldom lasts more than a minute or two. It appears quite promptly and lasts for a long time (an hour or more) if the tubes are not separately moveable but are resting on the bottom of the aquarium.

Supplementary experiments were carried on with flat free swinging substrates. One, two or three of the rays were put on the substrate and the others allowed to hang over the side on the floor of the aquarium half a cm. below. The part, on one substrate was often seen to migrate while that on the other remained stationary, and they were not infrequently seen to migrate in different directions. Of course this would not be likely to happen if the substrates were not separately moveable.

From the above experiments it would seem that a factor in the unity of the coordinated impulse is the unity of the substrate or rather of the animals relation to the substrate.
If
One might state the case rather paradoxically in metaphysical terms by saying that the animal's soul or entelechy, or some part of it at least resides in its substrate. (See Dreisch (1908) Sterne (1891).)

Therefore, if the activity of the animal caused the substrate to move in one direction with reference to one part and in another direction with reference to another part, as is the case in the righting and deviation reaction, we might expect that the unified impulse would be broken up in certain determinate ways.

Deviation reaction not interfered with by cutting nervous connections with interradial area.

That the coordinated impulse is thus broken up by mechanical traction in the deviation reaction, is made likely by the fact that the reaction is perfectly normal even after the nerve net on the outside of the epidermis was cut through between the obstacle and the ambulacral nervous system. This, of course prevented any stimulus from the contact of the starfish with the obstacle reaching the tube feet, but did not affect the mechanical factors in the relation of the substrate with the tube feet. It is therefore to be concluded that these mechanical factors play an important role in the deviation reaction.

Deviation reaction not elicited by prodding interradial area.

Moreover, if the nerve net between the bases of the two anterior rays be stimulated by jabbing it quickly with a knife or a blunt instrument, the deviation reaction will not follow. The animal will either continue undisturbed, stop and then continue or go into the attached condition and remain so more or less permanently. The first response is by far the most common if the specimen is normally active and not stimulated too harshly. I have never observed a marked change of direction as is seen in the deviation reaction to say nothing of the
complicated coordination of movements that are involved in the deviation reaction.

Quantitative aspects of the "deviation push" on different substrates and with different weights on the animal vary with mechanical conditions while quantitative aspects of contact stimuli required to initiate the negative reaction do not.

It was thought that the amount of push which the deviating animal exerted upon the obstacle when considered in connection with its pulling ability, and other reactions might throw light upon the mechanisms of the deviation reaction. The amount of push was measured by attaching the obstacle, a lever, swinging freely from a rigid fulcrum, by a thread to the recording spring above described. The push, then, was recorded as the average height of the curve, written on the slowly revolving drum. The appearance of the curve was as below for the different species studied. If the animal is placed on sand the values are similarly related to each other but are reduced as follows: Pulling 15 gm, pull-loaded with 60 gm, 32 gm, resistance 32 gm, deviation 150 and 38 gm.

Due to the laws of physics and anatomy are able to pull very The push continues to increase until the deviation begins, that or is, until the effectors (tube feet or spines) on one side of the body begin to reverse themselves and the rotation around the obstacle as an axis is initiated. From then on there is an irregular decline in the push until the animal is free pull of the obstacle. With the drum running at the same speed, the shape of the curve as well as its height is dependent upon the activity of the specimen studied. This was taken into account by means of its spines only. In deviating around an obstacle
it takes the same course as a starfish. This case is cited since the spines of the sea urchin do not attach and their behavior in this connection indicates a rather striking similarity between the physiology of the spine and that of the tube foot.

The value of the "deviation push" of this specimen, was found to average 13 g. This was increased to 17 g when a load (about 40 g) was placed on the dorsal side of the animal. The "pulling ability" was found to be (average of 6 trials) 10 g unloaded and 15 g loaded. Allowing for a certain amount of fatigue in the later trials the "pulling ability" was found to be approximately equal to the "deviation push".

The same relationship seems to hold with Pycnopodia. As seen above the pulling ability averages 47 g. the deviation reaction (average of four trials 60 g 45 g 60 g 30 g) is 48g. These are increased to 72 and 105 g respectively by loading the animal with 80 g. of glassware. If the animal is placed on sand the values are similarly related to each other but are reduced as follows. Pulling 15 gm, pull-loaded with 80 gm. 32 gm, deviation 29 gm, deviation loaded 35 gm.

Due to the fact that Pisaster and Asterina are able to pull very much harder in proportion to their size than are the sea urchin or Pycnopodia and since this pull is due to the constant increase of the attaching tendency correlated with the pull, we find that the deviation push correlates more closely with the pulling ability on sand, taking into account of course its lesser frictional coefficient, than with the pulling reaction on a solid substrate. The average deviation push of Pisaster (about 15 cm in diameter) is 20 g. on a solid substrate and 6 g on sand. Asterina (8 cm) on a solid substrate exerts a deviation push of 4 g, but with 4 g. weight on its back this is increased to 6 g. This is comparable with the pulling ability of a larger specimen on sand of 7.5g.
The answer to the question of "What is the significance of the phrase 'the utmost extent of all\"?' is as follows: It refers to the maximum possible extent or measure of something. The phrase is often used metaphorically to describe the limits or boundaries of a particular concept, idea, or phenomenon. The significance of this phrase lies in its ability to highlight the potential for growth, expansion, or development in a particular area or context. It encourages a sense of ambition and the pursuit of excellence.

The phrase 'the utmost extent of all\" is deeply rooted in philosophical and philosophical thought, where it is used to discuss the potential for human knowledge, understanding, and progress. It suggests that there is always room for growth and improvement, and that the pursuit of truth and knowledge is a never-ending process.

In modern contexts, the phrase can be applied to various fields such as science, technology, art, and society. It serves as a reminder that the limits of human knowledge and understanding are constantly expanding, and that there is always more to learn and discover. It encourages a sense of curiosity and a commitment to continuous learning and growth.

In conclusion, the phrase 'the utmost extent of all\" is a powerful and inspiring concept that encourages us to push the boundaries of our knowledge and understanding. It is a reminder that the pursuit of truth and excellence is an ongoing process, and that there is always more to learn and discover. It is a call to action to expand our horizons and to strive for excellence in all aspects of our lives.
and on sand weighted (40g) of 15 g (See p. 21). The above study of the mechanics of the deviation does not pretend to be statistically comprehensive. The object is merely to point out that the "deviation push" can be always increased by weighting down the animal and that in the sea urchin, which uses its spines, and in Pycnopodia which does not attach tightly while pulling hard (See p. 22) the pull can also be increased by weighting down the animal. The relationships of pull, and deviation push in the loaded and unloaded Asterina and Pisaster, are consistent with the above and comparable, quantitatively to the pulling ability of the animals, both loaded and unloaded on sand.

Thus, the attaching reflex that strengthens with the resistance to the ordinary step (see p. 19) does not appear comparably in the deviation reaction. This it seems to me is because the tube feet on one side of the obstacle overbalance in their traction those on the other side, cause a rotation of the animal in that direction and the various tube feet coordinate in the direction of this rotation. There is then no resistance to the step but merely a deviation of it in one direction or the other brought about by its relation to the substrate.

Another fact pointing to the conclusion that the factors of the deviation reaction have to do with the mechanical relationship of animal to substrate rather than with reflexes having their receptors at the point of contact is that if the tips (Asterina) of the rays instead of the dermis between the rays come in contact with one obstacle connected with the spring recorder the amount of pressure that it takes to cause a change in direction, does not vary if a weight is put on the back of the starfish. The value is about 2.5 g in each case. This shows
The problem with the conventional way of expressing ideas as a means to point out that the non-inclusion of the conventional does not present any difficulty is the opposite to what is necessary to improve the material. Can we please focus on metaphysical discussions and not in purely

philosophical blunt and authoritative view as the initial. The solution

is also to incorporate the authority from the initial and unchanged

methodology. My interest is connected with the scope and components. Conceptually, the initial to the different sections of the material part 10.0.0.0.0.0.0.0.

In the current case, there is a fusion of the authority in the instruction of this topic.

There are also connections to the gap but within a gap.

Now if it is to one instruction or to another prominent part of the reason.

Another factor

Another factor of the connection is the context.

And the conventional process have to go with the conventional method.

We refer to the journal of the conventional without any reference that we have come to consider.

A more important comment after the existing convention we mean at.

In another context, one can have a chance in instruction. The value to

not go. It is not to even mean. The same.
as might be expected from the configuration of the nervous system, that
the mechanism of the deviation reaction is altogether different from
the mechanism involved in a change of direction when the tips of the
rays are stimulated. In the one case we are dealing with the relatively
constant threshold of the receptors in the end of the ray while in the
other case we are dealing with factors that vary with the mechanical
data of load and friction.

In order that the obstacle may be left behind in the devia-
tion reaction there is usually a turn of at least $70^\circ$ which is often
recovered from, by the operation of a tendency, whose mechanism I have
not worked out, to continue crawling in the same direction as before
the disturbance, even if the action involve an actual change of direc-
tion, back, from one assumed as the result of the disturbance. This
tendency will also be noticed in connection with the righting reaction
(p. 75).

COORDINATION OF MOVEMENTS OF THE TUBE FEET WITH THOSE OF

THE ARM AS A WHOLE

Illustrations of the tendency of an arm to set itself more
at right angles to its actively cernized tube feet, when such move-
ments involve dorsal and ventral flexion and lateral twisting.

If an active starfish be suspended and a solid object be
brought in contact with the tip of one of the rays, there will be a
movement of the tube feet in the direction
of the object, an activation of their coordination toward the tip of the ray. This will be followed, almost immediately by a dorso-flexion of the tip of the ray. The ray can be said to set itself more nearly at right angles to the extended active tube feet. This reaction has been observed time and again in Pisaster orcaecum, Asterina, Pyonopodia, Lentasterias, Pister brevippinus and Evasterias. As are most movements of the animal it is a product of local reflexes in that it is not dependent upon connection with the oral nerve ring, but occurs equally well in active isolated arms.

If, for the gentle contact we substitute a harsh tapping of the tip of the ray, the tube feet will retract and the ray become more rigid and shorter, but without any sign of the dorsal flexion.

We have seen that if a tube foot in the middle of a ray be allowed to attach to an object and the object be then pulled to one side, the tube foot with it, other tube feet will also move to the same side and seemingly reach out for the object to which the tube foot is attached. Now if a sufficient number of tube feet become oriented in this manner, there will be a lateral twist of the ray toward the object. Here again the
ray can be said to set itself more nearly at right angles to the oriented active tube feet by lateral as well as by dorsal movement.

(See also Jennings (1907) description of the taking of food from the pedicellariae by the tube feet).

When the slender armed species of starfish (*Echinaster troschelii*) was suspended and a flat piece of thin celluloid was swung by a thread to the ventral side of one of the rays, the tube feet, oriented rather inactively toward the tip of the ray immediately seize the object and "walk" it in the direction of the base. This was observed to involve the orientation toward the object of quite a number of tube feet both above and below it and the bending of the ray so as to receive the object in a sort of hollow. The tube feet in actual contact with the object are, of course, undergoing the step-reflex, but above and below, where the tube feet are all directed toward the object, it can be said, again that the ray tends to set itself more at right angles to actively oriented tube feet, this time involving both dorsal and ventral flexion. In the region where the tube feet are undergoing the step-reflex, there is no bending of the ray.

# It has been shown by both Jennings (1907) and Mangold (1908).
any can be said to one person more worth of saving than of the other.

You say so long to your friends in the morning. The morning is long,
that as the tube feet carry a small piece of food toward the mouth there is a "humping up" of the ray in the region of the food which probably involves the factors described above. The behavior of the tube feet when the animal moves its arm in under the disc as a part of the food taking response (Jennings 1907) would be interesting but I have never been able to induce this response in the species at hand.

---

**Ventral flexion of rigid, of injured and nicotinized starfish**

If a *Pisaster* in a state of extreme rigidity be inverted there will be as we have seen, a rather inactive extension of the tube feet more or less at right angles to the rays. There will be no orientation of the tube feet at the tip in the direction of the ray. The rays, soon after inverting will lift themselves orally and assume a very symmetrical ventral flexion. This state may continue, in absence of disturbing stimulation for as much as twelve hours. If the radial nerves be cut or injured near the base, this ventro flexion is apt to be very much intensified so that the steps of the rays come nearly or quite in contact and the animal assumes what Romanes (1881) and Ewart (1881) who describe this response aptly call "a tulip like form". This is similar to the state of ventro flexion which Moore (1920) describes as a result of nicotine poisoning, and

---

The effect of nicotine on starfish had been described previously by Freyer (1886) and Greenwood (1890) which I have confirmed for *Pisaster*. The chief difference seems to be that the tube feet in the nicotinized *Pisaster* are completely retracted, while those of the rigid, or of the neurotomized animal show a certain amount of extension but no particular orientation. The strength of the spasm is greater in the nicotinized animal.

These movements are shown by the isolated ray from both the nicotinized (Moore) and the rigid animal.
Description of various other correlated movements of the tube feet and arms.

If an active Pisaster be suspended in water and away from contact stimulation, the rays move about for a while, flexing themselves dorsally and laterally, in a manner that we shall discuss later, but eventually assume a state of ventro-flexion similar to that assumed by the rigid animal. The active animal in ventro flexion differs, however, from the rigid or the nicotinized animal in that contact stimulations at once set up activities of the tube feet and arms. The tube feet react positively to gentle contact stimulation and retract upon severe stimulation. We have followed the immediate responses of the arms to these stimulations, but the positive and negative activities of the tube feet spread to the tube feet of the rest of the animal, as also do the corresponding movements of the arms. Thus if the stimulation be quite harsh the tube feet will retract over the whole animal and the arms themselves will become shorter and more rigid.

In connection with the positive response of the tube feet, it will be remembered that this does not spread as well when the tube feet are free from contact as it does when they are executing the step reflex. A weak positive response then, such as the positive differential activity of the unstimulated arms in case of a harshly stimulated animal, hardly makes itself noticeable in the suspended animal as it does in the negative response of the animal locomoting on a substrate.

Description of the formation of the coordinated impulse when the tube feet are free of the substrate.

A strong positive response, on the other hand, does spread, and in spreading involves movements of the arm, as the following experiment will show. An active Pisaster suspended and in a state of
At the time of the experiment, the rat was housed in a wire mesh cage. It received a daily schedule of food and water, and was observed for any changes in behavior.

The experiment was conducted in a room with a standard temperature and humidity. The rat was placed in a circular maze, and its behavior was recorded for a period of 24 hours.

The results showed that the rat's activity level increased significantly during the day, with a peak in the afternoon. There was also a noticeable decrease in activity during the night.

In conclusion, the experiment demonstrated that the rat's behavior is influenced by its environment, particularly in terms of lighting and temperature. Further studies are needed to understand the underlying mechanisms.
the side of the aquarium so that the tips of the rays a, e, b, c, and d are actively stretched out toward the wall, and attaching began to pull the tube feet at the tips of these rays farther toward the wall. The tips of the rays a, e, b, c, and d are flexed dorsally and began migrating in their own direction. In the meantime the coordination of the tube feet had spread so as to include all the extended tube feet of the animal, which were soon all pointed directly toward the wall of the aquarium. As the tube feet became oriented in this direction, there was a coordinated movement of the rays. Ray b twisted to the left and bent over toward the wall, ray d twisted to the right and bent over to the wall and ray e bent directly over the disc toward the wall. Each ray was seen to set itself more at right angles to the actively extended tube feet which had become coordinately pointing toward the wall.

As the rays a, e continued their activity, the disc was brought closer to the wall and with it, the other arms. As they touched the wall, since the tube feet were oriented in the direction of a, e began executing the step reflex in this direction and the animal started perfectly coordinated and normal locomotion in the direction of a, e (the suspending thread having been out).

**Correlation of these movements with the righting reaction.**

The above experiment is merely a simplification of the righting reaction of the uncoordinated active Pisaster. If we assume that two adjacent rays initiate the reaction by attaching to the substrate with their ventral sides turned toward each other, the above description will fit the righting reaction with the change of only a few words. The same dorsal flexion of the initiating rays and their migration toward their tips will be...
be observed. The tube feet will all coordinate pointing in the
direction of the initiating rays and the other rays will move
so as to come more at right angles to the direction of the
tube feet. The arm on the right will twist to the right, and
move over in the direction of the initiating rays. The arm
on the left will twist to the left and do the same thing. The
arm directly opposite the initiating arms will bend directly
over the disk and complete the somersault with locomotion, as
we shall show later, continuing generally in the direction of the
initiating rays. This as we shall see is perhaps the most common
method of righting at the disposal of the starfish.

Analysis of Jennings' Seven types of Right reaction.

Jennings (1907 pp. 125ff ff) however, describes seven
main types about which the extremely variable righting reaction
may be grouped. The first type is:

1. "The simplest and neatest method is the following. Two
adjacent rays twist their tips in such a way that the ventral
surfaces of the two face each other. Then the tube feet of
these rays attach themselves and throw the starfish over in a
neat somersault."

This is essentially the method described by me above.
Jennings description leaves out, here, the coordinated action
of the unattached arms though he mentions it elsewhere in
general terms, and he does not recognize the spread of the
coordination among the tube feet nor its relation to the
movements of the arms. As above stated this is the commonest
method of turning. We shall inquire as to the reason for the
turning of the rays toward each other in a majority of cases
in connection with our discussion of the righting of the
oriented starfish.
Jennings second type is as follows.

2. "The tips of the two adjacent rays may so twist that the ventral surfaces do not face each other, but both face in the same direction. The tube feet then take hold and throw the starfish over, twisting it about an axis which passes lengthwise through one of the attached rays. This method of turning is extremely difficult and awkward but is seen at time. Usually however a third ray takes hold and aids in the turning, the method then forming a transition to that given next."

I have observed this method of righting only a few times, and variations of it (Type 5 (6) of Jennings) where only one ray attaches a few times also. In each case the coordinated impulse could be seen to spread from the initiating ray or rays and involve coordination of the rest of the tube feet and to some extent the arms in the manner described above. The ray that might be expected to attach coordinately (facing) the ray that bends down is usually seen lifted above the substrate and reaching out in the direction of the righting. Locomotion after righting is usually toward the rays that initiate the reaction.

Jennings third type is as follows.

3. "Three adjacent rays attach and remain attached, all pulling throughout the reaction. Usually the animal turns primarily by the aid of the two outer rays, while the middle one is relatively passive and compelled to double back under as the animal turns. Often this middle ray walks backward beneath one of the other rays, or the other walks actively over its surface, or there is a combination of these two movements till the normal position is reached. (A model of the starfish in paper or cloth will make clear the necessity of such movements when three of the rays remain attached.)"

There is no new principal involved here, except that of
ladding some names may as well as

as the title of the the advertisement may in order that they

assertion which is not a good order of a test to but to have the

same precipitation. The only rest that you may have upon the

safety. There is no point in acting by act or Mr. Bloom in the

women and women of the opposite character. The coming of the

extremely difficult and awaken full to each of their

Pannar a first class person and thing in the future.

the unholy. Fusing forming a man to a man next]

I have announced the wishes of my children only to

variation of it is a (8) of the children's

instructive to a person else to. To each come the entire change

and cannot be seen to display these the information may to whom

leading assumption of the test of the future and to some

they are not worth reading assistance to the same to the same

be especially to arrest the consideration (lasting) or that may be

gamemany need. This change is one which has the entire change

one to the consideration of the situation. Communication after action

in any manner. Rewarding that which infinite the transaction

2. This assistance in a slight and temporary advantage. If

but for some minor with the transaction. Devote the entire change

must in the way of the same [also], while the minority are

to information bearing and confirming to persons and may as well

the process when they are thinking. The other methods of the

leavage of the matter to the necessary of many as a means by

all when more than the necessary to many as a means by

A matter of the necessity of paper on

To
the passive movement of the middle x ray which will be discussed in connection with the fourth type. The impulse spreads to the tube feet of the two unattached rays. The coordination of these is followed by their raising up over the disc and moving toward the initiating rays in the same way and according to the same principles as described above (types 1 and 2).

The fourth type is as follows.

4. "Four of the rays take hold, two extending to the right, two to the left. Then the fifth ray, (which we may call the posterior one) is lifted straight up and swings directly over till its ventral surface reaches the bottom, while the anterior attached pair walks backward beneath the posterior attached pair the latter walking forward over the surface of the (former)"

This type of righting is sketched in case of Pisaster it is more apt to occur if the animal is very much relaxed. The sequence of the events as I have observed it is as follows. The anterior rays twist toward each other and the coordinated impulse spreads over (or is already in) the starfish as in type 1. This results in the twisting toward them of the lateral rays and the bending up of the posterior ray. Due to the relaxed state of the starfish or some other physiological factor which prevents the lateral arms assuming their usual state of ventro flexion, these droop to the substrate and become the "posterior attached arms" (rays y in fig 1b). Now the factor which causes the moving forward of the back rays when the direction of the coordinated impulse, as seen by the activity of the initiating rays causes locomotion in the opposite direction is the same factor, I think, which causes the complex coordination of the deviation reaction. I have presented the evidence which leads me to think that the factor in question has to do with
The present movement of the Union is to maintain a firm
position in connection with the Co-operative Union.

The purpose of this paper is to follow up this question of the
attitude taken by the member societies to the same point of
view. It may seem strange to the initiatory mind to the same view.

...
the relation of the moving parts of the animal to the substrate and a consequent orientation of the tube feet in the direction of the movement.

Jennings' fifth type is as follows:

(4) 5. All of the rays attach themselves. Now the turning can be accomplished only by the release of certain rays, when the method passes to one of the types already described.

The method of release as I have observed it is of two kinds. (1) The pull of the other parts of the starfish tear loose attached tube feet. These then retract and other tube feet attach but usually not so tightly as those that were first attached. As this continues the tube feet in the region in question either all become retracted and the ray is pulled free of the substrate and swung over in the righting, or the tube feet become oriented in the direction of the pull and righting proceeds according to method three or four with possibly a lifting of the locomotor ray free of the substrate.

Jennings' sixth type has already been described in connection with his second type.

Jennings' seventh type is as follows:

(6) 7. A still more unusual type is seen in the performance of the righting action without attachment of the tube feet of any of the rays. Preyer (1886) and Romanes (1885) have given account of certain ways in which this is sometimes accomplished. The typical method seems for the starfish to raise its disk high standing on the tips of all the five rays, then to swing one or more rays over, or one or more under or both until the body topples over ventral side down. In my own observations, the righting without attaching the tube feet was seen only when these were experimentally prevented from taking hold. The starfish then writhed and squirmed irregularly, taking various
bizarre forms, until it had succeeded in getting its ventral side down when the squirming ceased.

The method of righting, described by Romanes and Preyer seems to be confined to Astropfroien and its allies. I have never had access to one of these species and therefore shall regard this highly specialized sand burrowing group as outside the scope of the present paper. The peculiarities of their righting reaction are said (Romanes 1881) to be contingent upon the fact that the tube feet are not equipped with suckers and hence do not attach.

Description of the righting reaction as it occurs when the tube feet are prevented attaching by inverting the animal on sand.

With the animals at my disposal it was thought possible to prevent the attachment of the tube feet by inverting upon sand.

The behavior of a large sluggish Pisaster, when inverted on sand is interesting in connection with Moore (1916, 1918, 1920a, 1920b) recent observations on strychnine poisoned starfish. The tube feet at the tips of all the rays of the large sluggish animal I had under observation extended out toward the tips and the rays bent dorsally, setting themselves more nearly at right angles to the actively extended tube feet. The tube feet however did not attach as they came in contact only with sand. The coordination of tube feet did not spread back very far and the dorsoflexion involved only the distal parts of the rays. For some time all five rays remained dorsoflexed. When the animal was placed on its ventral side on the sand, there was still every marked tendency for the rays to all bend dorsally at the tips.

Now when a similar specimen, large and sluggish, was placed in a dish of strychnine sulfate in sea water 1-10,000 the same picture appeared, with the additional factor that the tube feet suckers were so paralyzed that they could not attach to a solid substrate. There was then, a tendency toward dorsoflexion at the tip of the rays and a failure of the coordinated impulse to spread readily among the tube feet as a result either of the paralysis of the tube feet by strychnine and of prevention of their attachment on sand.

These results are probably merely analogous to those of Moore on Astarian forbesi and tend to demonstrate the many ways in which a given response may be brought about in the various representatives of the asteroida. I have, moreover, so far been unable to get in Pisaster the marked dorsoflexion which Moore figures for Astarian forbesi.
The reasons given for not having achieved the necessary
situation where we can demonstrate any improvement in
the number of flights, increase revenue, and improve
operations have been discussed in detail. I have
noted the potential benefits of increasing operations and
making better use of our resources. The main obstacles to
these improvements include:

- Limited resources
- Technical difficulties
- Competition

I believe that with proper planning and investment, we can
achieve these goals. However, it is clear that we need to
make some changes to our current operations.

We should consider the following steps:

1. Increase training for staff
2. Improve communication systems
3. Invest in new equipment

In conclusion, I believe that with a focus on these key areas,
we can make significant progress towards our goals.

I look forward to hearing your thoughts on this matter.

Sincerely,

[Your Name]
It would be obviously impossible for the suckers to attach, yet the animals (Asterina especially) righted themselves quite as neatly as on a solid substrate. Pisaster, however, would not right easily unless in active locomotion at the time of inversion.

A specimen actively crawling in the direction of a e (fig. 16) was quickly inverted on sand. The tube feet, which were retracted because the animal was lifted from the substrate, extended at once toward a e. B and d moved up orally and twisted toward a e. c. bent up and over the disk while q & r twisted toward each other and the tube feet, as soon as they came in contact with the sand, began executing the step reflex. Thus each ray moved so as to set itself more nearly at right angles to its actively extended (Oriented) tube feet. The stepping activity of the tube feet on a e resulted in their doubling back under themselves, so that the tube feet were striking out toward the disk instead of away from it (see rays, fig. 18, 19, 20). The step reflexes of the tube feet in contact with the sand were very active, the ends of the feet ploughing back through the sand and scattering the grains on all sides to a distance of one or two centimeters. The movements thus initiated continued until the rays a e had walked back under the disk and the other rays had moved up over the disk far enough to overbalance the animal and complete the somersault. Locomotion then continued in the direction of a e.

The righting reaction of Asterina on sand is even neater than that of Pisaster. This is due to the very great flexibility of the ray tips and to the strength and size of the large disked tube feet. The animal rights nearly as quickly and easily as on a solid substrate.

**INTERPRETATION OF THE RIGHTING REACTION AS A PHASE OF LOCOMOTION**

Evidence from the movement of the tube feet and arms.
A certain social, emotional state leading to the relaxation of the mind and body.

The mental process when the mind is not occupied with any particular thought or concern.

Lately, there has been a growing interest in mindfulness and its benefits for mental well-being.
In general terms, the above interpretation is that the oriented tube feet extend out in the direction of their orientation and in this state are ready to give the step reflex upon contact stimulation. In the absence of such contact stimulation there are reflex connections between the myodermal sheath and the ambulacral nervous system of such a nature that the ray, by twisting or bending or both sets itself more nearly at right angles to the actively oriented tube feet. Fig. 18 illustrates the first movements of an animal inverted during active locomotion toward a e. All of the extended tube feet are protruded in the direction of the former anterior. Figs. 19 and 20 illustrate the movements of the arms as described already (pp. 62) which result in righting and in the ray assuming a position more nearly at right angles with the oriented tube feet. During the righting process the unstimulated tube feet remain extended toward the animal's anterior. The rays a:e, however, in accordance with the above principle, bend toward one another and down so that the tube feet come in contact with the substrate, execute the step reflex and in the manner outlined above initiate the righting.

The tube feet, however, have been regarded (Romanes and Ewart 1881, Preyer 1886, Loeb 1900, Jennings 1907, Moore 1910;1910b) Cole (1913a) as taking hold of the substrate and pulling the animal over. Observation of the reaction as it occurs on sand show that this pulling is not a fundamental or necessary part of righting. Pulling by oriented tube feet is, however, a part of the step reflex. Since attachment increases with the resistance to the step (pp. 19ff), and the resistance to the step, in the initiation of the righting reaction, is very great, it follows that attachment is tight and pulling is the most noticeable activity of the tube feet. It is this pulling, that has obscured the eyes of observers, the more important and fundamental thing, of which this pulling is merely a part, namely the step reflex.
In general, power is some information or process that enables one to perform an action or effect a change. Power is the capacity or authority to act or influence others or to control events. It involves the ability to exert influence or control over others or over situations.

In the context of social media, power refers to the ability to influence others or to control events. It involves the ability to exert influence or control over others or over situations.
If then the righting movements of the arms are dependent upon the initial stages of the step reflex (oriented tube feet) and the righting movements of the tube feet are slightly modified step reflexes, righting is itself a phase of locomotion.

This condition is met in such a way that only in the early movements would any righting movements be effective. These movements were similar to the arms, but at right angles to the tube feet. In a few cases they righted themselves quite quickly.

(particularly)

---

<diagram>

- Normal feet
- Inverted tube feet
- Righting movements
- Locomotion

---
Evidence from the fact that the stimulation of the dorsal myodermal sheath of the ray is not an essential factor in the righting reaction.

If the righting reaction is simply a modification of ordinary locomotion, it would be expected first that contact stimulations on the dorsal myodermal sheath of the ray do not play an essential part in the ordinary locomotion and second, that, since the locomotor impulse persists in a given direction for some length of time, the righting reaction in the locomotor specimen shows a direction which is very closely correlated with locomotion before and after righting.

Several large active starfish were picked up when in rapid locomotion and balanced inverted with the central part of their disks resting upon the bottom of a small inverted beaker. Care was taken in the manipulation to touch only the disk and not to remove the animals from the water or subject them to any other unnecessary stimulation. In every case two or more of the rays started to bend down (dorsally) while the rays on the opposite side began to bend up. The latter movements were more rapid than the former and the starfish soon overbalanced and fell off the beaker. This was repeated so many times that there is no doubt in my mind that the dorsoflexion and ventroflexion results of the operation of the "unified impulse" persisting from the locomotion. That these movements are homologous with the early righting movements (Jennings type 1) is indicated by the fact that the rays which turn down turn also, usually, toward each other.

This conclusion is rendered more probable by the fact that some of the neurotomized starfish when coordinated in locomotion would show righting movements if inverted quickly and gently. These movements were similar in direction to those of the normal animal but were complicated by the fact that sooner or later these animals tended to take the "tulip form". (Romanes and Swartz 1881). In a few cases they righted themselves quite promptly.
Learn how to motivate your team to work together.

The key to successful motivation is simply a combination of action.

In the long run, it means getting a team to stay together.

This involves making sure that the goals are clear and that everyone is aware of the importance of the task.

In the short term, it means focusing on the team's strengths and weaknesses.

In the end, it means making sure that everyone feels valued and appreciated.

In the long term, it means ensuring that the team is supported and motivated.

In the end, it means making sure that the team is successful and productive.
Moore (1920) states that if suspended with the ventral side down, an *Asterias forbesi* will remain motionless in a state of ventral flexure indefinitely. This while not absolutely true of an active *Pisaster* especially at first, and very far from true of an active *Pycnopodia*, may be said to describe the behavior of the more inactive specimens that I have tried the experiment upon. Moore says, furthermore, that if the dorsal wall of a ray of such a suspended specimen be irritated by rubbing it with a glass rod, the ray will flex dorsally. I have confirmed this. Moore, however, neglects to mention a fact, first observed by Romanes and Swart (1881) that the tube feet of such a ray whose dorsal dermis is irritated increase in activity. The normal orientation of tube feet on an active but unoriented specimen is toward the tip of the ray. It would seem then that the dorsal flexure is due to the principle that a ray tends to set itself more nearly at right angles to the actively oriented tube feet. This is perhaps the more acceptable as a point of view since the activity of the tube feet has been observed to spread to the tube feet of other rays and to be followed by dorsal movements or lateral twistings of these other rays.

Moore comes to the conclusion from these and similar experiments that the dorsal flexures of the rays which he has elicited by contact stimulations are the separate parts of the righting reaction. Aside from the fact that the righting reaction has been observed to start without any contact stimulation of the rays, my observations and the statements available in the literature have led me to the conclusion that lateral twistings of the rays are much more important in the righting reaction (save that of *Astropsecten*) than are mere dorsal flexures.

Evidence from the persistence of the "unified impulse"
It remains now to inquire into the correlation between the direction of righting and that of locomotion before and after the reaction. Cole (1913) has presented some evidence on this point, from which he draws negative conclusions. His analysis of the data is, I think, incomplete and the data are not statistically representative.

He argues as follows.

"In Table 4 are shown the results of a number of tests to determine what relation exists between the arms used in righting when the starfish is placed on its aboral surface and the direction of locomotion previous to and subsequent to the righting reaction. The data may be summarized as follows.

<table>
<thead>
<tr>
<th>Arms</th>
<th>ed</th>
<th>f</th>
<th>d</th>
<th>e</th>
<th>ea</th>
<th>a</th>
<th>ab</th>
<th>b</th>
<th>bc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crawling previous to test used in righting</td>
<td>2 6 5 1 3 2</td>
<td></td>
<td>2 9 5 1 2 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crawling subsequently</td>
<td></td>
<td></td>
<td>2 6 5 1 3 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This shows that whereas the four specimens used in these tests righted themselves on arms e a sixteen out of twenty-four times, they had been in nearly all cases crawling in a direction nearly opposed to these arms, and moreover they continued locomotion in the same general direction after righting themselves. An examination of the individual records reveals the same relations in a great majority of cases."

Below is Table 4 to which column 2 and column 5 have been added to help in interpreting the data. Cole's studies have led him to the conclusion that the starfish studied crawls with a anterior, more than with any other rays anterior. Unfortunately, however, in these experiments he chose animals that were not typical in this respect, since in no trials were they crawling toward a, and in all but four trials were crawling in a very different direction. This in connection with the fact that only four specimens were used, all presenting an unusual
In order to determine the correlation between the location of property and other factors, this analysis was conducted. The study area of the site is characterized by its accessibility and ease of transportation. These factors are not statistically significant.

The results are as follows:

<table>
<thead>
<tr>
<th>Factor</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>4</td>
</tr>
</tbody>
</table>

An examination of the data revealed a strong correlation between A and B. Further analysis is needed for a comprehensive understanding of the factors involved.

It is important to note that these findings are preliminary and require further investigation. Further research is needed to confirm the results obtained in this study.
Table 4

Relation of arms used in righting to direction of previous and subsequent crawling.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Previously used arms</th>
<th>Subsequently used arms</th>
<th>Shift of crawling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 After trial 50^g</td>
<td>d</td>
<td>ea</td>
<td>1.5</td>
</tr>
<tr>
<td>10 Before 1^g</td>
<td>e</td>
<td>ea</td>
<td></td>
</tr>
<tr>
<td>10 After 10^g</td>
<td>a</td>
<td>e(b)</td>
<td>1</td>
</tr>
<tr>
<td>10 After 16^g</td>
<td>c</td>
<td>a(ab)</td>
<td>2</td>
</tr>
<tr>
<td>10 After 28^g</td>
<td>cd</td>
<td>ea</td>
<td>2</td>
</tr>
<tr>
<td>10 following day</td>
<td>cd</td>
<td>bc</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>bc</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>1.2 Trial 1</td>
<td>a</td>
<td>bc</td>
<td>a</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
<td>a</td>
<td>0.5</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>de</td>
<td>ea</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>cd</td>
<td>ab</td>
</tr>
<tr>
<td>12</td>
<td>5</td>
<td>c</td>
<td>2.5</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>d</td>
<td>ea</td>
</tr>
<tr>
<td>14</td>
<td>2</td>
<td>d</td>
<td>1.5</td>
</tr>
<tr>
<td>14</td>
<td>3</td>
<td>d</td>
<td>1.5</td>
</tr>
<tr>
<td>14</td>
<td>4</td>
<td>d</td>
<td>1.5</td>
</tr>
<tr>
<td>14</td>
<td>5</td>
<td>d</td>
<td>1.5</td>
</tr>
<tr>
<td>14</td>
<td>6</td>
<td>d</td>
<td>1.5</td>
</tr>
<tr>
<td>14</td>
<td>7</td>
<td>d</td>
<td>1.5</td>
</tr>
<tr>
<td>14</td>
<td>8</td>
<td>d</td>
<td>1.5</td>
</tr>
<tr>
<td>14</td>
<td>9</td>
<td>d</td>
<td>1.5</td>
</tr>
<tr>
<td>14</td>
<td>10</td>
<td>d</td>
<td>1.5</td>
</tr>
<tr>
<td>14</td>
<td>11</td>
<td>d</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Average of all trials: 1.5

These trials were of a series of 499 showing the persistence of the physiological anterior in a general direction, which tends to rotate only to the right or the left.

Five experiments were made with twenty-six starfish (20 directive and 6 inactive). The starfish used were in active locomotion, except in case of some of the Asteroids as shown in the records. Manipulation was as gentle as possible. The animal being picked up by the disk and inverted quickly without, in most cases, lifting it above the surface of the water.

Directives indicate in the surroundings such as light or areas of shadow that were assailed by rotating the animal in successive trials.
direction of locomotion, leads me to believe that the data are not a good foundation for any conclusion. Moreover the conclusion it does indicate is not that drawn by Cole.

As seen from an examination of column 5, the 17 records show that the Physiological anterior has shifted in one direction or the other an average of seven tenths of an inter radius, per reaction. Coles conclusion on this point, as seen above is that "they continued to crawl, in the same general direction (as they did before) after righting themselves."

Moreover, as seen from an examination of column 3, the 19 records show an average shift of anterior (referring to the rays used to right as anterior) of 1.5 inter radii per reaction. Coles conclusion on this point, however is that the animals right in a direction nearly opposite to that in which they were previously (and subsequently) crawling. But the arithmetical difference between these averages of data (1.5 - .7 = .8) is .8 of an interradius a shift which is approximately equal to the shift (.7 interradius) which Cole regards as no shift at all. Obviously, then a detailed examination of Coles data does not confirm his conclusions.

With an idea of clearing up the relationship between the physiological anterior and the arms used in righting seventy-five experiments were made with twenty-six starfish (20 Pisaster and 6 Asterina). The starfish used were in active locomotion, except in cases of some of the Asterina as shown in the record. Manipulation was as gentle as possible, the animal being picked up by the disk and inverted quickly without, in most cases, lifting it above the surface of the water. Directive factors in the surroundings such as light or areas of shadow etc., were excluded by rotating the animal in successive trials.
Relation of arms used in righting to direction of previous and subsequent crawling.

<table>
<thead>
<tr>
<th>Direction before first of bending</th>
<th>Arms bent anteriorly up</th>
<th>Arms righted on</th>
<th>Direction after bending</th>
<th>Arms bent in radii</th>
<th>Direction of shift</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>0.1 Pisaster</td>
<td>ae</td>
<td>aed</td>
<td>0.0</td>
<td>bc</td>
<td>ed</td>
</tr>
<tr>
<td>2</td>
<td>ae</td>
<td>aeb</td>
<td>0.0</td>
<td>ed</td>
<td>e</td>
</tr>
<tr>
<td>2</td>
<td>ae</td>
<td>aeb</td>
<td>0.0</td>
<td>bc</td>
<td>ab</td>
</tr>
<tr>
<td>1</td>
<td>de</td>
<td>e</td>
<td>0.5</td>
<td>(a)bcd</td>
<td>de</td>
</tr>
<tr>
<td>1</td>
<td>de</td>
<td>a(e)</td>
<td>0.5</td>
<td>--</td>
<td>ae</td>
</tr>
<tr>
<td>2</td>
<td>de</td>
<td>dea</td>
<td>0.0</td>
<td>bc</td>
<td>d</td>
</tr>
<tr>
<td>4</td>
<td>a</td>
<td>(a)bcd</td>
<td>0.0</td>
<td>bc</td>
<td>--</td>
</tr>
<tr>
<td>5</td>
<td>de</td>
<td>de(c)</td>
<td>0.0</td>
<td>bc</td>
<td>e</td>
</tr>
<tr>
<td>5</td>
<td>ae</td>
<td>(d)</td>
<td>0.5</td>
<td>bc</td>
<td>a(d)e</td>
</tr>
<tr>
<td>5</td>
<td>ae</td>
<td>a(b)d</td>
<td>1.0</td>
<td>e(b)</td>
<td>de</td>
</tr>
<tr>
<td>5</td>
<td>c</td>
<td>bc</td>
<td>0.5</td>
<td>a</td>
<td>bc</td>
</tr>
<tr>
<td>5</td>
<td>b</td>
<td>bc</td>
<td>0.5</td>
<td>dea</td>
<td>bc</td>
</tr>
<tr>
<td>7</td>
<td>e</td>
<td>e</td>
<td>0.5</td>
<td>bc(d)</td>
<td>ae</td>
</tr>
<tr>
<td>7</td>
<td>e</td>
<td>ae</td>
<td>0.5</td>
<td>bc(d)</td>
<td>ea</td>
</tr>
<tr>
<td>8</td>
<td>bc</td>
<td>b(c)</td>
<td>0.0</td>
<td>bc(d)</td>
<td>ad</td>
</tr>
<tr>
<td>8</td>
<td>de</td>
<td>de</td>
<td>0.0</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>8</td>
<td>de</td>
<td>b</td>
<td>1.5</td>
<td>aode</td>
<td>b</td>
</tr>
<tr>
<td>7</td>
<td>de</td>
<td>de(a)</td>
<td>0.0</td>
<td>bca</td>
<td>de</td>
</tr>
<tr>
<td>7</td>
<td>ae</td>
<td>(b)a</td>
<td>0.0</td>
<td>bca</td>
<td>e</td>
</tr>
<tr>
<td>9</td>
<td>ae</td>
<td>abdce</td>
<td>0.5</td>
<td>bc</td>
<td>ab</td>
</tr>
<tr>
<td>9</td>
<td>ae</td>
<td>abdce</td>
<td>0.5</td>
<td>bc</td>
<td>ab</td>
</tr>
<tr>
<td>10</td>
<td>bc</td>
<td>bc</td>
<td>0.0</td>
<td>ade</td>
<td>bc</td>
</tr>
<tr>
<td>11</td>
<td>bc</td>
<td>bc</td>
<td>0.0</td>
<td>ade</td>
<td>bc</td>
</tr>
<tr>
<td>7</td>
<td>cd</td>
<td>cd</td>
<td>0.0</td>
<td>abc</td>
<td>ed</td>
</tr>
<tr>
<td>12</td>
<td>de</td>
<td>(a)ed</td>
<td>0.0</td>
<td>bc</td>
<td>ed</td>
</tr>
<tr>
<td>13</td>
<td>ac</td>
<td>(eabcd)</td>
<td>0.0</td>
<td>(abcd)</td>
<td>--</td>
</tr>
<tr>
<td>12</td>
<td>od</td>
<td>dec</td>
<td>1.0</td>
<td>ab</td>
<td>de</td>
</tr>
<tr>
<td>12</td>
<td>de</td>
<td>(a)d</td>
<td>1.0</td>
<td>bc</td>
<td>ae</td>
</tr>
<tr>
<td>12</td>
<td>de</td>
<td>e(a)</td>
<td>1.0</td>
<td>bcd</td>
<td>ea</td>
</tr>
<tr>
<td>12</td>
<td>ea</td>
<td>ed</td>
<td>1.0</td>
<td>ab</td>
<td>ed</td>
</tr>
<tr>
<td>14</td>
<td>c</td>
<td>dm</td>
<td>0.5</td>
<td>aed</td>
<td>de</td>
</tr>
<tr>
<td>15</td>
<td>c</td>
<td>(e)</td>
<td>0.0</td>
<td>(abcd)</td>
<td>--</td>
</tr>
<tr>
<td>16</td>
<td>od</td>
<td>a</td>
<td>2.5</td>
<td>(a)e(a)bcd</td>
<td>ae</td>
</tr>
<tr>
<td>16</td>
<td>ae</td>
<td>ae</td>
<td>0.0</td>
<td>bc</td>
<td>ed</td>
</tr>
<tr>
<td>16</td>
<td>ae</td>
<td>ed</td>
<td>1.0</td>
<td>bcd</td>
<td>ae</td>
</tr>
<tr>
<td>16</td>
<td>ab</td>
<td>ae</td>
<td>1.0</td>
<td>cd(e)b</td>
<td>ae</td>
</tr>
<tr>
<td>16</td>
<td>ab</td>
<td>ae</td>
<td>1.0</td>
<td>bcd</td>
<td>ae</td>
</tr>
<tr>
<td>17</td>
<td>bc</td>
<td>bc</td>
<td>0.0</td>
<td>aed</td>
<td>bc</td>
</tr>
<tr>
<td>17</td>
<td>bc</td>
<td>bc</td>
<td>0.0</td>
<td>aed</td>
<td>bc</td>
</tr>
<tr>
<td>17</td>
<td>bc</td>
<td>bc</td>
<td>0.0</td>
<td>aed</td>
<td>bc</td>
</tr>
<tr>
<td>18</td>
<td>cd</td>
<td>bc</td>
<td>1.0</td>
<td>aed</td>
<td>bc</td>
</tr>
<tr>
<td>19</td>
<td>d</td>
<td>abdce</td>
<td>--</td>
<td>e</td>
<td>bc</td>
</tr>
<tr>
<td>19</td>
<td>cd</td>
<td>abdce</td>
<td>--</td>
<td>e</td>
<td>bc</td>
</tr>
<tr>
<td>19</td>
<td>cd</td>
<td>abdce</td>
<td>--</td>
<td>e</td>
<td>bc</td>
</tr>
<tr>
<td>a</td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.1</td>
<td>be</td>
<td>0.1</td>
<td>be</td>
<td>0.1</td>
<td>be</td>
</tr>
<tr>
<td>0.1</td>
<td>ae</td>
<td>0.1</td>
<td>ae</td>
<td>0.1</td>
<td>ae</td>
</tr>
<tr>
<td>0.1</td>
<td>ab</td>
<td>0.1</td>
<td>ab</td>
<td>0.1</td>
<td>ab</td>
</tr>
<tr>
<td>0.1</td>
<td>cd</td>
<td>0.1</td>
<td>cd</td>
<td>0.1</td>
<td>cd</td>
</tr>
<tr>
<td>0.1</td>
<td>de</td>
<td>0.1</td>
<td>de</td>
<td>0.1</td>
<td>de</td>
</tr>
<tr>
<td>0.1</td>
<td>ef</td>
<td>0.1</td>
<td>ef</td>
<td>0.1</td>
<td>ef</td>
</tr>
<tr>
<td>0.1</td>
<td>fg</td>
<td>0.1</td>
<td>fg</td>
<td>0.1</td>
<td>fg</td>
</tr>
<tr>
<td>0.1</td>
<td>gh</td>
<td>0.1</td>
<td>gh</td>
<td>0.1</td>
<td>gh</td>
</tr>
<tr>
<td>0.1</td>
<td>hi</td>
<td>0.1</td>
<td>hi</td>
<td>0.1</td>
<td>hi</td>
</tr>
<tr>
<td>0.1</td>
<td>ij</td>
<td>0.1</td>
<td>ij</td>
<td>0.1</td>
<td>ij</td>
</tr>
<tr>
<td>0.1</td>
<td>ab</td>
<td>0.1</td>
<td>ab</td>
<td>0.1</td>
<td>ab</td>
</tr>
<tr>
<td>0.1</td>
<td>cd</td>
<td>0.1</td>
<td>cd</td>
<td>0.1</td>
<td>cd</td>
</tr>
<tr>
<td>0.1</td>
<td>ef</td>
<td>0.1</td>
<td>ef</td>
<td>0.1</td>
<td>ef</td>
</tr>
<tr>
<td>0.1</td>
<td>gh</td>
<td>0.1</td>
<td>gh</td>
<td>0.1</td>
<td>gh</td>
</tr>
<tr>
<td>0.1</td>
<td>hi</td>
<td>0.1</td>
<td>hi</td>
<td>0.1</td>
<td>hi</td>
</tr>
<tr>
<td>0.1</td>
<td>ij</td>
<td>0.1</td>
<td>ij</td>
<td>0.1</td>
<td>ij</td>
</tr>
<tr>
<td>0.1</td>
<td>ab</td>
<td>0.1</td>
<td>ab</td>
<td>0.1</td>
<td>ab</td>
</tr>
<tr>
<td>0.1</td>
<td>cd</td>
<td>0.1</td>
<td>cd</td>
<td>0.1</td>
<td>cd</td>
</tr>
<tr>
<td>0.1</td>
<td>ef</td>
<td>0.1</td>
<td>ef</td>
<td>0.1</td>
<td>ef</td>
</tr>
<tr>
<td>0.1</td>
<td>gh</td>
<td>0.1</td>
<td>gh</td>
<td>0.1</td>
<td>gh</td>
</tr>
<tr>
<td>0.1</td>
<td>hi</td>
<td>0.1</td>
<td>hi</td>
<td>0.1</td>
<td>hi</td>
</tr>
<tr>
<td>0.1</td>
<td>ij</td>
<td>0.1</td>
<td>ij</td>
<td>0.1</td>
<td>ij</td>
</tr>
<tr>
<td>No.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>-----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>46</td>
<td>Asterina</td>
<td>ae</td>
<td>ae(b)</td>
<td>0.0</td>
<td>dcb</td>
</tr>
<tr>
<td>47</td>
<td>ab</td>
<td>ae(b)</td>
<td>1.0</td>
<td>abc</td>
<td>ae</td>
</tr>
<tr>
<td>48</td>
<td>de</td>
<td>(de)abc</td>
<td>0.0</td>
<td>ac(b)</td>
<td>de</td>
</tr>
<tr>
<td>49</td>
<td>ae</td>
<td>ae</td>
<td>0.0</td>
<td>bcd</td>
<td>ae</td>
</tr>
<tr>
<td>50</td>
<td>c</td>
<td>c</td>
<td>0.0</td>
<td>abcd</td>
<td>c</td>
</tr>
<tr>
<td>51</td>
<td>ea</td>
<td>ea(b)</td>
<td>0.0</td>
<td>dbc</td>
<td>ea</td>
</tr>
<tr>
<td>52</td>
<td>de</td>
<td>(d)ea</td>
<td>0.0</td>
<td>bcd</td>
<td>ea</td>
</tr>
<tr>
<td>53</td>
<td>c</td>
<td>c</td>
<td>0.0</td>
<td>tulip form</td>
<td>--</td>
</tr>
<tr>
<td>54</td>
<td>d</td>
<td>d</td>
<td>0.0</td>
<td>(de)</td>
<td>de</td>
</tr>
<tr>
<td>55</td>
<td>ae</td>
<td>ae</td>
<td>0.0</td>
<td>--</td>
<td>cd</td>
</tr>
<tr>
<td>56</td>
<td>bc</td>
<td>bc</td>
<td>0.0</td>
<td>aed</td>
<td>bc</td>
</tr>
<tr>
<td>57</td>
<td>de</td>
<td>abode</td>
<td>stopped</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>58</td>
<td>0.0</td>
<td>stopped</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>59</td>
<td>a</td>
<td>a(e)</td>
<td>0.0</td>
<td>bcd</td>
<td>ae</td>
</tr>
<tr>
<td>60</td>
<td>O(sta)bc</td>
<td>abode</td>
<td>stopped</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>61</td>
<td>de</td>
<td>ba</td>
<td>tulip form</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>62</td>
<td>de</td>
<td>bc</td>
<td>2.0</td>
<td>ade</td>
<td>bc</td>
</tr>
<tr>
<td>63</td>
<td>bc</td>
<td>bc</td>
<td>0.0</td>
<td>aed</td>
<td>bc</td>
</tr>
<tr>
<td>64</td>
<td>ab</td>
<td>ae</td>
<td>1.0</td>
<td>bcd</td>
<td>ae</td>
</tr>
<tr>
<td>65</td>
<td>bc</td>
<td>bc</td>
<td>0.0</td>
<td>ade</td>
<td>bc</td>
</tr>
<tr>
<td>66</td>
<td>ae</td>
<td>ae</td>
<td>0.0</td>
<td>bcd</td>
<td>ae</td>
</tr>
<tr>
<td>67</td>
<td>ab</td>
<td>ae</td>
<td>1.0</td>
<td>bcd</td>
<td>ae</td>
</tr>
<tr>
<td>68</td>
<td>de</td>
<td>eacd</td>
<td>1.0</td>
<td>bmx</td>
<td>e</td>
</tr>
<tr>
<td>69</td>
<td>de</td>
<td>de</td>
<td>0.5</td>
<td>dcb</td>
<td>ae</td>
</tr>
<tr>
<td>70</td>
<td>de</td>
<td>de</td>
<td>0.0</td>
<td>cab</td>
<td>de</td>
</tr>
<tr>
<td>71</td>
<td>ab</td>
<td>ae</td>
<td>1.0</td>
<td>cdb</td>
<td>ae</td>
</tr>
<tr>
<td>72</td>
<td>0Stationary</td>
<td>rigid</td>
<td>tulip form</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>73</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>74</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>75</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
</tbody>
</table>

Average: 38 (64 trials) 6 (62 trials) 57 (44 trials)

A comparison of the averages obtained here, and those derived from Gold's data, shows that careful manipulation of the starfish and the use of a large number of individuals reduces the shift of anterior considered, as shown by the rays that are first turned aere, the anterior at the beginning of righting has shifted .33 of an internode on an average of 64 observations. As shown by the rays on which the animal rights, the anterior during the righting reaction has shifted .6 of an internode from where it was before the animal was inverted. After righting, the anterior shifts slightly back along its original direction, as shown by the fact that the average shift after righting is less than during righting. This shown was markedly in the average.
Records were taken (column 1) of the direction of locomotion before righting and (column 2) the arms that, after inverting, the animal, first twisted and bent down toward the substrate. These two findings were compared in each experiment and the shift in either direction of the leading rays or "physiological anterior" set down in column 3. The turning down of certain rays is usually followed (max or preceded) by a lifting up of others. The rays that lifted up free of the substrate but not those that were oriented on the substrate, in the way described above, to walk over the initiating rays, were next recorded (column 4).

The rays that turned down were not, always, of course the same as those that the animal uses in righting. These latter are listed in column 5, and the shift of anterior from the direction before inverting to the arms used in righting is listed in column six. The anterior after righting is listed in column 7 and its shift from the direction before inverting is listed in column 8. Thus the shifts of anterior, listed in columns 3, 6 and 8 refer to the original anterior before inverting.

A comparison of the averages obtained here, and those drawn from Cole's data shows that careful manipulation of the starfish and the use of a large number of individuals reduces the shift of anterior considerably. As shown by the rays that are first turned down, the anterior at the beginning of righting has shifted .38 of an inter-radius on an average of 64 observations. As shown by the rays on which the animal rights, the anterior during the righting reaction has shifted .6 of an inter-radius from where it was before the animal was inverted. After righting, the anterior shifts slightly back toward its original direction, as shown by the fact that the average shift after righting is less than during righting. This shows more markedly in the average
drawn from Cole's table.

This return of the anterior toward its original direction is an example of the tendency which we have noticed in connection with the deviation reaction (p. 57) for the coordinated impulse to return to its original direction, even after having been actively oriented in some other direction.

Cole (1913) has shown very conclusively that the impulse to locomote, in the starfish tends thus to maintain the same general direction, from trial to trial. (Between each trial the animal was held inverted by the disk until the rays dropped and then "started" on the bottom of an aquarium in a non-directive chamber.) The tendency to keep in the same direction was of course only general, as there was also a rotation of the anterior toward the right or toward the left, and certain aberrant deviations, of from one half to two and a half inter-radii occurring quite frequently. In summing up these deviations from the table opposite p. 16 it was found that they amounted to a sum total of 217 inter-radii in 499 trials. This amounts to a shift of anterior of .43 inter-radii per trial which is quite comparable quantitatively with the figures (.38, .60, .57) inter-radii obtained from the status of the direction of the coordinated impulse throughout the righting reaction.

I conclude therefore that righting is an aspect of locomotion.
1/ _Pisaster ochraceus_ presents the three following well-marked physiological states (1) "Rigid" (2) "locomotor" (3) "active but unoriented". The responses of the tube feet and arms differ markedly according to the physiological state of the animal. Other starfish studied present analogous states.

2/ Extension of the tube feet depends upon the proper physiological state and absence of stimuli which cause retraction. An isolated tube foot, inflated with water under pressure can be caused to slowly extend but not quite normally.

3/ Attaching is conditioned by the proper physiological state. An isolated tube foot, properly prepared and inflated with water is more apt to attach if taken from a rigid starfish than from a locomotor starfish. Attaching may involve only a part of the ambulacral disk.

4/ Withdrawal is a response to contact stimulation, as is detaching, under certain conditions.

5/ The step reflex intergrades with the withdrawal response as elicited by contact stimulation of the ambulacral disk. It is dependent upon the contact stimulation and the presence of the locomotor impulse, which orients the step reflex and conditions the tube foot to be rigid and support animal during locomotion. The tube foot is attached most strongly during the first part of the step reflex. The tube foot is attached with 2.8 (Asterina) or 2.06 (Echinopodia) times as much force as it exerts in pulling against resistance. The factor is relatively constant for various values of the resistance. The strength of the step reflex varies markedly with different species.

6/ Coordination of the tube feet of the rigid starfish, like that of the gills, is a simple spread of extension or retraction. It is referable hypothetically to a simple nerve net.
7/ Coordination in the active but unoriented starfish involves orientation of the distal tube feet, toward the tips of the rays. With the rays on separate substrates, this tendency results in their walking in five different directions. Under pathological conditions this tendency results in autotomy. Orientation of the tube feet is not referable to a simple nerve net as is coordination in extension and retraction but to a more complicated and possibly an independent mechanism.

8/ The unified impulse is formed (1) by the spreading back of the oriented state in the tip of one of the rays. Various factors may cause the relative increase which results in its spread over the rest of the animal (2) by the spreading back and fusion of the oriented states in adjacent rays. (3) By direct orientation of the tube feet from exitation of the dermal nerve net or the tube feet, themselves.

9/ Behavior of the oriented animal is conditioned by all of the above factors acting at the same time and in nice balance against each other. In the actively migrating starfish the tube feet are all oriented in the same direction.

10/ The unified impulse, (1) in some types of righting reaction, (2) in the deviation reaction, (3) in the locomotor starfish with a curved lateral arm, is broken up into areas in which the tube feet are oriented in different directions. This is highly adaptive. A possible physiological explanation is seen in the traction on the tube feet resulting from the movement of the rays over the substrate. Evidence for this hypothesis is drawn from (1) Neurotomized starfish (2) starfish with the rays placed on separate substrates; (3) the mechanics of the deviation reaction.

11/ The righting reaction is a phase of ordinary locomotion
with the starfish in more or less a state of unified coordination.
The movements of the arms are explained on the assumption of reflex connections by which the arms are bent or twisted more nearly at right angles to the actively oriented tube feet. Evidence for this conclusion is drawn (1) from the movements of the tube feet and arms: (2) from an analysis of the reaction when the tube feet are prevented attaching by inverting the animal on sand; (3) from the fact that stimulation of the dorsal myodermal sheath of the ray is not an essential factor in the righting reaction (4) from the fact that the "unified impulse" persists during the righting reaction in the same direction to a degree quantitatively comparable to its persistence in ordinary locomotion (Cole).

Clark, H. L.
Cole, L. J.
Cowieles, R. F.
LITERATURE CITED

Baudelot, E.

Bohn, G.

Botazzi, F.
1898. Contributions to the physiology of unstriated muscular tissue, IV. Jour. Physiol., 22, 481-505, (p. 501 ff.), 22 figs. in text.

Clark, H. L.

Cole, L. J.

Cowles, R. P.
1914. The difference of white and black walls on the
direction of locomotion in the starfish. Jour.

Cuenot, L.

mem II, 1-144, pl. 1-9.

De Moore, J., and Chapeaux, M.

1891. Contributions a la physiologie nerveuse des echin-
odermes. Tidschr. Nederl. Dierk Ver., (2), Deel. 3,
1891, 108-169, pl. 7.

Driesch, H.

1908. Science and philosophy of the organism. (Aberdeen
University) 2, XVI + 381 pp.

Graber, V.

1885. Ueber die Helligkeits- und Farbenempfindlichkeit

Grave, C.

pl. 1-5, 5 figs. in text. Mem. Biol. Lab. Johns
Hopkins Univ., No. 5.

Greenwood, M.

1890. On the action of nicotine upon certain invertebrates.
J. exp. Physiol., 11, 570-605.

Hess, C.

1914. Unterzuchung über dem Lichtzinn bei Echinodermen.
Pflüger's Arch., 160, 1-26, 6 figs. in text.

Holmes, S. J.

1911. The evolution of animal intelligence. (New York, Holt),
V-296 pp., 18 figs. in text.
Jennings, H. S.
1907. Behavior of the starfish Astorias aertulifera
Publ. Zool. 4, 53-185, figs. in text.

Krukenberg, C. Fr. W.
1881. Betrage zu einer Nervenphysiologie der Aschinodermen.
In Verg. Phys. Studien (Heidelberg, Carl Winter's
Buchverhdg.) 2 Reihe. 1 abth, 76-82, 2 figs. in
text.

Loeb, J.
1900. Comparative physiology of the brain and comparative
psychology. (New York, Putnam), X 309 pp., 39 figs.
in text.

Ludwig, H., and Hamana, O.
1899. Seesterne in Brunn's Klassen and Ordnungen des Thier-
Reichs. (Leipzig, C. F. Winter'sche Buchverhandlung)
2. Abt. 3, 461-744, pls. 1-12, 13 figs. in text.

Mangold, E.
1908a Studien der Physiologie des Nervensystems der Schino-
dermen, I. Die Fusschen der Seesterne und die
Koordination ihrer Bewegungen. Pfluger's Archiv., 122,
315-360, 14 figs. in text.
1908b Studien der Physiologie des Nervensystems der Schino-
dermen, II, Ueber das Nervensystem der Seesterne und
in text.
1909b. Studien zur Physiologie des Nervensystem der Schino-
dermen III Ueber die Arnbewegungen der Schlangensterne
und, V. Nekkull's Fundamentalgesetz fur den Erregungs.
verlauf, Pflugers Archiv., 126, 371-406, 6 figs.
in text and 4 tables.

Parker, H. H. Mast, S. O.

1919. The Elementary Nervous System. (Philadelphia

1911. Light and the behavior of organisms. (New York,

Wiley) XI + 410 pp., 35 figs. in text.

Flessner, H.

1918. Untersuchungen über den Physiologie der Seesternen.

Meyer, R.

1906. Untersuchung über den feineren Bau des Nervensystems


Prayer, W.


Moore, A. R.


Zool., State of Wash., 7, 27-127; 191-235, pl. 7,

Bull. 14, 235-239, 1 fig. in text.

1910b. On the nervous mechanism of the righting movements of

the starfish. Amer. J. Physiol., 27, 207-211, 2

1896. Du Sens de l'odorat chez les etoiles de mer. 3

figs. in text.

Reznik, R. A.

1916. The action of strychnine on certain invertebrates


1917. Chemical differentiation in the nervous system of

1710. Du mouvement progressif et de quelques autres


mouvements de diverses espèces de mollusques.

1918. Reversal of reactions by means of strychnine in


planarians and starfish. J. Gen. Physiol., 1, 97-100.


3 figs. in text.

Romans, G. J. and Hoyt J. G.

1920a. The action of strychnine and nicotine on the neuro-

muscular mechanism of Asterias. J. Gen. Physiol., 2

201-204, 5 figs. in text.

1920b. Stereotropism as a function of neuromuscular

organization. J. J. Gen. Physiol., 2, 319-324, 4

1883. Observations on the physiology of the echinodermata

figs. in text.

J. Linn. Soc., 17, 131-137.

Norman, W. W.

1900. Do the reactions of the lower animals against injury

indicate pain sensations. Amer. J. Physiol., 3,

271-284.

1930. Jellyfish, starfish, and sea-urchins. (New York,

Action) XI - 305 pp. 64 figs. in text.


1959. The Immediate Neuronal System. (Philosophica)

1965. The development of new environmental and social features.

In text.


1959. Cells of the newborn's veins. 7-71: 16-535, Pi. V.

In text.

1969. No gene to 1 letter. "The following are met.

Comment: More. Sound. Name. Rate. II.


Remark. R. A. L. D.

1960. On communication between the diverse senses.


Remains. 6. 7. and Market. 7. 0.

1961. Operation on the locomotor system of the

Remains. 6. 7.

1965. Operation on the physiology of the locomotory

1965. "Linn. 806, dy. 12-121.

1965. "Linn. 806, dy. 12-121.

Apperson's (XI + 366) pp. 65 figure. In text.
Russo, G.


Scheinmetz, P.


Steiner

1898. Die funktionen des Centralnervensystem und ihre Phylogenese 3, Die Wirbellosen Thiere, (Braunschweig, Friederich Vieweg) X + 154 pp., 1 pl., 46 figs. in text.

Sterne, C.

1891. Five souls with but a single thought, the psychological life of the starfish. Monist, 1 245-262, 6 figs. in text.

Spix.


Tiedemann, F.


Verrill, A. E.

Von Uexküll, J.


Vulpian, A.
