that has been done in the attempt to protect animals against infectious abortion. Many experiments are reviewed in this article which are not to be found in the general literature of abortion. Many of these are scattered through Danish veterinary journals and many others are here published for the first time. The results of the experiments given indicate that there is some hope of producing immunity by means of vaccines or serums. There is, however, need of many long continued and carefully planned experiments to prove this. The insidious nature of the disease makes it very difficult to obtain crucial evidence. The above cited paper is an excellent summary of the work so far done in this direction.

Not the least interesting phase of the study of infectious abortion is that which has recently appeared from the laboratory of Dr. Theobald Smith.[13] In these papers Smith and Fabyan have clearly demonstrated a fact which has been overlooked by previous students of this subject, viz., that the abortion bacillus is able to cause marked pathological lesions in guinea-pigs and other laboratory animals. Further, these lesions are by no means confined to the reproductive organs, but affect in particular, the spleen, liver, bones, lungs, lymph-nodes and kidneys. The lesions are not unlike those produced by tuberculosis. In a few cases death ensued after some weeks, in others the animals appeared to recover and maintain a general good health. No external symptoms, other than a slight loss in weight, were present in the majority of cases. In some instances paralysis of the hind quarters was noted. Occasional cases of blindness and the enlargement of the lymph nodes were other symptoms.

The interest in the disease is increased by the fact pointed out by Smith and later by the U. S. Department of Agriculture[14] that the abortion bacillus occurs in the milk of infected cows and that the injection of such milk into healthy guinea-pigs will produce lesions similar to those noted above. Further, it is possible to recover the abortion bacilli from animals inoculated with such milk.

The fact that a large portion of dairy milk contains the abortion bacilli and the further fact that in cattle the most common means of infection is through the alimentary canal make it at least suggestive that this organism may be an etiological factor in certain human infections.

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[13] Smith, Theobald, and Fabyan, Marshall, "Ueber die Pathogene Wirkung des Bacillus abortus Bang," *Central. f. Bakt. usw.*, I., Orig. Bd. 61, pp. 549–556, January, 1912. Fabyan, Marshall, "A Contribution to the Pathogenesis of *B. abortus* Bang," *Jour. Med. Research*, Vol. XXVI., pp. 441–489, July, 1912.

[14] Bureau of Animal Industry, U. S. Department of Agriculture, Circular No. 198, March, 1912.

SPECIAL ARTICLES

THE EFFECTS OF ALKALOIDS ON THE DEVELOPMENT OF FISH (FUNDULUS) EMBRYOS

In previous experiments it was found that a large number of neutral salts and many anesthetics, including alcohols, when applied to *Fundulus* embryos, in concentrations slightly below the fatal dose, produce abnormalities in the eyes. The most striking of these abnormalities is the presence of one median eye instead of the usual eyes, a condition known as cyclopia. In some embryos but one eye is present and is lateral, as in the normal fish, a defect designated as monophthalmia asymmetrica.

Considering the variety of the "poisons" used, one might suspect that the *Fundulus* embryo reacts to all poisons by developing defects in the eyes, provided the right concentration of the harmful substances is found. To determine this, it is not necessary to try an infinite number of concentrations of the reagent, since I found that the concentrations producing cyclopia were the highest concentrations in which the embryos could live. It is only necessary to determine the lethal dose, and then make a finely graduated series just below this limit. In this way I have tried out

members of an entirely different class of substances, namely, alkaloids.

Of the alkaloids so far tried theobromine is not sufficiently soluble in sea water to affect the embryos noticeably. The effects of caffeine and theine[1] are identical. Nicotine is four times more toxic, but when used in proper concentration produces similar results ($M/400$ nicotine $= M/100$ caffeine).

The effects of these alkaloids is cumulative, *i. e.*, the greater the length of time the embryos remain in a solution, the less the concentration of the latter needed to produce a certain effect.

In the majority of the experiments, the embryos at about the four-cell stage, were placed in sea-water solutions of the alkaloids and allowed to remain thirty-six hours, then transferred to sea water.

The very constant effects of these alkaloids[2] are the enlargement of pericardium, ear and brain vesicles and cœlom, together with the suppression of the circulation. The heart may or may not beat, and may or may not contain erythrocytes. Erythrocytes are seen in the embryo, but not on the yolk sac. They are often clumped in masses of various sizes along the non-functional blood vessels. Black pigment cells migrate over the lower side of the pericardium and red pigment cells over the heart in an abnormal manner.

Primary cyclopia is extremely rare. In fact, the only cases found were two in the nicotine solutions. However, there are cases of secondary "one-eyedness" due to degeneration of one of the eyes or fusion of the eyes.

Many of the alkaloid embryos sooner or later begin to degenerate. Since degeneration occurs in other classes of experiments with *Fundulus* embryos in which the circulation is suppressed, the lack of a circulation might be considered the cause of degeneration. However, I consider this improbable, since many embryos lacking a circulation show no signs of degeneration, unless the œdema of serous cavities be considered such. The degenerative effects of alkaloids may not appear until after the period when the circulation is normally established, even though the embryos were removed from the solutions before this period. But this does not prove that degeneration is due to lack of a circulation.

One eye may degenerate before the other, but usually the degeneration is symmetrical. The degenerating eye becomes irregular in outline and finally its boundary can not be distinguished. The retinal pigment is the only part of the eye substance that remains identifiable in living specimens. In one specimen the two pigment masses moved from their position in the head and formed an attachment to the venous end of the heart.

In the stronger solutions, the cells over the whole surface of the embryo become loosened at an early stage. A process of de-differentiation occurs, and there finally remains but an irregular patch of cells, among which only the pigment cells are distinctive. In this condition the embryo may live for many days.

Similar degeneration may occur as the effect of other poisons, but seems to be more common as an effect of alkaloids. On the other hand, cyclopia is rarer in alkaloid embryos than in those treated with certain other substances. Whereas in solutions of ethyl alcohol 100 per cent. of the embryos may show primary defects in the eyes; such occurred in only about one in a thousand of the nicotine embryos. Although thousands of eggs were placed in caffeine and theine, this number is too small to exclude the possibility that cyclopia might occur as frequently as in nicotine.

Much has been said for and against the idea of the specificity of the action of various substances on embryos. The data found in the literature indicate that more qualitative and quantitative observations are needed on this subject. Organisms are not simply chemical compounds. In studying the mechanism of the effects of chemicals, the *structure* of the organisms should be especially considered; and not only the morphological structure, but

[1] Considered identical chemically.

[2] And of a number of others used since this went to press.

the chemical and physical nature of the component parts.

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On the Relationship between the Bilateral Asymmetry of the Unilocular Fruit and the Weight of the Seed which it Produces

The problem of symmetry, radial and bilateral, is of such great interest that it can not be approached from too many angles. The purpose of the present note is to discuss on the basis of a rather extensive series of quantitative data the question: "Do bean pods with an 'odd' number of ovules produce lighter seeds than those with an even (2, 4, 6, etc.) number?" Here the "odd" or "even" character of the pod is to some extent an index of bilateral asymmetry. Pods with an odd number of ovules must have them unequally divided between the two carpellary margins which form the ventral suture, while those with an even number generally have them equally divided. Thus with respect to the distribution of ovules, pods with an odd number must be bilaterally asymmetrical; those with an even number are generally bilaterally symmetrical.

The results which led up to the present study were the discovery of an intra-individual selective elimination of ovaries with a larger number of "odd" locules in *Staphylea*[1] and the demonstration of a usually lower fertility and fecundity in "odd" pods of *Phaseolus*.[2]

[1] For literature, see: "The Selective Elimination of Organs," Science, N. S., XXXII., 519–528, 1910; "On the Selective Elimination occurring during the Development of the Fruit of *Staphylea*," *Biometrika*, VII., 452–504, 1910; "Further Observations on the Selective Elimination of Organs in *Staphylea*," *Zeitschrift f. Ind. Abst.- u. Vererbungsl.*, V., 273–288, 1911; "The Measurement of Natural Selection," *Pop. Sci. Mo.*, LXXVIII., 521–538, 1911.

[2] "On the Relationship between Bilateral Asymmetry and Fertility and Fecundity." In press in Roux's *Archiv f. Entwickelungsmechanik*.

Among the series of individually weighed bean seeds gathered for a study of the pure line problem are five in which the number of ovules in the pod from which the seed was taken is recorded. These series (designated by key letters) are:

L. Golden Wax. Grown at Lawrence, Kansas, 1906. 2,861 seeds.

LL. Golden Wax. Plants the offspring of the L series, grown at Lawrence, Kansas, 1907. 3,947 seeds.

GG. Burpee's Stringless. Grown at the Missouri Botanical Garden, 1907. 8,364 seeds.

H. Navy. Grown near Sharpsburg, Ohio, 1907. 5,778 seeds.

D. Navy. Another series, grown under very different conditions near Sharpsburg, Ohio, 1907. 2,362 seeds.

The material is, therefore, rather extensive and diversified. Two methods of analysis are possible. (*a*) The pods may be merely classified as "odd" and "even" and the mean weight of the seeds produced by each kind determined. (*b*) A regression equation can be fitted to the whole data and the weighted mean deviation of the empirical means from the theoretical means determined for either "odd" or "even" pods.

Let o = number of ovules per pod, w = weight of seed in units of .025 grams. Then correlations and regression straight line equations are:[3]

Series	Correlation	Regression Equation
L	$r = -.0401$	$w = 16.4645 - .1597\ o$
LL	$r = +.0586$	$w = 13.0281 + .2060\ o$
GG	$r = +.0109$	$w = 17.3881 + .0354\ o$
NH	$r = -.1410$	$w = 11.0961 - .2806\ o$
ND	$r = -.1227$	$w = 8.5554 - .2583\ o$

The correlations are in all cases low. Testing the influence of the "odd" (asymmetrical) character of the pod upon the weight of the seed by the weighted mean deviation (regarding signs) of the average weights of seeds produced by odd pods from the theoretical means calculated from these equations as well

[3] Data from which all the constants given here may be checked will be eventually published for another purpose.