it can be shown mathematically that the carbon dioxide tension of the more concentrated sea water would then be higher than the carbon dioxide partial pressure of the atmosphere. This would form a "ridge" or "peak" of high carbon dioxide tension water on the outer edge of the diluted sea water. There would then be a carbon dioxide tension gradient from the mouths of rivers out to the extent of their diluting influence into the ocean. This area would in turn be bounded by waters having carbon dioxide tensions higher than the carbon dioxide partial pressure of the atmosphere.

The question is now raised, do fishes respond to a gradient of carbon dioxide tension water? Researches that have been carried on indicate that fishes do respond to a carbon dioxide tension gradient. Brilliant work done in the field of mammalian physiology has shown that the carotid bodies are sensitive, though to a less extent than the respiratory center, to a change in carbon dioxide tension of the blood. The carotid bodies alone are responsive to low oxygen tension of the blood. It is a well-known fact among all biologists that fishes avoid the high carbon dioxide tension and low oxygen tension hypolimnion water of a stratified lake. Now going back to our area of sea bounded by a "ridge" of high carbon dioxide tension it is obvious that if a salmon should cross this ridge it would be in an area dominated by another river and would be a stray (see discussion that follows).

It is a well-known fact that there is an increase in protein metabolism in the salmon when approaching sexual maturity. Increased protein metabolism tends toward acidosis, *i.e.,* a lowering of the alkali level of the blood. It is suggested that this lower alkali level of the blood brings about a response to a lower carbon dioxide tension of the water. At first this might constitute a drift, wandering, that would carry the salmon that were approaching sexual maturity, but not the immature, into lower carbon dioxide tension water. The carbon dioxide tension gradient is still steeper in the lower carbon dioxide tension water. The protein metabolism of the salmon is further increased as it approaches nearer sexual maturity. This still lower alkali level of the blood increases the response to lower carbon dioxide tension water which is more effective since there is an increased carbon dioxide tension gradient. The salmon finds the spawning streams by following the carbon dioxide tension gradient. The steeper the gradient, *i.e.,* the greater the volume flow of the stream, and the nearer the approach to sexual maturity the more vigorous the response of the salmon. When the salmon reach the mouth of the river they respond to current and ascend the spawning stream.

These suggested behaviors of the salmon are in complete accord with all known facts concerning the migratory movements of the salmon. It also explains why the immature salmon do not enter rivers *en masse.* The cycle is physiological, sexual and less environmental, seasonal. Of course we all understand that all physiological and sexual cycles are tied up with the environment, *i.e.,* seasonal.

The spawning ground chosen is a matter of reactions to environmental factors.[2]

These views are in keeping with Huntsman's[3] findings that salmon are held within the influence of natal streams, the "parent stream" theory and the specific races of the European workers. These are all discussed in the forthcoming paper. The author is well aware that much detail remains yet to be worked out. The author also wishes to emphasize the fact that no one factor can be responsible for all migratory movements of salmon.

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THE PERIODIC DIE-OFF IN CERTAIN HERBIVOROUS MAMMALS AND BIRDS

GREEN and others[1,2] have recently found that the cyclic decline of hares (*L. americanus*) in Canada is due in the main to a non-infectious disease which they call shock disease. The animals die suddenly in convulsions from a hypoglycaemic shock, due to degeneration of the liver with resultant failure of glycogen storage. The authors surmise that a similar disease may account for the four-year cycle in mice, since similar symptoms have been noted in these animals without any infectious agent being demonstrable. The cause of this liver damage in *L. americanus* has not been found, but several explanations are suggested, one of them being that "the increasing population may eradicate certain plants that contain food elements essential for the maintenance of healthy populations."

Now, there are some peculiarities in the behavior of the animals which do suggest deficiencies in the food, more specially mineral deficiency. The Danish civil engineer, Mr. J. O. B. Petersen, who has been working for several years in the northern parts of the Canadian forests, told me that "the rabbits" during their peak in numbers were very eager to gnaw or lick at anything which had been touched by sweaty hands; they could even be a nuisance in attacking measuring instruments, etc. This was not observed at other times; it was even possible to know whether a thrown-away boot had been lying in the forest since the last maximum, since in that case the sole would be gnawed away by the hares. As a matter of fact this behavior has been recorded (as a curiosity) by Soper,[3] who during

[2] E. B. Powers, Publ. Amer. Assoc. Adv. Sci., No. 8: 72–85 and citations, and H. B. Ward, Publ. Amer. Assoc. Adv. Sci., No. 8: 60–71.

[3] A. G. Huntsman, SCIENCE, 85: 582–583, 1937.

[1] R. G. Green and C. L. Larson, *Amer. Jour. Hyg.*, Baltimore, 28: 190, 1938.

[2] R. G. Green, C. L. Larson and J. F. Bell, *Amer. Jour. Hyg.*, Baltimore, 30: 99, 1939.

a period of maximum abundance observed from traces in the snow how the animals had assembled in the night, nosing up to "every conspicuous object about camp—the water pail, axe, overturned boots, etc." The occasional carnivorous habits also referred to by Soper would seem to be restricted—at least mostly—to years of maximum abundance. Many other cases of depraved appetite in herbivorous mammals could be cited. Jacobi,[4] in his monograph of the reindeer, has brought together many interesting instances. We are concerned here with symptoms known to indicate mineral deficiency. It is not necessary to look for special food plants, the lack of which may bring about fatal results, because most plants are known to vary enormously as to minerals.[5] To veterinarians it is a familiar fact that serious diseases may result from deficiencies of minerals in pasture, and there is no reason why wild animals living on the same food should not be affected in a similar way. While, to judge from cattle pathology, the lack of certain "trace" elements (Cu., Co) occurs in restricted areas only, it appears that deficiencies affecting the acid-base balance are sufficiently wide-spread to account for the sudden drop in health observed in herbivorous mammals and birds at certain times. As an instance of such diseases in cattle may be mentioned licking disease, the name of which is derived from symptoms strikingly similar to those referred to above; even liver damage has been observed.[6] It is caused by a deficit of K (and Na) in proportion to the sulfuric and hydrochloric acids formed when the grass is digested. The enormous variations in this proportion found from year to year[7] are dependent on bacterial processes in the soil, and these in turn are said to be influenced to some extent by climate.[8] On the whole, climatic conditions appear to be one of the set of factors influencing the mineral contents of plants, and moreover the various elements are not affected alike.[9] It may be possible therefore to account for the regularity of the cycles in numbers by oscillations in the biological and chemical processes in the soil regulated by or adjusted to climatic cycles.

While it is true that the ten-year cycle in hares, ruffed grouse, etc., can not be correlated with sunspots,[10] a well-marked climatic oscillation of the same average length seems, nevertheless, to exist,[11,12] and parallels to the cycles of four years in mice, and six years in red grouse[13] and crossbills,[14] are also found in meteorological literature.[15,16] These climatic cycles may need further confirmation, but their close agreement as to length with the biological ones, in spite of the fact that in most cases these have been unknown to the authors, strongly suggests that they are real. Elton's[17] theory that the fluctuations in numbers are caused by meteorological cycles seems so far confirmed, but there is probably general agreement to-day that it is impossible to explain the phenomenon by *direct* climatic influence on the animals, as was at first supposed.

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PURIFICATION OF THE PITUITARY INTERSTITIAL CELL STIMULATING HORMONE[1]

THE paper by Shedlovsky, Rothen, Greep, van Dyke and Chow[2] on "The Isolation in Pure Form of the Interstitial Cell-stimulating (Luteinizing) Hormone of the Anterior Lobe of the Pituitary Gland" reports results in such contrast with those found in our own laboratory[3] that we consider it important to emphasize these differences.

Both papers describe the preparation of an apparently pure protein with similar biological properties, the minimal effective dose (MED) also happening to be the same. The evidence for belief in the purity of the substance herein reported is as follows:

1. *Specificity of biological behavior.* The substance has a specific effect on the ovary and testis of hypophysectomized immature rats—the repair of the interstitial cells. When injected intraperitoneally into normal immature female rats, it reduces the potency of certain concordantly administered gonadotrophins (pregnant male serum and chorionic gonadotrophin). When injected into hypophysectomized immature males, it stimulates the accessory organs of reproduc-

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[4] Jacobi, *Zool. Anz.*, Leipzig, 96 Ergb.: 226, 1931.
[5] A. H. Word and Wakeham, *Univ. Colorado Studies*, 25 (3): 181, 1938.
[6] Lars Slagsvold, 4—*Nordiska Veterinärmötet*, Helsingfors, 1933, 203, 1934.
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[9] J. B. Orr, "Minerals in Pastures," London, 41: 1929.
[10] D. A. MacLulich, *Jour. Roy. Astron. Soc. Canada*, 30: 233, 1936.
[11] Walther, *Ber. Deutsch. Bot. Ges.*, 54: 1936, 616; 1937.
[12] F. W. Braestrŭp, *Ann. d. Hydrographie u. marit. Met.*, Berlin; 1940 (in print).
[13] A. D. Middleton, *Jour. Animal Ecol.*, 3: 241, 1934.
[14] J. M. Speirs, *Auk*, 56: 411, 1939.
[15] A. H. R. Goldie, *Quart. Jour. Roy. Met. Soc.*, 62: 81, 1936.
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[17] C. Elton, *Brit. Jour. Exp. Biol.*, 2: 119, 1924.

[1] Aided by grants from the Board of Research of the University of California, from The Rockefeller Foundation and from Parke, Davis Company. Assistance was rendered by the Works Progress Administration, Project No. OP 665-08-3-30, Unit A-5.
[2] SCIENCE, 92: 178, 1940.
[3] C. H. Li, M. E. Simpson and H. M. Evans. "The Interstitial Cell Stimulating Hormone. II. Method of Preparation and Some Physico-chemical Studies." *Endocrinology*, in press.