proved. Records are kept in detail. Management has been maintained as nearly as possible like that in 1923.

TABLE 1

Year*	Average† egg weight in oz	Average number of eggs per hen per year	Average weight in oz of eggs produced by each hen per year
1923	1.85	168	310.8
1929	1.85	220	407.0
1946	2.30	237	545.1‡

* Records begin in the autumn of the year the birds are hatched. 1946 is the last year on which completed records are available.

† Taken during the spring.

‡ The 1948 flock promises to exceed 600 ounces.

The birds are housed in units of 100. The number of pullets in this group has ranged from a low of 300 in some years to a high of 800 in other years. The daughters of parents already proved good are kept in a separate group. Their records are not included in this report.

The average annual egg production of these flocks multiplied by the average egg weight gives the amount of product of each hen. From 1923 to 1929, efforts were concentrated on increasing the number of eggs, the size remaining constant. Then, forced by the demand for larger eggs, efforts were made toward increasing and fixing the size of eggs desired by the trade and toward making such gains in egg number as the inverse correlation between egg size and some of the factors entering into egg number permitted. The results of this work are shown by the averages in Table 1.

As Table 1 shows, the average hen in today's flocks is laying 234.3 oz more eggs than in 1923. This is an increase in efficiency of 75.4%.

Inspection of the table shows that the rate of gain from 1929 to 1946 is about half that from 1923 to 1929. It proved much easier to increase number of eggs, leaving egg size constant, than to combine the desired egg size with high rate of lay and early maturity, but this has finally been accomplished.

The enormous losses in the laying houses from deaths due to disease were not generally recognized when the present method of measuring gains in efficiency was established in 1923. This happened because these losses were obscured by the prevalent practice of culling nonproductive birds. A few years later the New Jersey Agricultural Experiment Station (*1*) stated that losses from death and culling during the year sometimes reached 60%. This was confirmed later by the Ohio Agricultural Experiment Station (*6*). Meanwhile, the losses from deaths in our unculled flocks, under exceptionally high standards of sanitation, were reaching the same amount in some years, thus indicating that culling merely anticipated deaths that would otherwise occur.

TABLE 2

Year	Number of pullets at beginning of year	Number dying during year	% dying
1923	304	138	45.4
1929	399	99	25.0
1946	801	148	18.5

The losses in the laying flocks for the three years of Table 1 are shown in Table 2.

A reduction in mortality increases the efficiency of a poultry plant by permitting it to operate toward maximum capacity. If the plant of 1923 had operated at full capacity for the year, i.e., without deaths, each unit of 100 hens would have produced 31,080 oz of eggs. As the records show that deaths occur at a fairly uniform rate throughout the year, each unit operated with an average of 77 hens for the year, thus producing only 23,932 oz of eggs. In 1946, however, with each unit operating with an average of 90.8 hens, it produced 49,495 oz of eggs—an increase of 25,563 oz, or an increase of 106.8% in the efficiency of the plant over 1923.

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Low Temperature and Survival of Embryonic Tissue

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The effect of low temperature on embryonic tissue has a practical as well as a theoretical interest. Various reports have appeared in the literature on hypothermia in relation to neoplastic tissue (*6, 33, 15*). Preyer (*11*) observed that no further development of the incubating chick occurred after the temperature went below 25° C. But the individual embryonic tissues survive a much lower temperature. Hetherington and Craig (*8*) found that small fragments of chick heart may be stored in Ringer-Tyrode's solution at 0° C for as long as 15 days with little apparent effect on viability. Stone (*14*) concluded that the best temperature for preserving alive the enucleated eyes of the salamander was between 4° C and

6° C. Bucciante (*3*) reported on survival time of various tissues of the 6-to-12-day chick embryo when kept in Ringer's solution at 5° C. He found a wide variation—hepatic cells survived 3 days, while skin survived 21 days. Waterman (*18*) has shown that different tissues of the rabbit embryo and of the chick embryo vary in their sensitivity to refrigeration. He found that 5° C is the most suitable temperature at which to preserve embryonic tissue alive, and that at this temperature brain tissue remains viable for a few days, intestine for many days, and skin up to 3 weeks. He also noted that embryonic tissues survive refrigeration at 0° C for a short time only.

To determine the lowest temperature at which embryonic smooth muscle will survive, the amnion of the chick was used. It is a structure containing smooth muscle but devoid of nervous elements of any description (*7*). When suspended as a muscle strip in oxygenated physiological solution at 41° C, it manifests spontaneous rhythmicity, which may be recorded on a smoked drum (41° C is the approximate temperature of bird's blood). Its motility is increased by acetylcholine, eserine, or barium chloride (*1*). This spontaneous activity or its response to a drug served as a criterion of survival after the structure had been exposed to a low temperature.

Fertile hen's eggs were incubated for 10–17 days. The amnion was removed and placed in a test tube which contained 10–15 cc of either oxygenated Sollmann-Rademaekers' solution (designated S-R solution) or oxygenated cooled expressed almond oil. By placing the tube in a freezing mixture the temperature was lowered to the desired level and held at that point, as closely as was practicable, for 10 min. In some instances, when S-R solution was used, ice formed in the tube. When the structure was thawed out, however, and set up as a strip in S-R solution at 41° C, it exhibited spontaneous activity or reactivity to drugs. Several determinations were made after chilling the S-R solution to various degrees. But when freezing occurred the temperature rose rapidly.

To overcome this difficulty almond oil was used. This oil being moderately unsaturated, iodine number 93–100 (*4*), it remained liquid to about −10° C. Vernon (*17*) found that oil dissolved oxygen more readily than water did. After a muscle had been kept in oil at −2° C for 10 min it would still respond, although it had been frozen. However, the preparations which had been kept in oil at −3° C or lower for 10 min neither developed spontaneous rhythmicity nor reacted to eserine or barium chloride. From experiments in which 12 different preparations were used, it was concluded that smooth muscle of the amnion of the chick irreversibly loses its irritability when kept at a temperature between −2° C and −3° C for 10 min.

Others, experimenting with exsected heart muscle of the frog, found the lethal temperature to be about −3° C (*5*). Ice formation may occur in the muscle; still the muscle survives. It is probable that part of the water in the tissue is in the bound form and as a consequence has properties which differ from those of free water. Newton and Gortner (*10*) found that a portion of the water in expressed plant juice took no part in dissolving cane sugar which was added.

However, freezing of the amnion delayed its recovery in developing a spontaneous rhythmicity. Simonin (*12*) observed the injurious effects of ice formation on subsequent growth of embryonic tissue. The influence of the rate at which tissue is frozen is problematical. It is commonly implied that slow freezing is more injurious to tissue than rapid freezing, as larger ice crystals are associated with the former, and hence more mechanical damage results. However, the results of Breedis and Furth (*2*) indicate that cells survive slow freezing better than rapid freezing. But Thoennes (*16*) found that when small bundles of muscle fibers are immersed in liquid air (−195° C) and rewarmed rapidly they can still respond to electric stimulation.

It is apparent that embryonic tissues survive a much lower temperature than the developing embryo. Cameron (*4*) suggested that the coordinating centers of the central nervous system of the frog fail at a temperature much above that which is injurious to the muscle tissue.

In summary, our results show that: the smooth muscle of the amnion of the chick irreversibly loses its irritability when kept at a temperature between −2° C and −3° C for 10 min. Recovery is influenced by the degree of chilling. The greater the chilling, the longer is the time required for recovery. Ice forms in the structure in some instances, yet still it may survive. Part of the water of the tissue may be in the bound form. Isolated nerve-free muscle survives a much lower temperature than the intact embryo has been reported to survive.

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