When the ducks were sacrificed after several weeks of treatment, the DDE level in shell gland mucosa was about 1/20 and in egg yolk about equal the dietary level of 40 ppm (Table 1). The corresponding blood level in treated ducks was only about 0.4 ppm DDE compared to about 0.004 ppm for untreated controls and not surprisingly the carbonic anhydrase activity of whole blood was unaffected (kindly measured by R.M. Woodworth and T.H. Maren). In the shell gland mucosa, three likely components of the calcium carbonate forming mechanism were also examined, i.e., calcium binding protein, carbonic anhydrase, and in a preliminary way several ATPases. No difference was found in the activity of calcium binding protein extracted from mucosa of ducks treated with DDE as compared to controls (Table 1) and no effects was observed with the addition of 4, 20, or 40 ppm DDE under *in vitro* conditions.

On the other hand carbonic anhydrase did decrease with increased DDE in the mucosa of individual birds (correlation coefficient 0.78, mean values in Table 1). Although moderate inhibition of mucosal carbonic anhydrase after exposure of birds to DDE has been noted before (Peakall, *Science* 168,592-594, 1970), a dose-response has not previously been reported. In addition to ATPase dependent on Mg++ alone, both a Na+-K+ and a Ca++ activated ATPase were demonstrable in the shell gland mucosa of laying ducks. The latter two ATPases are generally thought to be associated with transport of the activating ion(s) and Ca++ ATPase activity (approximately 0.2 micromoles Pi/mg protein x hr at 40 C) has not been reported heretofore in shell gland mucosa. Although activities of all three ATPases appeared unchanged in fresh mucosa from the DDE-treated birds, preliminary work with frozen control mucosa suggests that as little as 2 ppm DDE added under *in vitro* conditions inhibits both ion transporting ATPases by about 15 percent.

In conclusion the laying White Pekin, commercially available year-round, is a suitable experimental bird for further investigation of DDE-induced eggshell thinning in general and the roles of shell gland ATPases and carbonic anhydrase in particular.

We are grateful for the support in part by U.S.P.H.S. Fellowship ES 51600 and Grants GM 00306 and AM 15973.

1972 #38

EGG SHELL POROSITY AND GAS CONDUCTANCE DIFFERENCES IN A PRECOCIAL CHICKEN AND AN ALTRICIAL BIRD (DOUBLE-CRESTED CORMORANT *Phalocrocorax auritus)*

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The normal development of an avian embryo depends upon a continuous gas exchange between the internal and external environment. This process is by simple diffusion of gases through fixed pores in the egg shell which in turn establish the precise diffusive gas conductance for O_2, CO_2, and water vapor. These pores must be designed in such a manner that diffusion will supply the increasing oxygen demands of the embryo right up to the pipping stage before hatching. These pores will therefore also determine the CO_2 level of the embryo at all stages as well as the water loss during incubation.

In this study the possible differences in oxygen consumption, shell pore area, and gas conductance of eggs of a precocial species (chicken) and an altricial species (cormorant) were studied. Egg weight, surface area, and shell thickness are nearly the same for both species. The cormorant in contrast to the chick is born naked, immature, and must be fed for many weeks by the parents before it leaves the nest.

Method. By repeatedly weighing eggs in a desiccator under standard conditions, one can determine the egg shell conductance of water vapor. Since a gas conductance is proportional to its diffusion coefficient, the conductance of CO_2 and O_2 can be predicted, and by assuming a finite O_2 gradient across the shell at pipping time (45 torr), the oxygen consumption at the end of incubation can be calculated. By applying Fick's Law of Diffusion one can furthermore calculate the total pore area of the shell if its thickness and the gas conductance are known (*Respir. Physiol.* 11, 16-30, 1971; *Respir. Physiol.* 11, 31-45, 1971; *Proc. I.U.P.S.* IX, 436, 1971).

Results. The data are shown in Table 1. In spite of similar size, shell area, and thickness, the conductance for H_2O, and therefore O_2, is considerably greater in eggs of the precocial chicken. The predicted oxygen uptake at pipping time is also greater than that of the altricial cormorant. This difference requires a proportionately larger total pore area in the egg shell of the chicken at time of hatching.

TABLE 1

	Chicken	Cormorant
1. Incubation (days)	21	24
2. Egg weight (g)	54	50
3. Shell area (cm^2)	68	64
4. Shell thickness (mm)	0.35	0.39
5. H_2O conductance ($mg \cdot day^{-1} \cdot torr^{-1}$)	14.4	5.6
6. O_2 conductance ($cm^3 \cdot day^{-1} \cdot torr^{-1}$)	13.8	5.4
7. $\dot{V}_{O_2}$ at pipping stage ($ml \cdot day^{-1}$)	622	243
8. Pore area of shell (mm^2)	2.16	0.93

(Row 1-5 measured; row 6-8 calculated values.)

Thus during shell formation the shell gland must lay down a precise number of pores with a given radius (total pore area) which are compatible with the surface area, the thickness of the shell, and the diffusion coefficent of oxygen in order to anticipate and provide the exacting oxygen demands right up to pipping stage of incubation. The egg's water content must also be adjusted to this pore area since its vapor pressure and the nest humidity determine the total water loss. Any interference with the normal structural characteristics of the shell, such as the reported effects of DDT, will have a deleterious effect upon embryonic development.