Contributions from the Biological Laboratory of the U. S. Fish Commission, Woods Hole, Massachusetts.

SOME CHEMICAL CHANGES IN THE DEVELOPING FISH EGG.

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The two chief functions of living matter are growing and dying, but of these only the latter has attracted sufficient attention of the biological chemist, and our knowledge of the process of growth remains very unsatisfactory. Most of what has been studied in that direction up to the present time has been done by the plant physiologist. The developing egg offers very good material for the study of this subject in relation to the animal kingdom, hence this work.

The substances most peculiar to the living organisms are the different nitrogenous compounds that take part in the formation of the proteid compounds and reappear on the decomposition of the latter. These compounds may be classified in a general way into two groups: First, those consisting of carbon, hydrogen, oxygen, and nitrogen; and, second, those in which some other elements, mainly sulphur, phosphorus, and fluorin (each of them separately or all together) join the former in the formation of their molecule.

The first group may be again divided into substances with a well-defined acid nature, as the monoamido acids, like leucin, and into those of a well-defined basic nature, which are very numerous and quite different in their composition.

The second group may be divided into simple proteids, containing only carbon, nitrogen, hydrogen, oxygen, and sulphur, and combined proteids as nucleo compounds, mucin, etc. It is the molecule of the latter compounds that may contain, besides carbon, hydrogen, oxygen, and nitrogen, also phosphorus and fluorin.

The aim of this work was to study the distribution of nitrogen between the main groups just enumerated, in different stages of the development of the egg, or, to be more precise, to attempt to estimate the quantity of nitrogen in the form of compounds not basic by nature, like amido acid, those in the form of bases, and finally those in the form of proteids. Further, an attempt was made to ascertain whether in the course of development a new formation of the combined proteids (only the nucleo-compounds were dealt with) was taking place. The amounts of ash and water were also estimated.

The material used was the egg of the cod. It was examined in the following four stages: Unfertilized, 24 hours after fertilization, 11 days after fertilization, and about 20 days after fertilization. All the material was furnished by the courtesy of the United States Fish Commission from its station at Woods Hole, Massachusetts.

The results of the analyses are presented in the following series of seven tables, showing the chemical changes in the developing cod egg during four different periods:

I.—*Water and ash determinations.*

Character of eggs.	Total substance (grams).	Dry substance.		Ash.	
		Grams.	Per cent.	Grams.	Per cent.
Unfertilized	9.7612	0.5737	5.33	0.058	10.09
24 hours after fertilization	8.2201	0.4760	5.20	0.0648	17.17
11 days after fertilization	7.06005	0.564	7.98	0.099	17.55
20 days after fertilization	8.097	0.5315	6.31	0.1045	19.66

II.—*Distribution of nitrogen.*

Character of eggs.	Total substance (grams).	Total nitrogen (grams).	Percentage of nitrogen.	Average.
Unfertilized	0.5405	0.059568	11.01	10.90
	0.403	0.0438	10.80	
24 hours after fertilization	0.3914	0.039858	10.16	9.96
	0.4299	0.042048	9.77	
11 days after fertilization	0.2985	0.033288	11.15	11.22
	0.3225	0.036354	11.29	
20 days after fertilization	0.318	0.029346	9.52	9.52

III.—*Nitrogen in phosphotungstic precipitate (= proteids + bases).*

Character of eggs.	Total substance (grams).	Nitrogen.		
		Grams.	Per cent.	Average.
Unfertilized	0.3670	0.03066	8.32	8.60
	.2956	.02628	8.88	
24 hours after fertilization	.1791	.014016	7.82	7.83
	.3296	.025842	7.84	
11 days after fertilization	.2855	.024528	8.52	8.68
	.3366	.029784	8.85	
20 days after fertilization	.2251	.021462	9.53	9.53

IV.—*Proteid nitrogen.*

Character of eggs.	Total substance (grams).	Nitrogen.		
		Grams.	Per cent.	Average.
Unfertilized	0.1650	0.012264	7.43	7.29
	.2940	.020828	7.15	
24 hours after fertilization	.5267	.028470	5.40	5.33
	.5504	.028808	5.26	
11 days after fertilization	.5535	.041610	7.52	7.27
	.654	.04599	7.03	
20 days after fertilization	.2575	.01752	6.84	6.84

V.—*Distribution of nitrogen in eggs of different ages.*

Character of eggs.	Nitrogen in monoamido compounds.		Nitrogen in form of bases.		Nitrogen in form of proteids.	
	Percentage to dry substance.	Percentage to total nitrogen.	Percentage to dry substance.	Percentage to total nitrogen.	Percentage to dry substance.	Percentage to total nitrogen.
Unfertilized	10.90—8.60=2.30	21.10	8.60—7.29=1.31	12.07	7.29	66.00
24 hours after fertilization	9.96—7.83=2.13	21.37	7.83—5.33=2.50	25.10	5.33	53.57
11 days after fertilization	11.22—8.67=2.55	22.72	8.67—7.27=1.40	12.48	7.27	64.79
20 days after fertilization	9.52—9.53=0.01	.....	9.53—6.84=2.69	28.25	6.84	71.84

VI.—*Digestive experiments.*

Character of eggs.	Substance (grams).	Residue.	
		Grams.	Percentage.
24 hours after fertilization	2.0442	0.0428	2.08
11 days after fertilization	1.698	.0570	3.35
20 days after fertilization	1.7767	.1297*	7.24

* Phosphorus determination in the residue of eggs 20 days after fertilization, 0.137 grams of the residue: MgP_2O_3=0.014 gr., P=2.65 per cent.

VII.—*Determination of the nucleo-bases.*

Character of eggs.	Substance.	Grams.	Per cent.
Unfertilized	1.8611	0.0022	0.12
24 hours after fertilization	2.0227	.0438	2.16
11 days after fertilization	1.519	.0325	2.14
20 days after fertilization	1.2132	.0455	3.75

It would be premature to draw any very broad conclusions from the little work done for the present. Such conclusions should be deferred until the data have increased considerably. The results of this work, however, tend to indicate that in the developing fish egg the processes of synthesis are preceded by those of decomposition. (Consult Table V.) In the first stage after fertilization the proteids diminish in quantity; basic nitrogenous substances are formed at their expense. Later the basic substances decrease in quantity and proteids grow. Whether the molecules of those proteids are formed from the basic substances will be investigated in the future. It is also seen that the character of the proteids is changed during the development of the egg, the combined proteids as we may term them, such as nucleoproteids, increasing greatly in quantity. The importance of mineral salts for the formation of tissues can be illustrated by the increasing quantity of mineral substances in the egg in the course of its growth.