

XXVIII. *Some experiments on the changes which take place in the fixed principles of the egg during incubation.* By WILLIAM PROUT, M. D. F. R. S.

Read June 20, 1822.

IN the year 1816, I was induced to commence a series of experiments on the egg during incubation, with the view of ascertaining the nature of the changes which take place during that process. My inquiry was chiefly limited to the fixed principles, namely, the earthy and saline matters; but my attention was more particularly directed to the source whence the earthy matter, constituting the skeleton of the chick, was derived.

With these views, the egg was analyzed in its recent and unaltered state, and at the end of the first, second, and third weeks of incubation. My experiments were chiefly confined to the eggs of the domestic fowl, but have been likewise partially extended to those of the duck and turkey. The investigation has been renewed, and the experiments repeated at various intervals since the period above mentioned; but the difficulty of the subject, and various accidents, have prevented me from completing them till the present time; and the results, which, after all, are much less perfect than I could wish, I have now the honour of submitting to the Society.

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*Preliminary experiments on the egg in its recent and unaltered state.*

The specific gravity of new laid eggs has been found to vary from 1.080 to 1.090. When kept for some time, eggs, as is well known, rapidly lose weight, and become so specifically light as to swim in water. This diminution of specific gravity, however, is only apparent, and depends on the substitution of air for a portion of the water of the egg which escapes; for it is obvious, that the specific gravity of the constituent principles of the egg must be rather increased than diminished by the escape of water. The following table shows the gradual loss of weight of an egg during a period of two years.

The original weight on the 19th May, 1820, the day it was laid, was 907.5 grains.

	Grains.	Loss per day.		Grains.	Loss per day.
19 May, 1820.	907.5		5 May, 1821.	648.7	.59
20 . . .	906.5	1.00	6 . . .	647.8	.90
24 . . .	901.3	1.30	5 December	488.2	.75
31 . . .	894.2	1.01	7 . . .	486.6	.80
8 June . .	886.6	.95	21 March, 1822.	413.5	.70
17 . . .	879.3	.81	25 April . .	384.6	.82
27 . . .	870.7	.86	26 . . .	383.7	.90
19 July . .	848.5	1.01	17 May . .	365.2	.84
7 August .	829.6	.99	18 . . .	364.3	.90
26 . . .	810.8	.99	19 . . .	363.2	1.10
30 September	778.5	.92	Total Loss	544.3	.744 Mean

Hence we learn, that a moderately sized egg loses on an average about .75 grain in twenty-four hours, and that

uniformly during a very long period.\* The loss appears to be somewhat greater in summer than in winter, owing, doubtless, to the difference in temperature, which, in the present instance, varied from  $40^{\circ}$  to  $70^{\circ}$ . On being broken, the whole of the contents of this egg were found collected at the smaller extremity in a solid state, but on being put into water, they absorbed a large portion of that fluid, and assumed an appearance not much unlike those of a recent egg; the smell also was perfectly fresh.

The relative weights of the shell, albumen, and yelk of different eggs are very different. With the view of investigating this point, and of obtaining something like an average, the following experiments were made. The eggs were boiled hard in distilled water, and the different parts weighed immediately in their *moist* state.

Shell and Membrane.	Albumen.	Yelk.	Total.
Grains.	Grains.	Grains.	Grains.
80	394.3	289	763.3
108	593	273.5	974.5
107.3	575.8	236.2	919.3
71.5	516.5	215	803
103	503.7	269.3	876
107	515.3	273.4	895.7
93.2	605.5	252.4	951.1
92.7	515.7	257	865.4
96.8	510.6	210.8	818.2
77.6	567.4	241.5	886.5
Mean	93.7	251.8	875.3

If we suppose each of these eggs to weigh one thousand

\* If the average of the above means be taken, the loss per day will be about .9 grain.

grains, the weights of the constituent principles of each, when reduced to this common standard, will be as follow :

Shell and Membrane.	Albumen.	Yelk.
Grains.	Grains.	Grains.
104.8	516.6	378.6
110.8	608.5	280.7
116.7	626.3	257.0
89.0	643.2	267.8
117.6	575.0	307.4
119.5	575.3	305.2
98.0	636.6	265.4
107.1	596.0	296.9
118.3	624.0	257.7
87.5	640.0	272.5
Average	604.2	288.9

Hence, if we suppose a recent egg to weigh one thousand parts, the relative proportions of the shell, albumen, and yelk, will be as 106.9, 604.2, and 288.9 ; and for the sake of easier comparison in all the subsequent experiments, the numbers are reduced to the above standard, or to the supposition, that the original weights of the eggs employed were, when just laid, exactly 1000 grains.

When an egg is boiled in water, it loses weight, particularly if it be removed from the water when boiling, and be permitted to cool in the open air ;\* the water also on examination will be found to contain a portion of the saline contents of the egg. The loss of weight from boiling is by no means constant, but has been found to vary from 20 to 30 grains, on

\* When permitted to cool in water it sometimes gains a little in weight, owing to the absorption of water. Eggs placed in a strong solution of common salt are said to become highly saline throughout. This mode has been recommended for preserving them, but I have never tried the experiment.

the supposition, that the original weights of the eggs employed were 1000 grains. On the same supposition, also, it has been found, that the quantity of saline matter obtained by evaporating to dryness the distilled water in which an egg has been boiled, amounts, at an average, to about .32 grain. This saline residuum is strongly alkaline, and yields traces of animal matter, sulphuric acid, phosphoric acid, chlorine, an alkali, lime and magnesia, and carbonates of lime and magnesia; in short, of almost every principle existing in the egg. The carbonate of lime, however, is generally most abundant, and is obtained by evaporation in the form of a fine powder.

The shells of eggs have been analyzed by VAUQUELIN\* and MERAT GUILLOT;† but these chemists seem to have over-rated the quantity of animal matter, and of phosphate of lime contained in them. When shells which had been dried in vacuo at 212°, were dissolved in dilute muriatic acid, the quantity of animal matter obtained was only about 2 per cent. while the quantity of phosphates of lime and of magnesia never amounted to quite 1 per cent.; the rest was carbonate of lime mixed with a little carbonate of magnesia. When burnt, egg-shells, as VAUQUELIN has observed, yield traces of sulphur and iron.

The *membrana putaminis*, on the supposition that the origi-

\* Annales de Chimie, tom. 29 et 81.

† Ibid. tom. 34. It is probable that the different results obtained by these chemists depended, in a great degree, on the different mode in which the experiments were made. The phosphate of lime present in egg-shells is apparently connected with the animal matter, and when the latter is destroyed by combustion, the whole quantity present will of course be obtained. The quantity of animal matter present also, being in this mode of analysis necessarily estimated from the loss of weight occurring during the process, must appear greater than it ought to do, because part of this loss will obviously depend on the escape of water.

nal weight of the egg be 1000 grains, weighs, when dried in vacuo at 212°, about 2.35 grains ; and on being burnt, yields traces of phosphate of lime.

It may be observed here, that the great differences in the quantities of the earthy matter existing in the shells of different eggs, have rendered the average totally inapplicable in these experiments, as will be shown hereafter ; hence, a more detailed analysis of this part of the egg was deemed unnecessary.

*Saline contents of the recent egg.*

As my attention at present is chiefly confined to the fixed principles of the egg, I shall not here enter on a description of its immediate principles, which will be found sufficiently detailed in all the modern chemical treatises. The saline principles, however, particularly of the yelk, have been less minutely examined ; hence, it becomes necessary to relate the manner in which the following analyses were conducted ; and here it may be premised generally, that all the results were obtained by combustion ; and that the following observations are to be understood as applicable to the whole of the experiments subsequently related in this inquiry.

The *albumen* burns with difficulty, unless care be taken to remove the saline matter by frequent washings ; but if this point be attended to, the whole of the carbonaceous matter may be burnt off even in a covered crucible. In the subsequent experiments, the saline and earthy matters were removed from the crucible after combustion by distilled water ; a little ammonia was then added, and the whole permitted to remain at rest for twenty-four hours ; the clear solution containing the alkaline salts was now carefully poured off, and the insoluble residuum, consisting of the phosphate of lime and triple phos-

phate of magnesia and ammonia, after being washed with distilled water, was dried and weighed. The alkaline solution, together with the washings of the earthy phosphates, were then evaporated to dryness, and exposed to a low red heat; and the weight of the saline residuum being accurately noticed, the whole was again dissolved in distilled water. A few drops of nitric acid being now added to neutralize the excess of alkali present, nitrate of barytes was dropped into the solution as long as any precipitate fell. The precipitate was obtained by decanting off the solution as before, and, after being well washed, its weight ascertained: from this the quantity of sulphuric acid present was determined by calculation.\* To the solution, thus freed from sulphuric acid, nitrate of barytes, and afterwards ammonia, were added. The phosphate of barytes thus obtained was collected, washed and weighed as before, and the quantity of phosphoric acid present obtained by calculation.† Nitric acid was again added in slight excess to the original solution, and nitrate of silver dropped into it as long as any precipitate fell; from the chloride of silver obtained, the quantity of chlorine present was estimated.‡ Lastly, the weights of the sulphuric and phosphoric acids and chlorine were added together, and their amount subtracted from the weight of the alkaline residuum formerly obtained by evaporation, the remainder, of course, indicated the quan-

\* On the supposition that the weight of the atom of sulphuric acid is 50, and that of barytes 97.5, oxygen being 10.

† On the supposition that the weight of the atom of phosphoric acid is 35, that of oxygen being 10.

‡ On the supposition that the weight of the atom of chlorine is 45, and of silver 137.5, that of oxygen being 10.

tity of potash and soda,\* and carbonates of potash and soda present. Finally, the proportion of the earthy phosphates to one another was determined, and the quantities of the bases and acid obtained by calculation.

The *yelk* of the egg is exceedingly difficult of combustion; and indeed without proper precautions cannot be burnt at all, on account of the large quantity of phosphorus it contains; which, by undergoing a partial combustion, forms a glassy coating that effectually excludes the contact of the air from the coal, and prevents its farther combustion. After a variety of attempts, the following were the two methods employed. The yelk of an egg which had been boiled hard, and dried by exposure to the air, was rubbed in a mortar with a quantity of bicarbonate of potash. The mixture was then introduced into a platina crucible and exposed to a strong red heat, till the flame had ceased to escape from a small hole in the lid. The crucible being now removed from the fire, its contents, when cold, were again pulverised in a mortar with nitre. This mixture was then introduced a little at a time into the covered crucible till the whole was burnt. To the residuum distilled water was added, which of course took up every thing but the earthy phosphates, which were separated and weighed, while the alkaline solution, like that before mentioned obtained from the albumen, was submitted to the action of the appropriate re-agents, and thus the quantities of the different acids present ascertained. In this manner every thing was determined, except the proportion of alkaline matter present; and to ascertain this, other experi-

\* The quantity of soda equivalent to the sodium in union with the chlorine, was determined by calculation.



ments with different yelks were made, in which lime and nitrate of lime were substituted for the bicarbonate and nitrate of potash.

With respect to the modes in which the different fixed principles originally exist in the egg, it is very probable, as BERZELIUS has remarked, that the sulphuric acid obtained from albumen is a product of combustion, and exists in it naturally as sulphur. The same also appears to be the case, to a great extent at least, with respect to the phosphoric acid, especially that obtained from the yelk. The chlorine seems to exist originally in union with sodium, forming common salt. As to the earthy principles, BERZELIUS is of opinion that their metallic bases are probably to be considered as constituent principles of the primary animal compounds. These circumstances have induced me to state the quantities of the acids obtained separately from the bases.

It may be also remarked here, that as the following experiments were made almost entirely with the view of comparison only, my object was rather to conduct them in some general and uniform manner, than to enter into any very minute discriminations, which did not appear to be immediately necessary to my purpose. For this reason, the proportion of the potash to the soda, and the exact quantity of carbonic acid combined with them, were not attempted to be determined. With the same view also, the proportion of the lime to the magnesia, though ascertained, was not expressed, but the united weights of both introduced into the column. Lastly, every one acquainted with chemistry will perceive, that from the mode of operating, the weights of the different principles will be somewhat underrated.

The relative proportions of the saline principles of different eggs vary in some instances considerably.\* The three following are selected from a variety of other analyses as examples: the weight of each egg being reduced for the sake of comparison to 1000 grains.

No. 1.†

	Sulphuric Acid.	Phosphoric Acid.	Chlorine.	Potash, Soda, and Carb. of Ditto.	Lime, Magnesia, and Carb. of Ditto.
	Grains.	Grains.	Grains.	Grains.	Grains.
Albumen	.29	.45	.94	2.92	.30
Yelk -	.21	3.56	.39	.50	.68
Total -	.50	4.01	1.33	3.42	.98

No. 2.

Albumen	.15	.46	.93	2.93	.25
Yelk -	.06	3.50	.28	.27	.61
Total -	.21	3.96	1.21	3.20	.86

\* The most remarkable variations occur in the quantities of the sulphuric acid and chlorine: The tables exhibit instances of these, but I have met with still more striking anomalies, for which I was unable to account. I have sometimes thought these differences, as well as some other singular ones observed with respect to the earthy matters, might be connected with the sex of the future bird, but as no proof of this could be obtained, the results have been suppressed, on the supposition that they arose from some error in conducting the experiment. The three analyses given may be considered as average results. It may be also observed, that besides the above principles, *iron* is met with in almost all products of combustion; and the quantity in the egg, as the process of incubation proceeds, apparently increases considerably; but it was found impossible to ascertain its quantity with any degree of precision.

† The numbers in this and the following tables were obtained by calculation. In general, I did not weigh nearer than  $\frac{1}{40}$ th of a grain, but as the substances weighed were compounds, it was thought that the calculations of their constituent principles might be safely carried to the second decimal figure.

No. 3.

	Sulphuric Acid.	Phosphoric Acid.	Chlorine.	Potash, Soda, and Carb. of Ditto.	Lime, Magnesia, and Carb. of Ditto.
	Grains.	Grains.	Grains.	Grains.	Grains.
Albumen	.18	.48	.87	2.72	.32
Yelk -	.19	4.00	.44	.51	.67
Total -	.37	4.48	1.31	3.23	.99

Although the consideration of the immediate principles of the egg does not fall within my present design, yet I cannot refrain from giving the following analysis of the yelk of the recent egg.

The egg from which the yelk had been taken, which is the subject of the following experiment, had been boiled hard in distilled water, and the yelk, in its moist state, was found to weigh 316.5 grains. It was then partially dried by exposure to the air for several weeks; and to remove the remainder of the water was reduced to powder, and exposed to a temperature of somewhat more than 212°. The total loss of weight was 170.2 grains, which was supposed to indicate the quantity of water present. The remainder was now digested repeatedly in alcohol of specific gravity .807, till that fluid came off colourless. The residuum was perfectly white and pulverulent, and possessed many of the properties of albumen; but it differed from that principle, by the large proportion of phosphorus it contained in some unknown state of combination. The alcoholic solution was of a deep yellow colour, and deposited crystals of a sebaceous matter, and a portion of a yellow semi-fluid oil. On distilling off the alcohol, the

388 Dr. PROUT'S *experiments on the changes which take place*

oil was obtained in a separate state. On cooling, it became nearly solid, and weighed 91 grains. The albuminous principle above mentioned, weighed 55.3 grains. Hence this yelk consisted of

	Grains.
Water . . .	170.2
*Albumen ? . .	55.3
Yellow Oil. . .	91.0
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	316.5
	<hr/>

But I have reason to believe that the proportions of these ingredients differ a little in different eggs.

*Experiments on the egg at the end of the first week of incubation, or about the 8th day.*

At the end of the first week, it has been found, on an average, that on the supposition that the egg originally weighed 1000 grains, it has now lost about 50 grains, and the weights of the constituent principles of two eggs in their moist state, were as follow :

	No. 1.	No. 2.
	Grains.	Grains.
Unchanged albumen . . . . .	232.8	247.1
Modified albumen . . . . .	179.8	} 275.2
Liq. amnii, membranes, blood-vessels, &c. . . . .	97.0	
Animal . . . . .	22.0	
Yelk . . . . .	301.3	324.5
Shell and loss . . . . .	167.1	153.2
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	1000.0	1000.0

\* This proportion of the albuminous principle does not differ much from that stated to exist in the yelk of the common fowl, by Mr. HATCHETT. Philos. Trans. vol. cvi. p. 308.

The consideration of the organization, &c. of the incubated egg, like that of its constituent principles, does not fall within my present design ; yet, as some points connected with these subjects seem to be illustrated by the present inquiry, and as my experiments would be scarcely intelligible without them, I shall make a few brief remarks on the general phenomena presented by the different constituent principles of the egg at those periods at which it has been submitted to examination.

It has been remarked by many observers, that soon after the process of incubation has commenced, the yelk becomes more fluid than usual, and that as the liquor amnii increases, that portion of the albumen occupying the upper and larger end of the egg, begins to assume a peculiar appearance. In the present experiments (in which the egg was always previously boiled), the liquor amnii and portion of albumen in question, at the period now under consideration, exhibited somewhat the appearance of curds and whey. Nor did the analogy consist in mere appearance ; for the curdy looking matter, which was of a yellow colour, and which I have termed *modified* albumen, resembled the curdy part of milk in its properties, so far as to contain intermixed with it an oily or butyraceous principle. A portion of this oily principle, on being separated and examined, was found to be soluble in alcohol, of a bright yellow colour : and in short, to possess all the properties of the yellow oil existing in the yelk. The yelk at this period, as before observed, has become more fluid, and appears larger and of a paler colour than natural. HALLER, indeed, asserts, that it has not increased in weight, but the above table renders the reverse very probable. These appearances of the albumen and yelk have induced most

observers to believe that an interchange of principles takes place between them, while others seem to have mistaken the yellow modified albumen for the yelk itself. That an interchange of principles has taken place, at least under the above circumstances, there can be no doubt; yet the two are not indiscriminately mixed; for when the egg has been previously boiled, the yelk, though softer than natural, is nevertheless rendered of a firmer consistence than the modified albumen, and can thus be readily separated from it; there is, moreover, a distinct line of demarcation between them, arising, apparently, from the proper membrane of the yelk. Another argument in favour of the opinion of the intermixture of the albumen and yelk at this period, is derived from the following analyses of these constituent principles of the egg; from which it will be found, that the quantity of the saline matter is diminished in the albumen, and increased in the yelk. It is a singular and striking fact, however, that although the oily matter of the yelk has made its way to the albumen, very little of the phosphorus, which exists in such large quantities in the yelk, has been removed with it.

## No. 1.

	Sulphuric Acid.	Phosphoric Acid.	Chlorine.	Potash, Soda, and Carb. of Ditto.	Lime, Magnesia, and Carb. of Ditto.
	Grains.	Grains.	Grains.	Grains.	Grains.
Unchanged albumen	.13	.27	.19	1.03	.18
Modified albumen, liquor amnii, animal, membranes, &c. . }	.08	.38	.45	1.17	.12
Yelk. . . . .	.09	4.03	.60	.80	.68
	.30	4.68	1.24	3.00	.98

No. 2.

	Sulphuric Acid.	Phosphoric Acid.	Chlorine.	Potash, Soda, and Carb. of Ditto.	Lime, Magnesia, and Carb. of Ditto.
Unchanged Albumen	Grains. .18	Grains. .18	Grains. .24	Grains. 1.50	Grains. .12
<i>Modified</i> albumen, liquor amnii, animal, membranes, &c. }	.10	.25	.30	.70	.12
Yelk . . .	.08	4.00	.56	.75	.67
	.36	4.43	1.10	2.95	.91

The following are the results of an analysis made two days later, or on the 10th day of incubation.

	Sulphuric Acid.	Phosphoric Acid.	Chlorine.	Potash, Soda, and Carb. of Ditto.	Lime, Magnesia, and Carb. of Ditto.
Unchanged Albumen	Grains. .27	Grains. .14	Grains. .24	Grains. 1.13	Grains. .12
<i>Modified</i> albumen, liquor amnii, animal, membranes, &c. }	.08	.65	.68	1.36	.27
Yelk . . .	.05	3.35	.30	.62	.66
	.40	4.14	1.22	3.11	1.05

At this period the proportion of phosphorus is somewhat diminished in the yelk, and increased in the animal and its appendages. The chlorine and alkaline principles seem also to have diminished in the yelk, and to have increased a little in the albuminous portion.

How the above interchange of principles takes place between the albumen and yelk, does not appear to be distinctly understood. MAITRE JEAN, LEVEILLE, and others, suppose that it takes place through the chalazæ; and LEVEILLE has even pretended to demonstrate the tubular structure of one of the chalazæ. This tubular structure has been denied by some writers, and particularly by Dr. MACARTNEY,\* who even appears to doubt the fact of the intermixture in question. After what has been said, however, there cannot, I think, be much doubt of the circumstance; and future inquirers on this interesting, but difficult subject, will do well to turn their attention to it.

*Experiments on the egg at the end of the second week, or about the 15th day of incubation.*

At the end of the second week of incubation, an egg has lost upon an average about 130 grains, on the supposition that its original weight was 1000 grains, and the weights of the constituent principles of two eggs were as follow:

	Grains.	Grains.
Unchanged Albumen . . . .	175.5	208.0
Liquor amnii, membranes, &c.	273.5	218.2
Animal . . . . .	70.0	89.1
Yelk . . . . .	250.7	248.0
Shell and Loss . . . . .	230.3	236.7
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	1000.0	1000.0

At this period the animal has attained a considerable size, while the albumen has become diminished in a corresponding

\* Article INCUBATION, in REES's Encyclopædia.



degree. The albumen has also acquired a very firm consistence, especially when coagulated by heat. The liquor amnii has become more fluid, and the *modified* albumen, formerly mentioned, has very much diminished in quantity, or disappeared.\* The yelk, which at the end of the first week seemed to have increased in bulk and fluidity, has now apparently acquired its original size and consistence. The following are the results of the analyses of the constituent principles of the above two eggs.

No. 1.

	Sulphuric Acid.	Phosphoric Acid.	Chlorine.	Potash, Soda, and Carb. of Ditto.	Lime, Magnesia, and Carb. of Ditto.
	Grains.	Grains.	Grains.	Grains.	Grains.
Unchanged albumen. -	.07	.22	.09	.73	.10
Liq. amnii, membranes, &c.	.06	.21	.71	.96	.08
Animal - - -	.06	.23	.09	.46	.27
Yelk - - -	.30	3.34	.16	.68	.69
	.49	4.00	1.05	2.83	1.14

No. 2.

Unchanged albumen. .	.11	.19	.23	.97	.09
Liq. amnii, membranes, &c.	.03	.20	.70	1.07	.08
Animal - - -	.06	.24	.07	.44	.28
Yelk - - -	.20	3.30	.10	.42	.70
	.40	3.93	1.10	2.90	1.15

\* About this time HARVEY, and other observers, have noticed the appearance of a curdy or coagulated substance in the œsophagus, crop, stomach, and intestines of the animal. Is this a portion of the *modified* albumen above mentioned?

An egg, analyzed two days later, or on the 17th day of incubation, gave the following results :

## No. 3.

	Sulphuric Acid.	Phosphoric Acid.	Chlorine.	Potash, Soda, and Carb. of Ditto.	Lime, Magnesia, and Carb. of Ditto.
	Grains.	Grains.	Grains.	Grains.	Grains.
Liquor amnii, membranes, animal, &c. - - - }	.34	1.70	.68	2.40	1.10
Yelk - - - -	.10	2.50	.30	.56	.75
	.44	4.20	.98	2.96	1.85

At this period ossification, which, according to HALLER and others, begins about the 7th day, has made some progress. The yelk has parted with some of its phosphorus, which appears in the other principles of the egg ; this is particularly observable in No. 3. The quantity of earthy matter has also increased, particularly in No. 3.

*Experiments on the egg at the end of the third week, or at the full period of incubation.*

At this period an egg has lost upon an average about 160 grains, on the supposition that its original weight was 1000 grains ; and the weights of the constituent principles of two eggs in their moist state and without boiling, were as follow :

	Grains.	Grains.
Residuum of albumen, membranes, &c.	29.5	38.1
Animal - - - -	555.1	553.6
Yelk - - - -	167.7	151.3
Shell and loss - - - -	247.7	257.0
	1000.0	1000.0

At this period all the important changes of incubation are completed. The albumen has now disappeared, or is reduced to a few dried membranes and an earthy residuum (apparently consisting of the original earthy matter of the albumen which has remained unappropriated). The yelk is considerably reduced in size\*, and is taken into the abdomen of the chick, while the animal has attained a weight nearly corresponding to the original weight of the albumen, added to that lost by the yelk, *minus* the total weight sustained by the egg during incubation. The alkaline matters and chlorine, which have been decreasing from the commencement of incubation, have now undergone farther diminution in quantity,† while *the earthy matters have increased in the most striking manner*. The other principles seem to have suffered very little change in quantity. The following are the results of the analyses of the above two eggs.

No. 1.

	Sulphuric Acid.	Phosphoric Acid.	Chlorine.	Potash, Soda, and Carb. of Ditto.	Lime, Magnesia, and Carb. of Ditto.
	Grains.	Grains.	Grains.	Grains.	Grains.
Resid. of albumen, } membranes, &c. }	.04	.12	.09	.23	.12
Animal - - -	.44	3.02	.55	2.26	2.58
Yelk - - -	.04	1.06	.03	.06	1.26
	.52	4.20	.67	2.55	3.96

\* This has been denied or doubted by some writers, especially HALLER and Dr. MACARTNEY.

† We have seen that in boiling an egg, a portion of its saline matter makes its way through the shell into the water. Do the saline matters, in the present instance, escape with the water lost during incubation? An argument in favour of the supposition is, that the loss is chiefly confined to those salts already existing in the egg,

## No. 2.

	Sulphuric Acid.	Phospho- ric Acid.	Chlorine.	Potash, Soda, and Carb. of Ditto.	Lime, Mag- nesia, and Carb. of Ditto.
	Grains.	Grains.	Grains.	Grains.	Grains.
Resid. of albumen, membranes, &c. }	.03	.13	.09	.25	.12
Animal - -	.21	2.71	.68	2.12	2.60
Yelk - -	.02	1.23	.06	.03	1.10
	.26	4.07	.83	2.40	3.82

It may be proper to observe, that the above analyses are selected as the most perfect, from a variety of others made at each period, all of which confirm the results here given, though they differ, like those indeed given, in some subordinate particulars.\*

These experiments, then, demonstrate, or render probable, the following circumstances.

1. That the relative weights of the constituent principles of different eggs vary very considerably.

2. That an egg loses about one-sixth of its weight during incubation, a quantity amounting to eight times as much as it loses in the same time under ordinary circumstances.

namely, the chlorine and alkaline matters. With respect to the use of these saline matters we know very little. Do they perform an office in the animal economy analogous to acid solutions in the galvanic battery?

\* An interesting circumstance may be here mentioned, which I have never seen noticed by any writer on the present subject. At the end of the process of incubation, and for some time before, the animal is so situated in the egg, as, by its superior weight on one side, to cause the egg to assume such a position that the beak of the animal shall be uppermost, and consequently fully exposed to the air when it first makes its way through the shell.

3. That in the earlier stages of incubation, an interchange of principles takes place between the yelk and a portion of the albumen ; that this interchange is confined on the part of the yelk to a little of its oily matter, which is found mixed with the above mentioned albumen ; that this portion of albumen undergoes some remarkable changes, and is converted into a substance analogous in its appearance, as well as in some of its properties, to the curd of milk ; and lastly, that a portion of the watery and saline portion of the albumen is found mixed with the yelk, which becomes thus apparently increased in size.

4. That as incubation proceeds, the saline and watery parts again quit the yelk, which is thus reduced to its original bulk ; that in the last week of the process it undergoes still further diminution in weight, and loses the greater portion of its phosphorus, which is found in the animal converted into phosphoric acid, and in union with *lime*, constituting its *bony skeleton* ; and lastly, that this lime does not originally exist in the recent egg, but is derived from some unknown source during the process of incubation.

These, and other interesting circumstances, arising out of the present inquiry, suggest some important hints respecting certain operations of the animal economy. They also serve to direct the attention of the microscopic inquirer to the investigation of points, which it is probably within his power to elucidate, but of which, at present, we are ignorant. This part of the subject, however, cannot be in abler hands than it is at present. To the distinguished physiologists, therefore, who have been recently engaged in the investigation, I willingly leave it, and shall conclude with a few remarks only

on the uses of the yelk, and the apparent generation of earthy matter.

Sir EVERARD HOME and Mr. HATCHETT have concluded, from their experiments, that the yelk is analogous to the milk of viviparous animals, but more concentrated, and that its chief use is to afford a pabulum to the young animal during incubation.\* This opinion, which is indeed as old as ARISTOTLE,† is corroborated in a striking manner by the present inquiry. Mr. HATCHETT has also made the important and curious remark, that in the ova of those tribes of animals, the embryos of which have bones, there is a portion of oily matter; and in those ova whose embryos consist entirely of soft parts, there is none. Hence it is concluded, that a certain portion of oil is necessary for the formation of bone. The present inquiry cannot be said to confirm, or invalidate, this remark, for although in the earlier stages of incubation, before ossification has commenced, a portion of the oil of the yelk is appropriated to the purposes of the economy of the animal, yet by far the greater portion of it remains; and some of it is even retained by the yelk till its final disappearance.‡ One great use of the yelk evidently is to fur-

\* Philos. Trans. Vol. 106, p. 301, et seq.

† 'H μὲν οὖν ἀρχὴ τοῦ νεοττοῦ ἐστὶν ἐκ τοῦ λευκοῦ, ἡ δὲ τροφή διὰ τοῦ ὀμφαλοῦ ἐκ τοῦ ὀχροῦ. Aristotelis de Animal. Hist. VI. 3. (Ed. Schneider.) PLINY makes the same remark. *Ipsum animal ex albo liquore ovi corporatur. Cibus in luteo est.* Hist. Nat. X. 53.

‡ I examined a chick on the 18th day after incubation. The yelk was now reduced to less than 2 grains, but it was of its original yellow colour, and of course contained oily matter. When burnt, it left traces of phosphate of lime. Dr. MACARTNEY attempts to show that the yelk does not pass into the intestine through the ductus vitello intestinalis, but is taken up by absorption; and an argument he adduces in support of this opinion, is, that the earthy matter is left

nish the phosphorus, entering as phosphoric acid, into the skeleton of the animal; but that the earthy portion of the bones is derived from the transmutation of oil into lime cannot, perhaps, be safely asserted in the present state of the inquiry.

With respect to the earthy matter found in the skeleton of the chick when it quits the shell, I think I can venture to assert, after the most patient and attentive investigation, that it does *not pre-exist in the recent egg*; certainly not, at least in any known state. The only possible sources, therefore, whence it can be derived, are from the shell, or transmutation from other principles. Whether it be actually derived from the shell, cannot be determined by chemistry; because, as we have seen, the shells of different eggs differ so much, that the application of averages is out of the question; and we are of course precluded from ascertaining the exact quantity of lime any particular shell originally contains. There are, however, very strong reasons for believing that the earthy matter is not derived from the shell. In the first place, the *membrana putaminis* never becomes vascular, and seems analogous to the epidermis; hence the lime of the shell, which is exterior to this membrane, is generally considered by physiologists as *extra-vascular*;\* it is therefore extremely difficult

behind in the yelk. In the present instance, however, the quantity of earthy matter was very minute: it had therefore disappeared, as well as the other principles of the yelk. When the chick is younger, the quantity of earthy matter is said to be much larger. HALLER asserts that the yelk disappears about the 16th day; and ARISTOTLE long ago remarked, that very little of it was left on the 10th day, after the chick had left the egg.

\* See an Essay "on the connection between the vascular and extra-vascular parts of animals," by Sir A. CARLISLE. THOMSON'S Annals, Vol. VI. p. 174.

to conceive how the earth in question can be introduced into the economy of the chick from this source, particularly during the last week of incubation, when a very large portion of the membranes are actually separated from the shell. Secondly, both the albumen and yelk contain, at the end of incubation, a considerable proportion of earthy matter (the yelk apparently more than it did originally); why is this not appropriated, in preference to that existing in the shell? In opposition to these arguments it will be doubtless stated, that the shell of the egg becomes brittle at the end of incubation, and appears to undergo, during that process, some other changes not at present understood. To which it may be answered, that this brittleness has been attributed to the separation of the membrana putaminis, and the exsiccation of the parts by so long an exposure to the heat necessary to the process of incubation; and in this manner all the *known* changes produced on the shell by incubation may perhaps be satisfactorily accounted for. Until, therefore, it be demonstrated that some other changes take place in the shell, I confess this argument does not seem to me to have much weight. I by no means wish however to be understood to assert, that the earth is *not* derived from the shell; because, in this case, the only alternative left me is to assert that it is formed by transmutation from other matter; an assertion, which I confess myself not bold enough to make in the present state of our knowledge, however strongly I may be inclined to believe that, within certain limits, this power is to be ranked among the capabilities of the vital energies.