later this new leaven will doubtless be felt in agriculture, in technology, and in biology. Already we find a special chair of physical chemistry in Cornell University, from which we shall hear further.[1] Other universities may do well to recognize this middle field in fixing the limits of the several professorships. The time is at least ripe for a more general acquaintance with the subject.

THE COMPOSITION OF AMERICAN CHEDDAR CHEESE.[2]

By L. L. Van Slyke.

In the course of a large number of experiments made in the manufacture of cheese at the New York (Geneva) Experiment Station, a careful study was made of the composition of the cheese manufactured. Knowing the composition of the milk and of the resulting cheese, it was possible to trace the influence of the composition of the milk upon the composition of the cheese. The results given are for the green cheese as it came from the press. The composition of the cheese in a cured or marketable condition can be calculated by allowing for a loss of water varying from four to eight per cent. The first thoroughly reliable analyses of American cheese by an American chemist were published by Dr. Caldwell in 1877, but these were not large in number, and the composition of the milk was not given or known.

The points relating to the composition of cheese upon which I desire especially to dwell briefly are the following:

1. Water and solids.
2. Fat.
3. Casein and albumen.
4. Relation of fat to casein in cheese made from normal milk.
5. Relation of fat to casein in cheese made from skimmed milk.
6. Relation of fat to casein in cheese made from milk containing added cream or other fat.

[1] "The Fundaments of Chemical Theory," by Professor J. E. Trevor, *this Journal*, 15, 430–448.

[2] Read before the World's Congress of Chemists, August 24, 1893.

7. Changes in composition taking place during the ripening process.

I.—WATER AND SOLIDS IN CHEESE.

Taking all the cheese made from normal milk during six months the per cent. of water in the green cheese varied from 33.50 to 42.90 and averaged 36.50 per cent. There was a greater variation in water than in any other constituent of the cheese. Our work shows that cheese-makers are far from being able to control the amount of moisture to be retained in cheese. To discuss the question as to how much moisture it is desirable to retain in cheese would take us beyond the limits of this paper. The variation in solids was, of course, the same as that of moisture.

II.—FAT IN CHEESE.

The per cent. of fat varied from 30.84 to 37.24 and averaged 34.33 per cent. This variation in fat was caused quite as much by variation in the water retained as it was by variation in the composition of the milk used.

III.—CASEIN AND ALBUMEN.

The amount of casein and albumen varied from 22.11 to 26.10, and averaged 24.25 per cent. The amount of albumen retained in cheese from milk is very minute and probably does not exceed 0.10 per cent., so that we might justly speak of the nitrogen compounds contained in cheese as casein alone.

IV.—RELATION OF FAT TO CASEIN IN CHEESE MADE FROM NORMAL MILK.

In another paper I have shown that the fat and casein in normal milk bear a fairly definite relation to each other. A similar relation also holds good for cheese made from normal milk. We found that almost without exception cheese made from normal milk contained not less than 1.30 pounds of fat for one pound of casein; the average was 1.42 pounds of fat for one pound of casein, while the ratio does not often drop below 1.35.

V.—RELATION OF FAT TO CASEIN IN CHEESE MADE FROM SKIMMED MILK.

Removal of fat from milk influences the composition of cheese in much the same way that it does that of milk. Skimming milk increases the amount of casein relative to the fat not only

in the milk, but also in the cheese made from such skimmed milk. The greater the amount of fat removed from normal milk, the less will become the amount of fat relative to casein in the resulting skim-milk as well as in the cheese made from such skim-milk. In no case did we find cheese made from skim-milk to contain as much as 1.30 pounds of fat for one pound of casein. The nearest any cheese came to this was one made from milk, from which less than ten per cent. of its fat had been removed, and in this cheese the ratio was 1.27. When milk is skimmed before being made into cheese usually not less than one-fourth or one-third of its fat is removed, because it does not pay to remove less than this. In such cases, the cheese contains about equal parts of fat and casein. I feel quite confident that this relation can be made to serve as a basis for the identification of cheese made from skim-milk, and that, in case of cheese made from the mixed normal milk of herds of cows, there will rarely or never be less than 1.30 pounds of fat for one pound of casein, unless the cheese was made from skimmed milk. A well-known author says that a cheese which contains less than ten per cent. of fat may with propriety be called skim. I should say that any cheese is a skim-cheese if it contains less than 1.30 pounds of fat for one pound of casein even if it contained forty per cent. of fat.

VI.—RELATION OF FAT TO CASEIN IN CHEESE MADE FROM MILK CONTAINING ADDED CREAM OR OTHER FAT.

The effect of adding cream or other fat to normal milk is to make the amount of fat larger relative to the casein, and the same effect is produced in the cheese made from such milk, so that there will be 1.70 or more pounds of fat for one pound of casein.

The statement is commonly made that good whole-milk cheese consists of one-third water, one-third fat, and one-third casein. This certainly is a convenient statement to remember, but for accuracy it can not be commended; for I have never yet in my work met with a sample of normal milk of such composition as would make such cheese as the above three-thirds cheese; Such cheese could be made only from partially skimmed milk, if it could be made at all.

To summarize, we found that the composition of green Cheddar cheese as made in our American cheese factories, averaged during the season as follows in round numbers:

	Per cent.
Water	36.50
Solids	63.50
Fat	34.25
Casein	24.25
Ash, sugar, etc.	5.00

Such cheese would have approximately the following composition when it reached the consumer:

	Per cent.
Water	31.50
Solids	68.50
Fat	37.00
Casein	26.25
Ash, sugar, etc.	5.25

VII.—CHANGES IN COMPOSITION OF CHEESE TAKING PLACE DURING THE RIPENING PROCESS.

Cheeses were made from milk of varying composition and under certain different conditions; they were analyzed when green and again when five months old. They were kept in a room the temperature of which varied from 60°–70° F.

1st.—Loss of Weight.

(a) The total loss of weight varied from 10.65 to 17.20 per cent. and averaged 13.53.

(b) The loss of weight was greatest in the cheese which contained, when green, the largest amount of water of any cheese made from normal milk.

2d.—Loss of Water.

The amount of water lost in five months varied from 8.14 to 14.95 per cent. and averaged 10.60 per cent. This was equivalent to from 20.56 to 34.83 per cent. of the water in the cheese, with an average of 26.58.

3d.—Loss of Solids.

The amount of solids lost varied from 1.57 to 3.90 and averaged 2.88 per cent. of the cheese; this was equivalent to from 2.50 to 6.80 per cent. of the solids in the cheese with an average of 4.82 per cent.

4th.—Loss of Fat.

There was practically no loss of fat.

5th.—Loss of Casein.

In every case there was a loss of casein varying in amount from 0.90 to 2.20 per cent. and averaging 1.48; this was equivalent to from 4 to 7.83 per cent. of the total casein present in the cheese, with an average of 6.15 per cent.

6th.—Changes in the Form of Casein.

(a) In every case the amount of soluble nitrogen compounds increased very much in five months. In the cheese, when green, the amount of nitrogen in the form of soluble compounds varied from 0.10 to 0.26 per cent. of the cheese and averaged 0.16 per cent., which was equivalent to from 3.12 to 7.19 per cent. of the total nitrogen in the cheese, with an average of 4.23 per cent. At the end of five months the amount of nitrogen in the form of soluble compounds varied from 0.98 to 1.70 per cent. of the cheese, with an average of 1.24, which was equivalent to from 28.57 to 47.33 per cent. of the total nitrogen in the cheese, with an average of 35.52 per cent.

(b) The cheese, when green, contained no nitrogen in the form of amide compounds, while at five months there was contained from 0.26 to 0.50 per cent., with an average of 0.39, which was equivalent to from 7.58 to 13.93 per cent. of the total nitrogen in the cheese with an average of 11.66 per cent.

(c) The cheese, when green, contained no nitrogen in the form of ammonium compounds, while at five months there was contained from 0.078 to 0.126 per cent., with an average of 0.103, which was equivalent to from 2.42 to 3.51 per cent. of the total nitrogen in the cheese, with an average of 2.92 per cent.

(d) The cheese, in the manufacture of which the largest amount of rennet was used, contained considerably more of the soluble nitrogen compounds than did any other cheese when five months old. This would indicate that the amount of rennet used had some influence upon the rapidity of ripening.

(e) The cheese made from partially skimmed milk contained the smallest proportion of soluble nitrogen compounds at five months, while the cheese made from milk containing added

cream contained with a single exception the largest proportion of soluble nitrogen compounds. This would indicate that in cheese rich in fat the insoluble casein is converted into soluble forms more rapidly than in case of skim-milk cheese; in other words, cheese rich in fat becomes digestible in ripening more rapidly than skim-milk cheese.

THE PURIFICATION OF WATER, WITH SPECIAL REFERENCE TO BOILER FEED WATERS AND SCALE PREVENTION.[1]

By C. A. Doremus.

PROF. VIVIAN B. LEWES, of the British Royal Naval College, has epitomized in two papers read before the Institution of Naval Architects in 1889 and 1891 a series of the most highly interesting and instructive analyses and experiments on incrustations in marine boilers and their causes to be found in the literature relating to scale formation.[2] A careful study for some years of a great variety of boiler feed waters from all sections of the country has convinced me that many points brought forward by Professor Lewes are so generally applicable that they can not be overlooked by the chemist who attempts to rectify the serious troubles arising from these sources.

The following quotations are typical: "The presence of calcium sulphate exercises a very marked influence upon the condition and physical properties of the incrustation as under the conditions in which it is formed in a boiler it separates in a crystalline form and binds the deposit into a hard mass, an action which is also aided by the presence of magnesium hydrate." When calcium sulphate is deposited from sea water in a boiler it comes down in small crystals containing two molecules of calcium sulphate and one of water; whilst after deposition in the boiler and in contact with the heated plates and tubes, it undergoes a further change of crystalline form, and becomes "anhydrite, which is pure calcium sulphate free from

[1] Read before the World's Congress of Chemists, August 25, 1893.

[2] *Chemical News*, 59, 222, and 63, 191.