A STUDY OF THE COMPARATIVE CHEMICAL COMPOSITION OF THE HAIR OF DIFFERENT RACES.

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I. INTRODUCTION.

 Apparently the first authentic observations upon the chemical composition of hair were made by Vauquelin¹ and reported in 1806. He found that upon dissolving the hair in superheated


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steam or in mineral acids a transparent solution resulted which could be precipitated by an infusion of nut galls and which possessed the further property of blackening silver salts. He concluded that hair contained silica, carbonates, iron, manganese, calcium phosphate, and finally a considerable quantity of sulphur. Vauquelin found a lower percentage of sulphur in black hair than was present in white, blond, or red hair.

The investigations of v. Laer upon the chemical composition of human hair are widely quoted. He could detect no carbonate or manganese in the hair but, like Vauquelin, he found a high sulphur content. v. Laer found the percentage of sulphur in the hair of adult males to vary from 4.63 to 5.44.

Kühne and Chittenden claim that neurokeratin has a higher content of carbon and hydrogen and a lower content of nitrogen and sulphur than the keratin prepared from the hair of the white rabbit.

v. Bibra found only 3.83 per cent of sulphur in the hair of a boy ten years old whereas the red hair of a man of thirty contained 8.23 per cent. The same investigator found the average sulphur content of fifteen samples of human hair to be 4.62 per cent. He further found 3.7 per cent of sulphur in the hair of a Peruvian interred four hundred years and 4.4 per cent in the hair of a Bolivian interred one thousand years. As a result of a series of analyses of the hair of different animals v. Bibra determined that 4.25 per cent was the average sulphur content.

Mohr found the hair of adult females to contain 4.95 per cent of sulphur whereas that of a girl nine years of age contained 5.34 per cent. In the hair of a boy four years old Mohr found 4.98 per cent of sulphur, while the red hair of a boy six years of age contained 5.32 per cent.

II. SOURCES OF THE KERATIN ANALYZED.

Our investigation included the analysis of the hair of the following races: indian, caucasian, negro and japanese. The specimens of indian hair, ten in number, were furnished through

the courtesy of W. A. Mercer, Captain 7th Cavalry, Superintendent of the Indian Industrial School, Carlisle, Pa., and were obtained from students at the school. The negro hair, with the exception of samples 1-5, was kindly furnished us by Dr. M. M. Waldron, of the Hampton Institute, Hampton, Va. The hair of the living adult caucasians was obtained from various students of the University of Pennsylvania, and the children's hair was obtained through the courtesy of Richard Binder, Jr., of Philadelphia. The japanese hair was courteously furnished us by Mr. Okumura of the University of Pennsylvania.

The purpose of our investigation was to determine whether there were any differences in the chemical composition of the hair of the various races mentioned above. The samples of hair analyzed varied in color from an extremely light yellow to jet black and the ages of the individuals from whom the samples were obtained ranged from two and one-half years to sixty years. The average data for the hair of the different races are shown in Table X, p. 488.

III. PREPARATION OF THE HAIR FOR ANALYSIS.

The hair, after being thoroughly washed in distilled water, was placed in a large volume of artificial gastric juice and kept at 40° C. for forty-eight hours. The digestion mixture was then thrown upon cheese cloth and after draining thoroughly the hair was washed free from gastric juice by means of distilled water. The gastric fluid was now replaced by artificial pancreatic juice and the mixture again placed at 40° C. for forty-eight hours. At the end of this period the hair was removed from the pancreatic juice and washed with distilled water as before. It was now introduced into a round-bottomed flask, sufficient alcohol added to cover the sample, the flask provided with a reflux condenser and the mixture boiled on a safety water-bath for thirty-six hours. The alcohol was now removed by filtration and the hair boiled in ether for twenty-four hours. The sample was then removed from the ether, cut into exceedingly short lengths by means of scissors, and placed at 100° C. for four hours. It was then transferred to glass stoppered bottles ready for analysis.

The authors wish to express their thanks to Mr. John Thomson, who kindly assisted in the preparation of the hair for analysis.
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IV. METHODS OF ANALYSIS.

Sulphur was determined after fusing with sodium hydroxide and potassium nitrate. Nitrogen was determined by a modification of the Kjeldahl method in which the preliminary digestion is accomplished by means of sulphuric acid and cupric sulphate. Carbon and hydrogen were determined by Benedict's modification1 of the Liebig method. In this modification the carbon dioxide is absorbed by soda lime and the water by sulphuric acid.

The figures for the percentage composition of the various specimens analyzed are the averages of from two to six determinations.

V. DISCUSSION OF RESULTS.

1. Chemical composition of indian hair. Ten samples of indian hair were analyzed, the specimens being obtained from the representatives of ten different tribes. Six of the samples were from full-blood indians and the remaining four were from half-bloods. Seven of the specimens analyzed were from female subjects and three from males. The indians whose hair was analyzed were from twelve to nineteen years of age.

The data obtained from the analysis of the ten samples of indian hair are summarized in Table I, p. 464. The lowest sulphur content (4.55 per cent) is found in the hair of the half-blood female Klamath, whereas the highest sulphur content (5.03 per cent) is found in the hair of the half-blood male Shawnee. The lowest nitrogen content (14.80 per cent) is possessed by the full-blood female Pima and the highest nitrogen content (15.72 per cent) by the half-blood female Alaskan. Carbon is present in smallest percentage (41.68 per cent) in the hair of the half-blood male Shawnee, while it is present in largest percentage (45.69 per cent) in the hair of the full-blood female Shoshone. Hydrogen follows the carbon in showing the lowest percentage (6.04 per cent) in the hair of the half-blood male Shawnee but differs from the data for carbon in showing the highest content (7.10 per cent) in the hair of the full-blood female Chippewa. The average percentage composition of the ten samples of indian

1 Benedict: Elementary Organic Analysis, p. 49.
hair is given at the bottom of Table I, p. 464. By referring to these data it will be observed that the average percentage of sulphur in the ten samples of indian hair is 4.82, the average percentage of nitrogen is 15.40, the average carbon value is 44.06 per cent and the average percentage of hydrogen is 6.53.

Data for the ratio, S : N, are given in the last column of Table I, p. 464. An examination of these ratios reveals the fact that the lowest ratio, 1:3.0, is found in connection with the full-blood female Pima indian, whereas the highest ratio, 1:3.4, occurs in connection with the half-blood female Klamath indian.

2. Chemical composition of indian hair as influenced by the sex of the individual and the purity of breeding. A comparison from the standpoint of the sex of the individual and the purity of breeding is shown in Table II, p. 465. By referring to this table it will be noted that the two extremes of sulphur data occur in connection with the hair of the half-blood indian, the lowest percentage (4.69) being present in the hair of the half-blood female and the highest percentage (5.03) occurring in the hair of the half-blood male indian. On the other hand the hair of the full-blood male and female indians contains practically the same percentage of sulphur (4.85 and 4.86). Compared as to sex without reference as to whether the specimen is from half- or full-blood indians we find that the hair of the female indians contains somewhat less sulphur than that of the male indians, the percentage of sulphur in the hair of the females being 4.79 and in that of the males being 4.91. It will be further observed that, when compared as to the purity of breeding without reference to the sex, the hair of the full-blood indians contains a higher percentage of sulphur (4.86) than the hair of the half-blood indians (4.77). It is interesting to note that whereas the hair of the full-blood indians of both sexes contains practically the same percentage of sulphur (4.85 and 4.86) the hair of the half-blood female indian shows a lower percentage of sulphur (4.69) and the hair of the half-blood male indian shows a higher percentage (5.03).

By an examination of the data contained in Table II, it will be observed that the lowest percentage of nitrogen (15.20) occurs in the hair of the full-blood female indian where as the highest nitrogen content (15.60 per cent) is found in the hair of the half-blood male indian. In this connection it may be remembered
### Table 1. Chemical Composition of Indian Hair

<table>
<thead>
<tr>
<th>No. of Samples</th>
<th>Tribe</th>
<th>Sex</th>
<th>Age (years)</th>
<th>Blood</th>
<th>S</th>
<th>N</th>
<th>C</th>
<th>H</th>
<th>O</th>
<th>Average Percentage Composition of 10 Samples of Indian Hair</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pima Female</td>
<td>Male</td>
<td>16</td>
<td>Full</td>
<td>4.93</td>
<td>14.80</td>
<td>43.54</td>
<td>6.76</td>
<td>29.97</td>
<td>1:8.0</td>
</tr>
<tr>
<td>2</td>
<td>Ute Female</td>
<td>Male</td>
<td>15</td>
<td>Full</td>
<td>4.83</td>
<td>14.88</td>
<td>46.56</td>
<td>6.56</td>
<td>28.17</td>
<td>1:8.1</td>
</tr>
<tr>
<td>3</td>
<td>Chippewa Female</td>
<td>Female</td>
<td>19</td>
<td>Full</td>
<td>4.80</td>
<td>15.64</td>
<td>45.83</td>
<td>7.10</td>
<td>27.64</td>
<td>1:8.3</td>
</tr>
<tr>
<td>4</td>
<td>Shoshone Female</td>
<td>Female</td>
<td>14</td>
<td>Full</td>
<td>4.79</td>
<td>15.48</td>
<td>46.09</td>
<td>6.59</td>
<td>27.36</td>
<td>1:8.3</td>
</tr>
<tr>
<td>5</td>
<td>Shoshone Female</td>
<td>Male</td>
<td>21</td>
<td>Half</td>
<td>4.70</td>
<td>15.47</td>
<td>43.65</td>
<td>6.51</td>
<td>29.94</td>
<td>1:8.3</td>
</tr>
<tr>
<td>6</td>
<td>Shoshone Female</td>
<td>Male</td>
<td>20</td>
<td>Half</td>
<td>4.70</td>
<td>15.47</td>
<td>43.65</td>
<td>6.51</td>
<td>29.94</td>
<td>1:8.3</td>
</tr>
<tr>
<td>7</td>
<td>Alaskan Female</td>
<td>Male</td>
<td>16</td>
<td>Half</td>
<td>4.79</td>
<td>15.48</td>
<td>45.83</td>
<td>6.59</td>
<td>27.36</td>
<td>1:8.3</td>
</tr>
<tr>
<td>8</td>
<td>Alaskan Female</td>
<td>Male</td>
<td>15</td>
<td>Half</td>
<td>4.79</td>
<td>15.48</td>
<td>45.83</td>
<td>6.59</td>
<td>27.36</td>
<td>1:8.3</td>
</tr>
<tr>
<td>9</td>
<td>Arapahoe Male</td>
<td>Male</td>
<td>17</td>
<td>Full</td>
<td>4.70</td>
<td>15.47</td>
<td>43.65</td>
<td>6.51</td>
<td>29.94</td>
<td>1:8.3</td>
</tr>
<tr>
<td>10</td>
<td>Shawnee Female</td>
<td>Male</td>
<td>16</td>
<td>Half</td>
<td>4.70</td>
<td>15.47</td>
<td>43.65</td>
<td>6.51</td>
<td>29.94</td>
<td>1:8.3</td>
</tr>
</tbody>
</table>
that the lowest percentage of sulphur occurs in the hair of the half-blood female Indian instead of the full-blood female Indian which contains the lowest percentage of nitrogen. Comparing the data obtained from the analyses of the hair of the full-blood Indians we observe that the hair of the male contains considerably more nitrogen (15.54 per cent) than the hair of the female (15.20 per cent), and the same observation holds true for the hair of the half-blood Indians, i.e., the percentage of nitrogen in the hair of the half-blood male (15.60) is somewhat higher than the percentage of nitrogen in the hair of the half-blood female.

### Table II. Chemical Composition of Indian Hair as Influenced by the Sex of the Individual and the Purity of Breeding.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Blood</th>
<th>S</th>
<th>N</th>
<th>C</th>
<th>H</th>
<th>O</th>
<th>Ratio S : N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>Full</td>
<td>4.86</td>
<td>15.20</td>
<td>44.91</td>
<td>6.75</td>
<td>28.28</td>
<td>1 : 3.1</td>
</tr>
<tr>
<td>Female</td>
<td>Half</td>
<td>4.69</td>
<td>15.49</td>
<td>44.63</td>
<td>6.50</td>
<td>28.69</td>
<td>1 : 3.3</td>
</tr>
<tr>
<td>Female</td>
<td>Full and half</td>
<td>4.79</td>
<td>15.32</td>
<td>44.79</td>
<td>6.65</td>
<td>28.45</td>
<td>1 : 3.2</td>
</tr>
<tr>
<td>Male</td>
<td>Full</td>
<td>4.85</td>
<td>15.54</td>
<td>42.71</td>
<td>6.37</td>
<td>30.53</td>
<td>1 : 3.2</td>
</tr>
<tr>
<td>Male</td>
<td>Half</td>
<td>5.03</td>
<td>15.60</td>
<td>41.68</td>
<td>6.04</td>
<td>31.65</td>
<td>1 : 3.1</td>
</tr>
<tr>
<td>Male</td>
<td>Full and half</td>
<td>4.91</td>
<td>15.56</td>
<td>42.37</td>
<td>6.26</td>
<td>30.90</td>
<td>1 : 3.2</td>
</tr>
<tr>
<td>Male and female</td>
<td>Full</td>
<td>4.86</td>
<td>15.31</td>
<td>44.17</td>
<td>6.62</td>
<td>29.04</td>
<td>1 : 3.2</td>
</tr>
<tr>
<td>Male and female</td>
<td>Half</td>
<td>4.77</td>
<td>15.52</td>
<td>43.89</td>
<td>6.39</td>
<td>29.43</td>
<td>1 : 3.3</td>
</tr>
</tbody>
</table>

Average percentage composition of all specimens of Indian hair: 4.82 15.40 44.06 6.53 29.19 1 : 3.2

(15.49). As the result of a comparison of sexes without reference to the purity of breeding it is seen that the hair of the male Indians is much richer in nitrogen than the hair of the females, the percentage of nitrogen in the hair of the male being 15.56 and that in the hair of the female being 15.32. On the contrary, a comparison as to the purity of breeding without considering the sex of the individual, shows a balance of nitrogen in favor of the half-blood Indians, the percentage of nitrogen in the hair of the full-blood Indians being 15.31 and that in the hair of the half-bloods being 15.52.
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Carbon is seen to be present in smallest percentage (41.68) in the hair of the half-blood male Indian and present in the largest percentage (44.91) in the hair of the full-blood female Indian, and it is very interesting to note that the order is exactly the reverse of that in which the nitrogen occurs, i.e., the largest percentage of nitrogen is found in the hair of the half-blood male and the smallest percentage in the hair of the full-blood female Indian. Considering the female Indians apart from the males, it may be observed that the carbon follows the sulphur in showing a higher percentage in the hair of the full-blood female (44.91 per cent) than in the hair of the half-blood female (44.63 per cent). In the case of the male Indians however, the carbon follows a course the reverse of that taken by the sulphur and the nitrogen since it exhibits a higher percentage (42.71) in the hair of the full-blood male than is present in the hair of the half-blood male (41.68). A comparison of sexes shows the percentage of carbon in the hair of the female Indians (44.79) to be considerably higher than that in the hair of the male Indians (42.37) and in this point the occurrence of the carbon content again is the reverse of that of sulphur and nitrogen. Compared from the standpoint of purity of breeding, without reference to the sex of the individual, we observe that the carbon is present in larger percentage in the hair of the full-blood Indians than in that of the half-bloods and in this it exhibits a similarity to the sulphur content but is the reverse of that of nitrogen. Hydrogen runs parallel with the carbon in every instance.

The relation of the sulphur content to the nitrogen content is stated in the last column of Table II, p. 465. The most striking thing observed in this connection is the fact that the ratio, S : N, for the specimens of hair from the male Indians, without respect to the purity of breeding, is exactly the same as the ratio in the case of the specimens of hair from the female Indians, i.e., 1:3.2. Considering the female Indians alone we observe that the ratio varies with the purity of breeding, being 1:3.1 for the full-blood females and 1:3.3 for the half-blood females. In the case of the male Indians the ratios run differently since they show a ratio of 1:3.2 for the full-blood Indians and 1:3.1 for the half-bloods. It is interesting to note that the ratio 1:3.2 is common to four of the eight classes included in the table.
3. Chemical composition of negro hair. Fourteen specimens of negro hair were analyzed, five of them being obtained from dead individuals and the remaining nine from living individuals. Five of the latter were full-blood negroes ranging from seventeen to twenty-three years of age, two were half-blood negroes eighteen years of age, and two were three-quarter blood negroes eighteen and twenty years old, respectively. Of the fourteen specimens of negro hair analyzed eleven were obtained from females and three from males.

In Table III, p. 469 are summarized the data from the chemical analyses of the fourteen samples of negro hair. The first impression gathered from an examination of the table is the general similarity of the analytical results with those from the analyses of Indian hair, as set forth in Table I, p. 464. There is also observed to be a well marked tendency for both the sulphur and the nitrogen to occur in higher percentage in the hair of full-blood negroes than in the hair of the negroes less purely bred, this higher percentage occurring irrespective of the sex of the individual. It will also be noted that the analyses of the hair of dead negroes show a rather lower average percentage of sulphur and a somewhat higher average percentage of nitrogen than is shown in the data from the analyses of the hair of the living negroes. These three points, mentioned in this general way, are more fully discussed on pp. 470-476.

Considering the sulphur content of the various specimens of negro hair we observe that the lowest percentage (4.53) occurs in the hair of a dead female negro (sample 2), whereas the highest percentage (5.15) occurs in the hair of a living full-blood female negro (sample 8). Nitrogen follows the sulphur in being found in the largest percentage (15.55) in the sample containing the greatest abundance of sulphur but differs from it in showing the lowest percentage (14.51) in the hair of the living, three-quarter blood female negro. The lowest percentage of carbon (42.43) is found in the hair of a living male half-blood negro (sample 14), and the highest percentage (45.70) in the hair of a living, full-blood female negro (sample 6). In this connection it is exceedingly interesting to note that an examination of the data for carbon reveals the singular fact that the hair of the impurely bred negroes, i.e., the half- and three-quarter bloods, contains, uniformly considerably less carbon than the hair of any of the other negroes,
irrespective of the sex of the individual (see data for samples 9, 10, 11, and 14).

Hydrogen follows the carbon in showing the lowest percentage (5.60) in the hair of a living, half-blood male negro (sample 14) and the next lowest (5.97) in the hair of a living, half-blood female negro (sample 11), but differs from the carbon in the fact that it is found in greatest amount (6.90 per cent) in the hair of a living full-blood female negro (sample 7).

The average percentage composition of the fourteen samples of negro hair is given at the bottom of Table III, p. 469. From this it will be observed that the average percentage of sulphur is 4.84 and the average percentage of nitrogen is 14.90 whereas the carbon and hydrogen averages are 43.85 per cent and 6.37 per cent respectively.

The data for the ratio, S:N, in the various samples of negro hair, will be found in the last column of Table III, p. 469. Among the interesting observations in relation to this ratio is the general uniformity of the ratios for the samples of hair of the living, full-blood negroes and the decided variation of this ratio from that obtained from the data for the samples of the hair of dead negroes. The ratio for the hair of the living, full-blood individuals is 1:2.9 for two samples and 1:3.0 for three samples whereas the ratio for the hair of the dead individuals is 1:3.1 for two samples, 1:3.2 for two samples, and 1:3.4 for one sample, making a variation from 1:3.1 to 1:3.4 as contrasted with the lesser variation from 1:2.9 to 1:3.0 noted in the case of the living, full-blood negroes. The two instances in which the ratio for the living individuals is above 1:3.0 are both impurely bred negroes, one being a three-quarter-blood female and the other a half-blood male. The hair of each of these individuals shows a ratio of 1:3.2. An examination of the ratios for the various samples shows conclusively that the average ratio for the impurely bred individuals is considerably above the average ratio for the full-blood individuals. These average ratios are further discussed on p. 474. The average ratio for the entire fourteen samples of negro hair is 1:3.1.

4. Chemical composition of negro hair as influenced by the sex of the individual and the purity of breeding. In Table IV, p. 471, is portrayed the chemical composition of the hair of living and dead negroes as influenced by the sex of the individual and the
<table>
<thead>
<tr>
<th>Sample</th>
<th>Sex</th>
<th>Blood</th>
<th>Age (years)</th>
<th>Living or Dead</th>
<th>S</th>
<th>N</th>
<th>C</th>
<th>H</th>
<th>O</th>
<th>S:N</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Female</td>
<td>40-50</td>
<td>Dead</td>
<td>4.72</td>
<td>15.18</td>
<td>43.80</td>
<td>6.40</td>
<td>29.90</td>
<td>1:3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Female</td>
<td>40-50</td>
<td>Dead</td>
<td>4.53</td>
<td>15.31</td>
<td>44.76</td>
<td>6.53</td>
<td>29.07</td>
<td>1:3.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Female</td>
<td>40-50</td>
<td>Dead</td>
<td>4.81</td>
<td>14.76</td>
<td>44.80</td>
<td>6.77</td>
<td>29.86</td>
<td>1:3.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Female</td>
<td>40-50</td>
<td>Dead</td>
<td>4.84</td>
<td>15.18</td>
<td>44.13</td>
<td>6.32</td>
<td>29.53</td>
<td>1:3.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Female</td>
<td>40-50</td>
<td>Dead</td>
<td>4.77</td>
<td>15.14</td>
<td>44.61</td>
<td>6.26</td>
<td>29.22</td>
<td>1:3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Female</td>
<td>Full</td>
<td>17 Living</td>
<td>4.96</td>
<td>14.59</td>
<td>45.70</td>
<td>6.15</td>
<td>28.60</td>
<td>1:2.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Female</td>
<td>Full</td>
<td>18 Living</td>
<td>4.95</td>
<td>14.76</td>
<td>43.75</td>
<td>6.90</td>
<td>30.44</td>
<td>1:3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Female</td>
<td>Full</td>
<td>19 Living</td>
<td>5.15</td>
<td>15.55</td>
<td>44.70</td>
<td>6.79</td>
<td>27.81</td>
<td>1:3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Female</td>
<td>Three-quarter</td>
<td>18 Living</td>
<td>4.71</td>
<td>14.55</td>
<td>43.11</td>
<td>6.66</td>
<td>30.97</td>
<td>1:3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Female</td>
<td>Three-quarter</td>
<td>20 Living</td>
<td>4.56</td>
<td>14.31</td>
<td>42.90</td>
<td>6.45</td>
<td>31.68</td>
<td>1:3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Female</td>
<td>Half</td>
<td>18 Living</td>
<td>5.00</td>
<td>14.68</td>
<td>42.44</td>
<td>5.97</td>
<td>31.91</td>
<td>1:2.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Male</td>
<td>Full</td>
<td>20 Living</td>
<td>5.13</td>
<td>14.93</td>
<td>43.43</td>
<td>6.20</td>
<td>30.31</td>
<td>1:2.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Male</td>
<td>Full</td>
<td>20 and 23 Living</td>
<td>4.93</td>
<td>14.64</td>
<td>43.31</td>
<td>6.15</td>
<td>30.97</td>
<td>1:3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Male</td>
<td>Half</td>
<td>18 Living</td>
<td>4.69</td>
<td>14.80</td>
<td>42.43</td>
<td>5.60</td>
<td>32.48</td>
<td>1:3.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average percentage composition of 14 samples of negro hair: 4.84 14.90 43.85 6.37 30.04 1:3.1
purity of breeding. Considering first the sulphur content, one of the most striking points we observe is the similarity between the data for the living, full-blood female negroes and the living full-blood male negroes, the percentage of sulphur being 5.02 for the former and 5.03 for the latter. \textit{The value 5.03 for the full-blood male negroes is the highest percentage of sulphur found in any of the samples of negro hair analyzed.} The lowest percentage of sulphur (4.64) is found in the hair of the living, three-quarter blood female negro and the next lowest (4.69) occurs in the hair of the living, half-blood male negro. Grouping the female and the male negroes together for purposes of comparison we observe that the average percentage of sulphur is 5.02 for the full-blood negroes and the lower value of 4.84 for the half-blood negroes. The most striking variation, however, in the sulphur content of the hair of the full-blood and half-blood negroes is noted in the case of the male subjects in which connection it will be observed that the hair of the half-blood individuals contains only 4.69 per cent of sulphur whereas the hair of the full-blood individuals contains 5.03 per cent, which is, as has just been mentioned, the maximum percentage of sulphur for the negro hair examined.

Comparing the data from the analyses of the hair of the dead female negroes with the data from the analyses of the hair of the living, female negroes we observe that the percentage of sulphur in the hair of the former (4.73) is somewhat lower than that in the latter (4.89). One of the most interesting points emphasized by this table is the very close agreement in percentage of sulphur shown in the analyses of the hair of living, male and female negroes without reference to the purity of breeding. In this connection it will be noted that the hair of the female negroes contains 4.89 per cent of sulphur and the hair of the male negroes contains 4.92 per cent of sulphur, the variation being but 0.03 per cent which is within the limit of experimental error for such determinations. The average percentage of sulphur in all the specimens of negro hair without reference to the sex of the individual or the purity of breeding is 4.84 and is identical with that determined for the living, half-blood male and female negroes and within the limit of experimental error of that determined for the living and dead females (4.82), for the living, full-, half- and three-quarter blood female negroes (4.89) and the living, full- and half-blood male negroes (4.92).
TABLE IV. CHEMICAL COMPOSITION OF THE HAIR OF LIVING AND DEAD NEGROES AS INFLUENCED BY THE SEX OF THE INDIVIDUAL AND THE PURITY OF BREEDING.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Blood</th>
<th>Living or dead</th>
<th>Average Percentage Composition of Hair</th>
<th>Ratio S : N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>Full</td>
<td>Living</td>
<td>S</td>
<td>N</td>
</tr>
<tr>
<td>Female</td>
<td>Three-quarter</td>
<td>Living</td>
<td>5.02</td>
<td>14.96</td>
</tr>
<tr>
<td>Female</td>
<td>Half</td>
<td>Living</td>
<td>4.84</td>
<td>14.53</td>
</tr>
<tr>
<td>Female</td>
<td>Full, three-quarter</td>
<td>Living</td>
<td>5.00</td>
<td>14.68</td>
</tr>
<tr>
<td>Male</td>
<td>Full</td>
<td>Living and dead</td>
<td>4.89</td>
<td>14.77</td>
</tr>
<tr>
<td>Male</td>
<td>Half</td>
<td>Living</td>
<td>4.73</td>
<td>15.11</td>
</tr>
<tr>
<td>Male and female</td>
<td>Full and half</td>
<td>Living</td>
<td>4.82</td>
<td>14.93</td>
</tr>
<tr>
<td>Male and female</td>
<td>Half</td>
<td>Living</td>
<td>4.92</td>
<td>14.79</td>
</tr>
</tbody>
</table>

Average percentage composition of all specimens of negro hair: 4.84 14.90 43.85 6.37 30.04 1 : 3.1
472 Chemical Composition of Hair

The most noteworthy observation in connection with the nitrogen content of the samples of negro hair is the variation of the percentage of nitrogen in the hair of the dead female negroes from the percentage of nitrogen in the hair of all the other classes of living subjects whether male, female, full-, half- or three-quarter blood. The hair of the dead females contains 15.11 per cent of nitrogen whereas that of the other classes of subjects varies from 14.53 per cent to 14.96 per cent. One of the most interesting points concerning the nitrogen content of the samples of negro hair is the uniformity in the percentage of this element which is present in the hair of the various classes of living subjects as grouped in Table IV, p. 471. By referring to the table it will be seen that, with the exception of the hair of the three-quarter blood female negroes, all the percentage data for the nitrogen of the hair of all the classes in the table may be grouped together as duplicates which are almost within the limit of experimental error. Of such variations as occur in these data the most striking is the tendency of the nitrogen content to follow that of sulphur in being higher in the hair of the full-blood negroes than in that of the half-bloods, e.g., 14.89 per cent of nitrogen in the hair of full-blood male and female negroes and 14.74 per cent in the hair of the half-blood negroes. The average content of nitrogen for the entire fourteen specimens of negro hair analyzed is 14.90 per cent, a value which is practically duplicated by all classes in Table IV except the dead female negroes and the living, half- and three-quarter blood female negroes.

Carbon shows a well developed tendency to be present in the greatest amount in the hair of the purest bred negroes. This is most strikingly indicated in the data for the living female subjects where the hair of the full-blood individuals is shown to possess 44.72 per cent of the element, that of the three-quarter blood female 43.00 per cent and finally the half-blood’s hair showing 42.44 per cent of carbon. The series shows a decreasing carbon content as the purity of breeding is lowered, the maximum percentage occurring in the hair of the purely bred individual and the minimum in the hair of the half-blood. This series also practically includes the two extremes of the eleven classes as grouped in Table IV, since 44.72 per cent is the highest of those tabulated and 42.44 per cent is practically the lowest since it is almost
identically the same as the value (42.43 per cent) for the carbon content of the hair of the living half-blood male negroes which is the actual minimum percentage of carbon. This tendency to exhibit a variation in carbon content according to the purity of breeding is shown likewise in the case of the male negroes. In this instance the hair of the full-blood individual contains 43.37 per cent of carbon while that of the half-blood contains but 42.43 per cent. Grouping the males and females together we obtain as the averages 44.18 per cent of carbon in the hair of the full-blood negroes and 42.44 per cent in the hair of the half-bloods. In this last particular the carbon follows the tendency already noted in connection with sulphur and nitrogen. Dividing the female negroes into living and dead subjects we observe that the hair of the dead subjects contains considerably more carbon than that of the living subjects, e.g., 44.42 per cent being present in the hair of the former and 43.77 per cent in that of the latter. In this regard the carbon again follows the course of the nitrogen. Comparing the living females with the living males we note that the hair of the former contains a higher percentage of carbon than the hair of the latter, the averages being 43.77 per cent and 43.06 per cent respectively. The average percentage of carbon in the whole series of samples of negro hair was 43.85, a value most nearly duplicated by the hair of the living, female negroes (43.77), the living, full-blood male and female negroes (44.18) and the living and dead female negroes (44.06).

There is a very well defined tendency for the hydrogen to follow very closely the same scheme of distribution as that noted for the carbon content. First of all we observe the same general decrease in the percentage of hydrogen coincident with a lessening of the purity of breeding. This feature is particularly well illustrated in the case of the living, female negroes, where, it will be noted, the hair of the full-blood individuals contains 6.61 per cent of hydrogen, that of the three-quarter blood 6.55 per cent and that of the half-blood 5.97 per cent. This variation according to the purity of breeding is also well illustrated by the data for the analyses of the hair of the male negroes. Here the hair of the full-blood individual possesses a hydrogen content of 6.18 per cent as contrasted with a content of 5.60 per cent for the hair of the half-blood negro. The hydrogen again follows the carbon in showing its maximum percentage in the hair of the living, full-blood
female and its minimum percentage in the hair of the living, half-blood male. However, like the sulphur it is present in slightly higher percentage in the hair of the living, female negroes than in that of the dead female negroes. In a comparison of the living females with the living males it is noted that the hydrogen follows the carbon in being present in largest percentage in the hair of the former, the percentage being 6.49 for the hair of the females and 5.98 for the hair of the males.

The noteworthy uniformity with which the hair of the full-blood negroes, irrespective of sex, contains a higher percentage of each of the constituents determined by analysis, than the hair of the half-blood negroes is very strikingly portrayed in the lower portion of Table IV. Sulphur, nitrogen, carbon and hydrogen are found with absolute regularity in higher percentage in the hair of the full-blood negroes than in the hair of the half-blood negroes.

The ratio, S : N, is the lowest (1:2.9) for the living, half-blood female negroes and living, full-blood male negroes, and highest (1:3.2) for the dead female and the living, half-blood males. The average ratio for all specimens of negro hair is 1:3.1.

5. Comparison of the chemical composition of Indian and negro hair. By careful examination of Tables II and IV, pp. 465 and 471, some interesting observations may be made upon the comparative chemical composition of the hair of the Indian and negro. Referring first to the sulphur content it will be observed that the percentage limits are virtually identical in the two instances, the highest percentage of sulphur in the Indian hair being 5.03 and the lowest being 4.69, whereas the similar data for negro hair are 5.03 and 4.64. It is of interest in this connection to note that in each instance the hair of the male subject contained the higher percentage of sulphur, one of the most striking comparative observations portrays the influence of purity of breeding upon the chemical composition of the hair of the individual. An examination of the tables will show the great uniformity with which the hair of the full-blood male or female Indian or negro is shown to contain a higher percentage of sulphur, carbon and hydrogen than the hair of the half-blood, and, in the case of negro hair, nitrogen also. The only exception to this rule is the nitrogen content of Indian hair where the hair of the impurely bred male
or female subject is, in every instance, observed to contain a higher percentage of nitrogen than that of the full-blood subject. The variation in the chemical composition according to sex is clearly shown in the case of the sulphur content also. In both tables it will be seen that the hair of the male subjects contains a higher percentage of sulphur than the hair of the female subjects, the data for Indian hair being 4.91 and 4.79 and the data for negro hair being 4.92 and 4.89. The average percentage of sulphur is practically the same for each variety of hair, e.g., 4.82 for Indian hair and 4.84 for negro hair.

The most striking lack of uniformity is shown in the comparison of the nitrogen content. The hair of the Indian contains uniformly a higher percentage of nitrogen than that of the negro. This fact is emphasized by an examination of the tables which reveals the fact that the lowest percentage of nitrogen determined for Indian hair (15.20) is nevertheless somewhat higher than the maximum percentage of nitrogen (15.11) in negro hair. The percentage of nitrogen in Indian hair varies from 15.20 to 15.60 whereas the percentage of nitrogen in negro hair varies from 14.53 to 15.11. Indian hair contains an average of 15.40 per cent of nitrogen while the average nitrogen value of negro hair is 14.90 per cent.

An examination of the data for the carbon determinations reveals another interesting similarity. It is there shown that the maximum percentage of carbon in the hair of both the Indian and the negro is found in the hair of the full-blood female and the minimum percentage of carbon is found in the hair of the half-blood male. The tendency is well developed for the hair of the full-blood individual of either race to contain a higher percentage of carbon than the hair of any individual of that race less purely bred. The average percentage of carbon for the Indian hair (44.06) is somewhat higher than the average for negro hair (43.85) but the difference is almost within the limit of experimental error for carbon determinations. Contrasted according to sex it will be observed that in each table the hair of the females contains a higher percentage of carbon than that of the males.

Hydrogen follows carbon in the main characteristics. For instance we note the same marked tendency for the percentage of hydrogen to decrease as the purity of breeding is lowered, as well as
the strict uniformity with which the sex appears to a degree to regulate the chemical composition of the hair. Thus we find that the hair of the full-blood individuals contains a higher percentage of hydrogen than that of the half-blood individuals, and it is also noted in every instance, that the hair of the females contains a higher percentage of hydrogen than that of the males. In common with carbon, hydrogen is also present in maximum percentage (6.75) in the hair of the full-blood female Indian and in minimum percentage (5.60) in the hair of the half-blood male negro. The average percentage of hydrogen for the whole series of samples of Indian hair (6.53) is somewhat higher than the similar average for negro hair (6.37).

The ratio, S : N, for the Indian hair is higher throughout than the same ratio for the negro hair. This is due to the uniformly higher nitrogen content of the former.

### Table V. Comparative Chemical Composition of the Hair of Full-Blood Male Indians, Negroes and Japanese.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Percentage Composition of Hair</th>
<th>Ratio S : N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negro</td>
<td>S 5.03  N 14.79  C 43.37  H 6.18  O 30.63</td>
<td>1 : 2.9</td>
</tr>
<tr>
<td>Japanese</td>
<td>S 4.96  N 14.64  C 42.99  H 5.91  O 31.50</td>
<td>1 : 3.0</td>
</tr>
<tr>
<td>Indian</td>
<td>S 4.85  N 15.54  C 42.71  H 6.37  O 30.53</td>
<td>1 : 3.2</td>
</tr>
</tbody>
</table>

6. Chemical composition of Japanese hair. Unfortunately but a single sample of Japanese hair was available for analysis, this being the hair of a full-blood male Japanese. The data for the analysis of this specimen are given in Table V, p. 476, in which table are also given, for the purpose of comparison, the average data for the chemical composition of the hair of full-blood male Indians and negroes. It is rather interesting to note the similarity in the chemical composition of these samples of hair from three distinct races, in fact, the agreement of the data, with the exception of the nitrogen content, is as close as that previously noted as existing in some instances between the data for different sexes of the same race, or between those noted for full-blood and half-blood individuals of the same sex. Considering, for example, the sulphur content, we observe that the percentage of this element in the Japanese hair is an approximate mean of the percentage of
sulphur in the hair of the Indian and the percentage of sulphur in the hair of the negro, being a slightly lower percentage than that obtained from the analysis of negro hair and slightly higher than the determined percentage of sulphur in Indian hair. We do not note the same uniformity in the nitrogen content of the three varieties of hair. There is rather close agreement between the data for negro and Japanese hair, the percentage in the former case being 14.79 and in the latter case 14.64, but the percentage of nitrogen in the hair of the Indian is considerably higher (15.54), in fact, as may be seen from a comparison of Tables II and IV, the percentage of nitrogen is uniformly high for all the specimens of Indian hair as compared with the similar data for the negro hair. 

In connection with the carbon content the same conditions obtain as those noted in the discussion of the sulphur content, i.e., the percentage of carbon in the hair of the Japanese is an approximate mean of the similar data for the negro hair and Indian hair, being somewhat lower than the percentage of carbon in the hair of the negro and somewhat higher than the percentage of carbon in the Indian hair. The percentage of hydrogen is similar to that of nitrogen in showing the highest percentage (6.37) in the hair of the Indian and the lowest (5.91) in the hair of the Japanese, the percentage of hydrogen in the hair of the negro being an approximate mean of those percentages. The ratio, S:N, is lowest (1:2.9) for the hair of the negro, slightly higher (1:3.0) for the hair of the Japanese, while the maximum ratio (1:3.2) occurs in connection with the Indian hair.

7. Chemical composition of Caucasian hair. There were, in all, twenty specimens of Caucasian hair subjected to analysis, thirteen of which were obtained from adults. The remaining seven specimens were the hair of children ranging from two and one-half to twelve years of age. In order to be able to interpret the results more satisfactorily we will consider the analyses of the Caucasian hair in two divisions, i.e., adults and children.

(a) Chemical composition of the hair of adult Caucasians. Thirteen specimens of hair obtained from adult Caucasians were analyzed, five of them being from dead females and eight from living males.

The data for the analyses of the hair of adult Caucasians are given in Table VI, p. 478. Referring to this table and consider-
### TABLE VI. CHEMICAL COMPOSITION OF THE HAIR OF ADULT CAUCASIANS.

<table>
<thead>
<tr>
<th>No. of Sample</th>
<th>Color of Sample</th>
<th>Description of Subject</th>
<th>Percentage Composition of Hair</th>
<th>Ratio S:N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gray</td>
<td>Female, Old, Dead</td>
<td>S: 4.94 N: 15.84 C: 44.75 H: 6.24 O: 28.23</td>
<td>1:3.2</td>
</tr>
<tr>
<td>2</td>
<td>Gray</td>
<td>Female, Old, Dead</td>
<td>S: 5.00 N: 15.22 C: 44.66 H: 6.30 O: 28.82</td>
<td>1:3.0</td>
</tr>
<tr>
<td>3</td>
<td>Gray</td>
<td>Female, Old, Dead</td>
<td>S: 4.74 N: 14.97 C: 43.96 H: 6.36 O: 29.97</td>
<td>1:3.2</td>
</tr>
<tr>
<td>4</td>
<td>Brown</td>
<td>Female, Young, Dead</td>
<td>S: 4.82 N: 14.85 C: 44.02 H: 6.55 O: 29.76</td>
<td>1:3.1</td>
</tr>
<tr>
<td>5</td>
<td>Brown</td>
<td>Female, Young, Dead</td>
<td>S: 4.49 N: 14.70 C: 44.83 H: 6.67 O: 29.31</td>
<td>1:3.3</td>
</tr>
<tr>
<td>6</td>
<td>Light</td>
<td>Male, Living, 22</td>
<td>S: 5.27 N: 15.31 C: 44.44 H: 6.62 O: 28.36</td>
<td>1:2.9</td>
</tr>
<tr>
<td>7</td>
<td>Light</td>
<td>Male, Living, 24</td>
<td>S: 5.69 N: 15.31 C: 44.41 H: 6.25 O: 28.34</td>
<td>1:2.7</td>
</tr>
<tr>
<td>9</td>
<td>Light</td>
<td>Male, Living, 23</td>
<td>S: 4.72 N: 14.93 C: 43.47 H: 6.11 O: 30.77</td>
<td>1:3.2</td>
</tr>
<tr>
<td>10</td>
<td>Brown</td>
<td>Male, Living, 27</td>
<td>S: 5.26 N: 15.56 C: 45.79 H: 6.37 O: 27.02</td>
<td>1:3.0</td>
</tr>
<tr>
<td>11</td>
<td>Dark brown</td>
<td>Male, Living, 25</td>
<td>S: 5.51 N: 15.18 C: 44.67 H: 6.66 O: 27.98</td>
<td>1:2.7</td>
</tr>
<tr>
<td>12</td>
<td>Red</td>
<td>Male, Living, 26</td>
<td>S: 6.07 N: 15.19 C: 45.18 H: 6.86 O: 26.90</td>
<td>1:2.6</td>
</tr>
<tr>
<td>13</td>
<td>Red</td>
<td>Male, Living, 26</td>
<td>S: 5.73 N: 15.11 C: 45.07 H: 6.66 O: 27.43</td>
<td>1:2.6</td>
</tr>
</tbody>
</table>

Average percentage composition of 13 samples of caucasian hair: S: 5.22 N: 15.19 C: 44.49 H: 6.44 O: 28.66 Ratio S:N: 1:2.9
ing first the sulphur determinations we are struck at once by the
general tendency of the percentage of sulphur in these samples
to be much higher than the percentage of sulphur in the hair of
any of the races already considered. The maximum percentage
for the series is 6.07 which was found in the hair (red) of a living
male twenty-six years of age, whereas the minimum percentage
for the series is 4.49 which was found in the hair (brown) of a
dead female of unknown age. This tendency for the higher per-
centages of sulphur to be found in the hair of the living males is
quite well marked as will be seen from an examination of the
table. This point is more fully discussed on p. 482. The fact
that each of the samples of red hair analyzed contained a higher
percentage of sulphur than any of the other samples of hair, all races
and sexes included is particularly worthy of note. The nitrogen
determinations, as a rule, are seen to be higher than they were in
the case of the negro hair and lower than were found in the indian
hair. The maximum percentage of nitrogen (15.84) is found in
the hair (gray) of a dead female of unknown age, whereas the
minimum percentage of nitrogen (14.70) occurs in the hair (brown)
of a dead female of unknown age. After examining the data for
the carbon we note that they follow the sulphur in showing the
same well marked tendency to be higher than the similar data
for the hair of any of the other races examined. The maximum
percentage of carbon is 45.79 which occurs in the hair (brown) of
a male twenty-seven years of age, whereas the minimum per-
centage (43.15) occurs in the hair (light) of a male twenty-one
years of age. There is no striking difference in the general
trend of the percentage of hydrogen in the specimens of cauca-
sian hair from the percentages as noted for the hair of the three
other races examined.

The average percentage composition of the thirteen samples
of the hair of adult caucasians is given at the bottom of Table
VI, p. 478. It will be noted that the average percentage of
sulphur for this variety of hair is higher than that of any of the
other varieties of hair examined. This value for caucasian hair
is 5.22 per cent and is followed in descending sequence by japan-
esese hair (4.96 per cent), negro hair (4.84 per cent) and indian
hair (4.82 per cent). The average percentage of nitrogen is 15.19,
a percentage which is exceeded only by the percentage of nitrogen
Chemical Composition of Hair

in the hair of the Indian (15.40). The similar data for negro hair is 14.90 per cent and for Japanese hair 14.64 per cent. In common with the data for the percentage of sulphur the average percentage of carbon in the hair of adult Caucasians is higher than that for the hair of the three other races considered, the Caucasian hair containing an average of 44.49 per cent of carbon and being followed in descending sequence by Indian hair (44.06), negro hair (43.85), and Japanese hair (42.99). The average percentage of hydrogen in the Caucasian hair is 6.44 and is higher than the percentage obtained for Japanese hair (5.91) and negro hair (6.37) but is lower than the average of hydrogen in Indian hair (6.53).

The ratio, S : N, undergoes more pronounced variations in the analyses of Caucasian hair than were observed in the data for the analyses of the hair of other races. This ratio varies from 1:3.5 to 1:2.5, the higher ratio being that obtained from the analytical data for the hair (brown) of a female of unknown age and the lower ratio being possessed by the hair (red) of a male, twenty-six years of age. The next lower ratio, 1:2.6, also occurs in connection with the red hair of a male twenty-six years of age. The ratios 1:2.5, 1:2.6 and 1:2.7 are lower ratios than were obtained for any of the specimens of hair of the other races. The average ratio for the thirteen samples of hair of Caucasian adults is 1:2.9 and is the same ratio as was determined for the hair of the full-blood male negroes and is lower than the average ratios for the hair of the Japanese (1:3.0) and the Indian (1:3.2).

From what has gone before it will be observed that the data for the average percentage composition of the thirteen samples of Caucasian hair show a well marked tendency for the average values to run higher for sulphur, carbon and hydrogen than the similar data for the hair of the other races mentioned. The percentage of nitrogen is also high, being exceeded alone by the percentage of nitrogen in Indian hair.

(b) Chemical composition of the hair of adult Caucasians as influenced by the color of the hair and the sex of the individual. Data showing the influence of the color of the hair and the sex of the individual upon the chemical composition of the hair may be found in Table VII, p. 481. The most striking point brought out in this table is the pronounced variation in the sulphur con-
<table>
<thead>
<tr>
<th>Sex</th>
<th>Color of Hair</th>
<th>Living or Dead Subject</th>
<th>AVERAGE PERCENTAGE COMPOSITION OF HAIR</th>
<th>Ratio S : N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>Gray</td>
<td>Dead</td>
<td>S</td>
<td>N</td>
</tr>
<tr>
<td>Female</td>
<td>Brown</td>
<td>Dead</td>
<td>4.89</td>
<td>15.34</td>
</tr>
<tr>
<td>Female</td>
<td>All specimens</td>
<td>Dead</td>
<td>4.66</td>
<td>14.77</td>
</tr>
<tr>
<td>Male</td>
<td>Light</td>
<td>Living</td>
<td>5.33</td>
<td>15.23</td>
</tr>
<tr>
<td>Male</td>
<td>Brown</td>
<td>Living</td>
<td>5.26</td>
<td>15.56</td>
</tr>
<tr>
<td>Male</td>
<td>Dark brown</td>
<td>Living</td>
<td>5.51</td>
<td>15.18</td>
</tr>
<tr>
<td>Male</td>
<td>Red</td>
<td>Living</td>
<td>5.90</td>
<td>15.15</td>
</tr>
<tr>
<td>Male</td>
<td>All specimens</td>
<td>Living</td>
<td>5.49</td>
<td>15.24</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.22</td>
<td>15.19</td>
</tr>
</tbody>
</table>

Average percentage composition of all specimens.....
Chemical Composition of Hair

tent of the samples analyzed. As will be seen by an examination of Tables I and III, pp. 464 and 469, the percentage variation in the amount of sulphur in the hair of the Indian and Negro is only about 0.5 per cent (0.48 per cent for Indian hair and 0.62 per cent for Negro hair), whereas here in the case of the hair of the Caucasian adults the percentage of sulphur varies from 4.66 per cent to 5.90 per cent, a variation of 1.24 per cent. The brown hair of dead females contains the smallest percentage (4.66) of sulphur, whereas the red hair of living males contains the largest percentage (5.90). Another very interesting point shown by the analyses is the high sulphur content of the hair of the males as compared with the hair of the females the average percentage of sulphur in the hair of the males being 5.49 and the similar datum for the hair of the females being 4.80. It must be remembered, however, that the hair of the females was all obtained from dead subjects whereas that of the males was taken from the living subjects. Unfortunately we have no data obtained from the analyses of the hair of living females or dead males for comparison. Work along these lines is contemplated. However, we are inclined to believe that the color of the hair, the age and sex of the individual as well as the condition of the individual when the sample of hair is obtained, i.e., living or dead, contribute to influence the chemical composition. From an examination of Table III, p. 469, it will be seen that the data there recorded seem to indicate that the samples of Negro hair obtained from the dead subjects contain rather less sulphur than those samples which were obtained from the living individuals of the same sex.

Considering the sexes separately we find that the highest percentage (4.89) of sulphur in the hair of the females is present in the samples of gray hair, and the lowest percentage (4.66) in the brown hair. In the case of the samples of hair from the males the minimum percentage (5.26) of sulphur is found in the brown hair and the maximum percentage (5.90), as already mentioned, occurs in the red hair.

An examination of the data for the percentages of nitrogen in the hair samples fails to reveal the pronounced and uniform variation between the specimens of hair of the two sexes which was observed in the case of the sulphur. However, the brown hair of the males contains the maximum percentage of nitrogen.
whereas the brown hair of the females contains the minimum percentage of nitrogen (14.77). Taking the average nitrogen values for each sex separately, however, we find that the males show an average nitrogen value of 15.24 per cent and the females show an average of 15.12 per cent. There are no noteworthy variations to be observed among the nitrogen data for the samples of caucasian hair.

The data for carbon and hydrogen follow the nitrogen in being devoid of any pronounced variations. The average percentage of carbon in the hair of the females is 44.44 and the similar value for the hair of the males is 44.52. In the case of hydrogen the agreement is much closer being 6.42 per cent and 6.44 per cent for the hair of the females and males, respectively.

The ratio, S:N, appears to run on a lower plane for the caucasian hair than for the specimens of hair obtained from the representatives of the other races mentioned. The ratio for the hair of the females is uniformly 1:3.1, whereas the ratio for the hair of the males varies from 1:2.6 to 1:3.0 the minimum ratio occurring in connection with the red haired individuals and the maximum ratio occurring in connection with the brown haired individuals. Comparing the individuals by sex it will be seen that the average ratio for the females is 1:3.1 and the average ratio for the males is the rather lower ratio 1:2.8. It has already been pointed out that the percentage of nitrogen in the hair of the two sexes does not vary to any considerable degree, therefore this rather wide variation in the ratio, S:N, shown by the data for the analyses of the specimens of hair of the two sexes must be due, almost entirely, to the pronounced and uniform tendency of the hair of the males to contain a quantity of sulphur notably in excess of that contained in the hair of the females.

(c) Chemical composition of the hair of caucasian children. Seven samples of this variety of hair were analyzed, six of them being from females. Three of the samples from females were composite samples made up of from four to twelve different specimens of hair, the single sample of male hair was also a composite sample, being composed of hair from nine different individuals. Those from whom the various specimens of children's hair were obtained ranged from two and one-half to twelve years of age. Analytical data for these samples of hair
Chemical Composition of Hair

may be seen in Table VIII, p. 485. Taking the table as a whole the most notable feature is the somewhat lower values obtained for the various constituents of the hair as contrasted with the similar data (Table VI) for the hair of the Caucasian adults. This point is especially to be noted in the data for sulphur, nitrogen and carbon.

An examination of the data for sulphur fails to show any such variation according to the sex as is shown in the examination of the hair of adults (Table VI). In the case of the children we observe that the sulphur values range from 4.77 per cent to 5.10 per cent, a difference of only 0.33 per cent as contrasted with a variation of 1.24 per cent which is noted in the discussion of the data from the analyses of the hair of adults. Here for the first time we find the sulphur content of the hair of the male to be lower than that of the female. In all the other tables, as will be seen by an examination, the data show the females to possess hair of a lower sulphur content than that of the males. With the Caucasian children, however, this order is reversed and the lower sulphur content is shown to be possessed by the hair of the males. It should be mentioned, however, that this conclusion is based upon the analysis of a single sample of boys' hair and that further analyses of other specimens of hair may serve to show the average sulphur content of such samples to be higher than that of the samples of hair from the females and thus conform with the data of the analyses of the samples of hair of individuals of other races. However, the dependability of the data from the analysis of this single sample is enhanced from the fact that it was a composite sample containing hair from nine different individuals ranging from three to seven years of age. Another point to be borne in mind, in this connection, is the fact that the samples of hair under consideration were obtained from individuals much younger than those from whom the other samples of hair were obtained. It may therefore be possible that the relative chemical composition of the hair changes with the development of the individual and that in childhood the hair of the male may contain less sulphur than that of the female, but that the condition is reversed with the maturing of the individual and that later in life the hair of all races would show uniformity in that the hair of the male would contain the larger percentage of sulphur. It will be
### Table VIII. Chemical Composition of the Hair of Caucasian Children.

<table>
<thead>
<tr>
<th>No. of Sample</th>
<th>Color of Sample</th>
<th>Description of Subjects</th>
<th>Percentage Composition of Hair</th>
<th>Ratio S : N</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Auburn</td>
<td>Girl 7</td>
<td>4.80 14.56 43.87 6.26 30.51</td>
<td>1 : 3.0</td>
<td>Composite sample, 4 specimens.</td>
</tr>
<tr>
<td>2</td>
<td>Dark brown</td>
<td>Girl 7</td>
<td>5.05 14.68 44.34 6.66 29.27</td>
<td>1 : 2.8</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Dark brown</td>
<td>Girl 8</td>
<td>5.10 14.64 41.66 6.18 32.43</td>
<td>1 : 2.9</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Dark brown</td>
<td>Girls 6 to 9</td>
<td>4.83 14.38 43.21 6.90 30.68</td>
<td>1 : 3.0</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Dark brown to red</td>
<td>Girls 4 to 12</td>
<td>5.03 14.52 43.26 6.57 30.62</td>
<td>1 : 2.9</td>
<td>Composite sample, 12 specimens.</td>
</tr>
<tr>
<td>6</td>
<td>Light brown to dark brown</td>
<td>Boys 3 to 7</td>
<td>4.77 14.76 43.56 6.22 30.69</td>
<td>1 : 3.1</td>
<td>Composite sample, 9 specimens.</td>
</tr>
<tr>
<td>7</td>
<td>Light</td>
<td>Girls 2 to 9</td>
<td>4.93 14.51 42.72 6.40 31.44</td>
<td>1 : 3.0</td>
<td>Composite sample, 9 specimens.</td>
</tr>
<tr>
<td></td>
<td>Average percentage composition of 7 samples of children's hair.</td>
<td>4.93 14.58 43.23 6.46 30.80</td>
<td>1 : 3.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
remembered that Mohr\textsuperscript{1} found a lower percentage of sulphur in the hair of a boy of four than in the hair of a girl of nine.

Two striking points are brought out in connection with the data for nitrogen, as shown in Table VIII, p. 485. It will be noticed that the nitrogen percentage in these samples of hair is uniformly lower than that of any of the other forms of hair examined, those forms of hair most nearly approaching it in point of nitrogen content being the hair of the Japanese and the negro. The second point of interest is the close agreement in the data for the nitrogen content of the various samples. The minimum percentage of nitrogen (14.38 per cent) is found in the composite sample of the dark brown hair of girls who were from six to nine years of age, and further, this is not only the minimum percentage of nitrogen for the hair of Caucasian children but for each of the varieties of hair investigated. The maximum percentage of nitrogen (14.76) is found in the composite sample of the brown hair of boys who were from three to seven years of age. The close agreement of the nitrogen values obtained from the various samples is shown by the fact that the maximum variation is only 0.38 per cent, i.e., from 14.38 per cent to 14.76 per cent. This actual difference is very little larger (0.05 per cent) than that observed in the case of sulphur, and when calculated upon the basis of the total amount of sulphur and nitrogen present in the hair the difference between the variation in the nitrogen values is only a little over one-third as great as the variation in the sulphur values. The data for carbon do not show the uniformity observed in the case of nitrogen and sulphur. The values vary from a maximum of 44.34 per cent for the dark brown hair of a girl, seven years of age, to a minimum of 41.65 per cent for the dark brown hair of a girl three years of age. The data for hydrogen also fails to show any particular uniformity. The minimum percentage of hydrogen (6.18) is found in the sample of hair containing the least amount of carbon, i.e., the dark brown hair of a three year old girl; whereas the maximum percentage of hydrogen (6.90) is found in the composite sample of the hair of girls who varied in age from six to nine years.

The ratio, \(S : N\), is rather uniform varying only from 1:2.8 to

\textsuperscript{1} Mohr: \textit{Loc. cit.}
1:3.1. The minimum ratio is possessed by the dark brown hair of a seven year old girl, and the maximum ratio is possessed by the hair of the boys.

The average percentage composition for the whole number of samples of children's hair analyzed is given at the bottom of Table VIII, p. 485. It will be noticed that the average percentage sulphur content (4.93) is the same as that determined for the light hair of girls who were from two and one-half to nine years of age. The average percentage of nitrogen (14.58) is practically duplicated (14.56) by the data from the analysis of the auburn hair of the seven year old girl. The average percentage of carbon (43.23) is in very close agreement with the carbon value obtained from the analysis of the samples of hair obtained from girls from four to twelve years old, whereas the average hydrogen value (6.46 per cent) agrees quite closely with the similar data for the analysis of the light hair of girls two and one-half to nine years of age. The average ratio, S : N (1:3.0), is duplicated by three different samples of hair as will be seen by referring to the tabulated data.

(d) Chemical composition of the hair of caucasian children as influenced by the color of the hair and the sex of the child. The data for consideration here will be found in tabular form in Table IX, p. 488. An examination of this table will reveal the fact that the variations among the data for the several specimens of hair analyzed are not so great in the case of caucasian children as were noted in the consideration of the hair of the caucasian adults (see Tables VI and VII, pp. 478 and 481), particularly as far as sulphur and nitrogen are concerned. In Table IX we see the maximum percentage of sulphur (5.00) is found in the brown hair of the girls while the minimum percentage (4.77) is found in the hair of the same color obtained from the boys. Of the hair of the females the auburn variety contains the lowest percentage of sulphur (4.80) while the brown hair contains the maximum amount (5.00 per cent) of the element. An examination of the data for the content of nitrogen reveals the fact that the samples of female hair contain amounts of nitrogen which are closely comparable, whereas the specimen of male hair contains rather more of the element. In this connection it is interesting to note that the brown hair of the boys contains the largest
amount of nitrogen (14.76 per cent) as well as the smallest amount (4.77 per cent) of sulphur. The data for the carbon content of the various samples analyzed do not run uniformly with either sulphur or nitrogen but show the maximum percentage (43.87) to be present in the auburn hair of a girl seven years of age and the minimum percentage (42.72) to be present in the light colored hair of girls ranging in age from two and one-half to nine years.

TABLE IX. CHEMICAL COMPOSITION OF THE HAIR OF CAUCASIAN CHILDREN AS INFLUENCED BY THE COLOR OF THE HAIR AND THE SEX OF THE CHILD.

<table>
<thead>
<tr>
<th>Subjects.</th>
<th>Color of Hair</th>
<th>Average Percentage Composition of Hair.</th>
<th>Ratio S : N</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girl</td>
<td>Auburn</td>
<td>4.80 14.56 43.87 6.26 30.51</td>
<td>1 : 3.0</td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>Brown</td>
<td>5.00 14.56 43.12 6.57 30.75</td>
<td>1 : 2.9</td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>Light</td>
<td>4.93 14.51 42.72 6.40 31.44</td>
<td>1 : 3.0</td>
<td>Composite sample of 9 specimens.</td>
</tr>
<tr>
<td>Girls</td>
<td>(All specimens)</td>
<td>4.96 14.55 43.18 6.49 30.82</td>
<td>1 : 3.0</td>
<td>Composite sample of 9 specimens.</td>
</tr>
<tr>
<td>Boys</td>
<td>Brown</td>
<td>4.77 14.76 43.56 6.22 30.69</td>
<td>1 : 3.1</td>
<td></td>
</tr>
</tbody>
</table>

Average percentage composition of all samples of children’s hair............. 4.93 14.58 43.23 6.46 30.80 1 : 3.0

TABLE X. AVERAGE PERCENTAGE COMPOSITION.

<table>
<thead>
<tr>
<th>Subject.</th>
<th>Percentage Composition of Hair.</th>
<th>Ratio S : N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S</td>
<td>N</td>
</tr>
<tr>
<td>Indian</td>
<td>4.82</td>
<td>15.40</td>
</tr>
<tr>
<td>Japanese</td>
<td>4.96</td>
<td>14.64</td>
</tr>
<tr>
<td>Negro</td>
<td>4.84</td>
<td>14.90</td>
</tr>
<tr>
<td>Caucasian (adults)</td>
<td>5.22</td>
<td>15.79</td>
</tr>
<tr>
<td>Caucasian (children)</td>
<td>4.93</td>
<td>14.58</td>
</tr>
</tbody>
</table>

Hydrogen, on the other hand, resembles sulphur in being present in largest amount (6.57 per cent) in the brown hair of girls and in smallest amount (6.22 per cent) in the brown hair of boys. The ratio, S : N, runs from 1 : 2.9 to 1 : 3.0 for the hair of the females while the male subjects show the slightly higher ratio, 1 : 3.1.

It is interesting to note the close agreement between the results of the analyses of the hair of the caucasian children and the hair
of the Japanese. This is shown clearly by a comparison of the
data for the Japanese hair, as given in Table V, with the average
data for the children's hair as given in Tables VIII or IX.

VI. CONCLUSIONS.

The data obtained from the analyses of specimens of hair from
the representatives of various races indicate that the chemical
composition of the hair is influenced by six factors, as follows:

(1) Race of the individual.
(2) Sex of the individual.
(3) Age of the individual.
(4) Color of the hair.
(5) Purity of breeding of the individual.
(6) Whether the hair sample was obtained from a dead or liv-
ing person.
A STUDY OF THE COMPARATIVE CHEMICAL COMPOSITION OF THE HAIR OF DIFFERENT RACES
Thomas A. Rutherford and P. B. Hawk


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