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DETERMINATION OF THE DEPTH OF THE MILKY WAY.

BY T. J. J. SEE.

(Read January 5, 1912.)

INTRODUCTORY REMARKS.

The problem of determining the depth of the Milky Way, as accurately as possible, is one which has now engaged my attention for over twenty years, and I will therefore take this occasion to bring together the results at which I have arrived, partly because they are of high general interest, and partly because the progress thus made will prove instructive as to the methods which must be adopted for the measurement of the distances of the most remote objects of the sidereal universe. Here we have to deal with distances so immense that the method of annual parallaxes, commonly used for the stars comparatively near the sun, utterly fails; and recourse must be had to other methods which will serve for the greatest distances to which our modern giant telescopes can penetrate.

Alpha Centauri, the nearest of the fixed stars, was also the first to be successfully measured for parallax, by Thomas Henderson, of the Cape of Good Hope, in 1831; but the work was not reduced till January, 1839, and meanwhile Bessel had measured the parallax of 61 Cygni in 1838 and promptly published the result of his triumph.

Of late years astronomers have given greatly increased attention to the question of the distances of the stars, and systematic campaigns of the most laborious kind have been carried on by Gill; Elkin and Chase, of Yale; Kapteyn, of Groningen; and Schlesinger, at the Yerkes Observatory, Chicago. Some 350 stars have now been studied by the standard method of parallaxes, and for most of these objects, perhaps about 200 in number, fairly satisfactory data have been deduced; but the method can be extended only to stars within less than 100 light-years of our sun, and is therefore very limited in its applicability, owing to the small diameter of the earth's orbit, and the insensible effects of the annual displacements resulting from the orbital motion of our planet. As nature herself has fixed the limits of this method, astronomers have naturally cast about for other methods of greater generality and have finally developed processes of surprising power, of which an account will be given in the present paper.

§ 1. Outline of the Methods Adopted.

Among previous investigators who have occupied themselves with the difficult problem of the profundity of the Milky Way the first place will be universally assigned to the incomparable Sir William Herschel, who extended his researches over many years, and reached results which were for a time accepted, but have been rejected for three quarters of a century, and yet are now proved to be essentially correct. It is very remarkable and exceedingly unfortunate that Herschel's conclusions have been generally rejected by his son, Sir John Herschel, and other astronomers during the past seventy-five years. But before discussing the circumstances which led to this outcome I shall recall the modern attempts at the solution of the problem of determining distances in the Milky Way.

After the spectroscope came into use and Huggins had applied Doeppler's principle to the motion in the line of sight (1868) it was pointed out by Fox Talbot in 1871 (Brit. Assoc. Report, 1871, p. 34, Pt. II.) that the possibility existed of determining the absolute dimensions of the orbit of a pair of binary stars which had a known angular dimension in the sky, and thus parallaxes might be found of systems very remote from the earth. In 1890, while a post-graduate student at the University of Berlin, I developed this method still further, and showed how it could be used also to test the accuracy of the law of universal gravitation in the stellar systems. The spectroscopic method then outlined was brought to more general form in 1895, and it at once occurred to me to point out its use for measuring the distance of clusters in the Milky Way (A. N. 3,323), as more certain than Herschel's method of star gauges.

Our age is one of rapid improvement in all scientific processes, and during the past sixteen years naturally much progress has been made in double-star astronomy, as well as in our knowledge of nebulæ and clusters. On looking more closely into the spectroscopic method, which in 1895 had been shown to be applicable to objects 1,000 light-years from the sun, and might thus include all suitable double stars within this sphere, I became convinced that while it is a great theoretical advance over the old method of parallaxes, it still is quite inadequate for finding the distances of the most remote objects in the sidereal universe. Accordingly in 1909 I returned to the improvement of Herschel's method as the most promising, for the determination of the distances of *the most remote objects*. Here are the grounds for this decision:

1. It was noticed, as remarked by Burnham, that revolving double stars are rare, if not unknown, in clusters, and among the star-clouds of the Milky Way—not because such systems are not present in these masses of stars, but because they cannot be separated, owing to the great distances at which these masses of stars are removed from us.

2. When double stars cannot be clearly separated in the telescope they cannot be used for parallax by the spectroscopic method; and thus the spectroscopic method, while having a wider range of application than the method of parallaxes, in something like the ratio of the size of the double star orbit to that of the orbit of the earth, is yet applicable only to stars within about 1,000 light-years of our sun.

3. It will be shown below that the most remote stars are separated from us by a distance of at least 1,000,000 light-years, and as this space is a thousand times that to which the spectroscopic method may be applied, it follows that there is no way of fathoming these immense distances except by the improvement of the method of Herschel.

And just as in my "Researches on the Evolution of the Stellar Systems," Vol. II., 1910, p. 638, I had been able to adduce substantial grounds for returning to the vast distances calculated by Herschel, so also during the past year I have been able to add to the proof there brought forward, and will proceed to develop it in the present paper.

§ 2. Herschel's Method Depending on the Space Penetrating Power of Telescopes.

In his celebrated star gauges Herschel employed a twenty-foot reflector of 18 inches aperture, and calculated the space-penetrating power of such an instrument from the ratio of the aperture of the telescope to that of the pupil of the eye. The comparative distance to which a star would have to be removed in order that it may appear of the same brightness through the telescope as it did before to the naked eye may thus be calculated. Herschel found the power of this 20-foot reflector to be 75; so that a star of 6th magnitude removed to 75 times its present distance would therefore still be visible, as a star, in the instrument.

Admitting such a 6th magnitude star to give only a hundredth part of the light of the standard first magnitude star, it will follow that the standard star could be seen as a sixth magnitude star at ten times its present distance; and if we then multiply by the space penetrating power, we get 750 as the distance to which the standard star could be removed and still excite in the eye, when viewed through the telescope, the same impression as a star of 6th magnitude does to the naked eye. Thus if Alpha Centauri be distant 4.5 light-years, it would be visible in Herschel's telescope at a distance of 3,375 light-years. This is about the distance ascribed to the remoter stars of the Milky Way by Newcomb and many other modern writers; but of course it is much too small, for the following reasons:

(*a*) Newcomb and other astronomers cite the possibility of some of the stars being as much as 1,000,000 times brighter than the average solar star, and in that case the star might be seen at $\sqrt{1,000,000} = 1,000$ times that distance, or 3,375,000 light-years, with an instrument having a space penetrating power no greater than that employed by Herschel, provided that no light is extinguished in its passage through space.

(*b*) If the telescope be more powerful than Herschel's 20-foot reflector, the light gathered will be increased in the ratio of $x^2/(18)^2$, where $x =$ diameter of mirror; and for the 60-inch reflector at Pasadena, $x = 60$, over nine times as much light could be gathered, or stars seen over three times as far away. Thus if the stars have only about 10,000 times the luminosity of the sun, they could still be seen with the Pasadena reflector at a distance of over a million light-years. For 3,375 l.-y. $\times$ 3 $\times$ 100 $=$ 1,012,500 light-years.

(*c*) The sensitiveness and accumulative effects of the photographic plate, will enable us to extend our sounding line still further out into space by some three magnitudes, or four times the distance; and thus with a modern 60-inch reflector we could photograph stars at a distance of about four million light-years, if they have 10,000 times the standard solar luminosity, and no light is lost in space. How much light is really lost in space will be considered later, but it may be stated here that it probably is decidedly less than was concluded by Struve.

§ 3. Independent Calculation of the Distance of the Remotest Stars of the Helium Type.

From the data given in *Lick Observatory Bulletin* No. 195, we find that 225 helium stars employed by Campbell in his line of sight work have an average visual magnitude of 4.14. Of the four variables given in this *Bulletin*, we have used the maximum brightness in three cases, because they are of the algol type. In the case of u Herculis, we have used the mean magnitude, because the type of variable does not appear to be as yet well established.

Here then we have 225 helium stars at an average distance of about 540 light-years. For in *Lick Observatory Bulletin* No. 195, p. 121, Campbell finds the 180 class B, or helium, stars to have an average distance of 543 light-years, while in *Publications of the Astronomical Society of the Pacific* for June–August, 1911, p. 159, Professor Curtis gives 534 light-years as the average distance of 312 helium stars. The former distance for 180 stars being greater than the latter distance for 312 stars, we may take 540 light-years as the distance of the 225 helium stars here under discussion, the average magnitude of which is 4.14.

If the average magnitude were decreased to 21.14, by removal to 2,512 times their present distance, which would reduce the average brightness by 17 magnitudes, the distance of the stars would be multiplied by 2,512, and become 1,356,480 light years. This is for the helium stars as they are, without any hypothesis as to brightness, or as to the extinction of light in space, which will be considered later.

The question will naturally be asked whether helium stars really exist at these great distances. We may unhesitatingly affirm that they do, because of the well-known whiteness of the small stars of the Milky Way. It is true that Pickering has investigated the distribution of the helium stars in the *Harvard Annals,* Vol. 56, No. II., and Campbell quotes these data in *Lick Observatory Bulletin* No. 195 as showing that the helium stars are all bright objects. Pickering believed his tabulations to indicate "that of the bright stars, one out of four belongs to this class (B), while of the stars of the sixth magnitude there is only one out of twenty; and that few if any would be found fainter than the seventh or eighth magnitude." The implication here is that no helium stars exist at very great distances corresponding to small magnitudes; but of course such a view is untenable.

It probably is true that the group of helium stars at a distance of some 540 light-years from our sun, and thus comparatively near us, does cease after a certain faintness and distance has been reached; but is equally certain that other clusters or clouds of helium stars recur at greater distances, among the millions of small white stars constituting the Milky Way. For as Herschel long ago noticed the Galaxy is everywhere observed to traverse the circuit of the heavens in a *clustering stream;* and our view of it from the region of the sun is not essentially different from the view that could be obtained from other points in this starry stratum. Add to this consideration the fact of the well-known whiteness of the small stars in the Milky Way, and we are authorized to conclude that an indefinite number of clusters or groups of helium stars will be found in the Milky Way, and thus such stars will certainly exist at the greatest depths to which our giant telescopes can penetrate.

We must therefore be on our guard against the superficial view, that because the helium stars near the sun fade away as the sixth magnitude is approached, other groups of stars of this type do not occur at greater distances. The typical whiteness of the millions of small stars which make up the Milky Way, and the clustering character of that magnificent collection of stars, alike forbid any such inference.

Herschel had the correct view of the constitution of the Galaxy a century ago. Unfortunately his works have been very inaccessible, and are so little used that many erroneous conceptions have been given currency by more superficial investigators. It is impossible to commend too highly the movement now on foot in England to reissue the collected works of Sir William Herschel. In all that pertains to the sidereal universe as a whole he is easily the greatest of all modern astronomers, and will always remain unrivaled.

§ 4. Explanation of the Methods Employed by Campbell for Finding the Average Distance of the Group of Naked Eye Helium Stars.

This is essentially a combination of the line of sight motion as found at Lick Observatory, with the proper motions resulting from observations with the meridian circle, by many observers, as worked up by Boss of the Dudley Observatory, Albany, New York. By the recent study of several thousand of the brighter stars included in his Preliminary General Catalogue, Professor Boss has deduced their proper motions with a high degree of accuracy. Campbell found from 180 of these stars resembling our sun in spectral type that their average cross proper motion in the sky, from the values derived by Boss, was about 0.11 second of arc per annum, while at the same time their average speed in the line of sight shown by the spectrograph at Lick Observatory was 8.9 miles per second, or two hundred and eighty million miles a year. Having the average motion in the line of sight, in absolute units, and the average cross proper motion in seconds of arc, it is easy to find how far away a base line of 280 million miles would have to be to subtend an angle of 0.11 of a second of arc. It turns out to be ninety-two light-years.

In this way it is possible to get the average distances of large groups of stars. Here are some of the results found by Campbell.

Type.	No.	Average Yearly Cross-motion.	Average Radial Velocity in Miles per Second.	Average Relative Parallax.	Average Distance in Light-years.
$B-B_5$	312	0."0078	3.9	0."0061	534
B_8-B_9	90	0.0182	4.2	0.0129	253
A	172	0.0368	6.5	0.0166	196
F	180	0.1075	8.9	0.0354	92
G	118	0.0748	9.9	0.0223	146
K	346	0.0516	10 4	0.0146	223
M	71	0.0384	10.6	0.0106	308

This table contains the most important results of the Campbell-Boss method of obtaining average distances for large groups of stars. It need scarcely be remarked that its significance can hardly be overrated. But whilst the *average values* given are quite trustworthy, the method is of course inapplicable to the *individual stars;* and if their distances are to be found recourse would have to be had to the standard method of parallaxes, or to the spectroscopic method in the case of visual binaries.

§ 5. Some of the Distances of the Remotest Stars as Heretofore Calculated by Astronomers.

1. Sir William Herschel, *Phil. Trans.*, 1802, p. 498, "almost 2,000,000 light-years."
2. Sir John Herschel, "Outlines," edition of 1869, p. 583, "upwards of 2,000 light-years."
3. Guillemin, "The Heavens," trans. by Lockyer, 1867, p. 433, "upwards of 20,000 light-years."
4. Bartlett, "Spherical Astronomy," 1874, p. 149, "upwards of 2,437.5 light-years."
5. Newcomb, "Popular Astronomy," edition of 1878, p. 481, "about 14,000 light-years" (for the Herschel stars).
6. Clerke, "System of the Stars," 1890, p. 314, "less than 36,000 light-years."
7. Ranyard, "Old and New Astronomy," 1892, p. 748, "less than 70,000 light-years."
8. Young, "General Astronomy," edition of 1904, p. 563, "10,000 to 20,000 light-years."
9. Newcomb, "The Stars," 1908, p. 319, "at least 3,000 light-years."
10. See, "Researches," Vol. II., 1910, p. 638, "4,500,000 light-years."

From this table it will be seen that there was a great falling off in the distances following the epoch of Sir William Herschel; and that the present writer was the first to recognize the fallacy of the recent estimates of distance, and to restore the large values used by that unrivaled astronomer one hundred and ten years ago. Here we have a good illustration of the retrogradation of opinion in astronomy, under the cultivation of inferior genius. Sir John Herschel's preference for such small distances over the large values used by his father is indeed remarkable and very regrettable. Evidently the small value used by Newcomb is simply an echo of the reduction in distance made by Sir John Herschel. The absurdity of these small values—not over five times that of the helium stars of 4.14 magnitude investigated at Lick Observatory—ought to impress us with the small importance to be attached to any opinion merely because it is currently accepted. Thus we have a clear case of misleading tradition transmitted from the second Herschel, and the amazing spectacle of the whole world using values about a thousand times too small, for the greater part of a century, in times which were supposed to be very enlightened! Strange indeed that the correct work of the great Sir William Herschel should have been neglected all this time! Will it seem credible to future ages that such a remarkable retrogradation of opinion could have occurred and persisted during the nineteenth and twentieth centuries? If so, it must be attributed to the narrowing effects of extreme specialization, which, with the advance of science, has been difficult to avoid in our time, and yet is utterly disastrous to the growth of true natural philosophy as the study of nature in the widest sense.

§6. Other Methods for Confirming the Great Depth of the Milky Way.

(*a*) The girdle of helium stars about our sun, according to the Lick determination, has a mean distance of 540 light-years, or a mean diameter of 1,080 light-years. If this be one twentieth of the average thickness of the Milky Way stratum, as one may infer from the appearance of certain clusters in the constellation Sagittarius, which are near enough to be studied intelligently, then we have 21,600 light-years for the average thickness of the Milky Way.

Now when we traverse the Milky Way from Centaurus to Cepheus, over an arc of 180° in length, the central band appears to the naked eye to have a width of 3° or 4°, as was long ago remarked also by Herschel and Struve. This is an extension along the circle of the Galaxy of about 60 times its thickness. If then the thickness be 21,600 light-years, the double depth of the stratum in both directions becomes about two thirds of $21,600 \times 60 = 864,000$ light-years. And if only the faint or distant telescopic stars be considered, the width of their belt of distribution is narrower, and the depth would be found several times greater yet. Wherefore it seems certain that the profundity of the Milky Way, considerably exceeds a million light-years, and may be several times that depth.

(*b*) Accordingly if we make the very moderate hypothesis that the width of 3° or 4°, which was also noticed by Herschel and Struve, represents chiefly the nearer portion of the Galaxy; and that the remoter portion has a width not exceeding 1°, we should conclude that the depth may be found by multiplying the thickness or apparent angular width of 21,600 light-years by the number of degrees in the radius, 57.3. This gives for the depth 1,237,680 light-years, and this value might be considerably increased by adjustments in the data which are not improbable.

(*c*) In addition to these general arguments, founded on the principles of geometry, we might introduce another based on actual measurement. The Lick helium stars, of average brightness 4.14 mag., were found to have an average distance of 540 light-years. If they were brought near enough to us to appear of 1st magnitude, this distance would have to be divided by $4 = \sqrt{(2.512)^3}$, and thus we find for the first magnitude helium stars a distance of 135 light-years.

Now in calculating the plan of the construction of the heavens, from the apparent breadth of the Milky Way, Herschel arrived at the conclusion that the thickness of the stratum is about 80 times greater than the diameter of the sphere including the first magnitude stars represented by Sirius (*Phil. Trans.*, 1785, p. 254). And if the average distance of these stars be taken as 135 light-years, the mean diameter of the shell in which they are included will be 270 light-years. This would give exactly 21,600 light-years for the thickness of the stratum of the Milky Way, as before.

It is true that Herschel classed all first magnitude stars in one group, and took no account of the fact that the helium stars are the more remote and the more brilliant; yet regarding the Galaxy as a stratum of stars chiefly of the helium type, which certainly is true of all the more distant portions of that magnificent collection of stars, we may consider the reasoning of this great astronomer as still valid. And the argument in regard to the depth of the Milky Way is thus the same as that given above under (*a*) and (*b*).

§ 7. The Effects of the Extinction of Light in Space.

This problem has been treated with some detail in the 23d chapter of my "Researches," Vol. II., 1910, but we shall here examine the subject with greater care, especially as to the most probable average value of the coefficient of extinction. The light was shown by Struve to be defined by the equation

$$\xi = \frac{1}{x^2}(0.990651)^{x-1}, \tag{1}$$

where x is the distance of the star, in units of $\Delta = \sqrt{(2.512)^n}$ and n is the difference in magnitude. At very great distances nearly all the light is cut off, and it therefore becomes a question of high importance to determine as accurately as possible the proper value for the coefficient of extinction.

Struve's value, used in the above formula, seems to be too large, and I have therefore calculated a new table, to show the effect of decreasing the coefficient. In justification of this course it should be recalled that Sir William Herschel ignored extinction entirely; but while this procedure obviously is defective, it is pretty clear, from the aspects of the Milky Way as now made known by modern research, that Struve's coefficient is decidedly too large. The following table shows the effects of varying the coefficient, upon stars 17 magnitudes fainter, corresponding to a distance 2,512 times larger, where $x - 1 = 2{,}511$.

Table for Varying Coefficient of Extinction.

λ = Coeff. of Extinction.	λ^{x-1}.	Fractional Part of Light Transmitted, in Spite of Extinction.
0.990651	0.000,000,000,05709	$\frac{1}{17514\ 000\ 000}$ (Struve's value)
0.995	0.000,003,4072	$\frac{1}{293\ 490}$
0.996	0.000,042,571	$\frac{1}{23490}$
0.997	0.000,52923	$\frac{1}{1889.5}$
0.998	0.006,5567	$\frac{1}{152.51}$
0.999	0.081,091	$\frac{1}{12.332}$ (See's value)
0.9995	0.284,846	$\frac{1}{3.5107}$
1.00000	1.000,00	1.00000 (Herschel's value)

From the study of this table, we perceive that at the distance

$x = 2{,}512$, corresponding to an enfeeblement of 17 magnitudes, from mere increase of distance alone, the extinction of light varies from almost total loss, with Struve's coefficient, to no loss whatever, on Herschel's tacit hypothesis of zero extinction. This latter view, however, certainly is extreme, and probably all modern astronomers agree that there is extinction of light due to cosmical dust in space. A hazy background of dust is shown on the photographs of the Milky Way and other portions of the sky, and proved to pervade the solar system by the universal prevalence of meteors.

Since, however, both comets and nebulæ are found to be extremely tenuous bodies, and observed to transmit the light of stars with but excessively slight enfeeblement, it is obvious that the general extinction will be much smaller still, but yet appreciable. I have therefore adopted a coefficient of 0.999, about one hundredth larger than Struve's, as best harmonizing all known phenomena. This value, it is true, is much nearer to Herschel's than to Struve's coefficient, yet it admits an extinction of light which becomes appreciable at great distances, while for moderate distances it is nearly insensible; and I believe this to correspond closely with all the known facts of the sidereal universe.

An enfeeblement of one twelfth at a distance appropriate to stars 17 magnitudes fainter, could easily be compensated for by a corresponding abnormal brilliancy of the remotest stars, which on several grounds seems to be highly probable. Thus our procedure involves no extravagant assumptions as to the great brightness of the most distant stars, or as to large extinction of light, while on the other hand it avoids Herschel's tacit hypothesis of zero extinction, which certainly is unjustifiable.[1]

[1] In an important paper read to the Bavarian Academy of Sciences, June 10, 1911, p. 459, Professor H. von Seeliger likewise reaches the conclusion that the absorption is very small, amounting to 0.34 of a magnitude at 780 times the distance of Sirius, which Seeliger takes for the border of the sidereal system.

§8. A Graphical Method for Determining the Depth of the Galaxy, Based on the Study of Clusters.

1. Make a diagram of 10 or 20 concentric circles, separated by equal intervals, each corresponding to 100 million light-years. In this scheme no clusters will be included within the central circle, because the actual measurements for parallax have excluded this possibility. But the various clusters of the N.G.C. may be plotted within the outer circles, or beyond them all, according to the results given by Herschel's rule of brightness.

2. It is required therefore to locate the clusters, and to indicate their apparent angular diameters by dots of appropriate size. Some allowance must of course be made for the varying stages of development of the different clusters, but if there is a decreasing angular diameter with distance it may be held that the method of estimating distance devised by Herschel is essentially valid, and in fact our only method of fathoming these immense distances, and thus determining the depth or profundity of the Milky Way.

3. A careful attempt has been made to apply this method, using the data of the N.G.C., and the results of the Crossley photographs recently obtained at Lick Observatory. The results of this investigation are shown to confirm the present theory.

§9. Final Test of the Indefinite Extension of the Milky Way Desirable.

This should be made by the graphical method just outlined, but by means of more powerful instruments than any yet systematically employed in this work. To feel satisfied that the universe extends on indefinitely, we must have proof of additional clusters of stars of smaller magnitude, and more compressed constitution, as from the narrowing effect of perspective, at great distances. Probably we shall not know what the sidereal heavens contain in the way of *vanishing clusters* till the Milky Way is systematically photographed for just such objects, and this very likely will require a long campaign of photographic research with a large instrument. But as many large reflectors are now coming into use, we may hope for it before many years elapse. This would be completing on a modern scale the sidereal soundings left somewhat incomplete by the systematic explorations of the Herschels.

In a private letter, written in response to my recent inquiry regarding the power of the 60-inch reflector of the Solar Observatory at Mt. Wilson, Professor W. S. Adams, the Acting Director, informs me that this fine instrument probably will show visually stars as faint as 18th magnitude. He points out, however, that the magnitude scale is not well defined for such faint objects, and that very few astronomers have enough experience to fix it at the present time.

Adams also informs me that from a photograph of the region of the northern celestial pole of four hours' duration, Professor E. C. Pickering has derived a value of 21.0 magnitude for the faintest stars, by the system of photographic magnitudes in use at the Harvard College Observatory. Obviously there is some uncertainty in this value, but it probably is not extreme.

In answer to an inquiry as to the possibility of getting still fainter stars by prolonging the exposure, Professor Adams assures me that it can be easily done, the only limit being the brightness of the background of the sky; but that with the clear air of Mt. Wilson this would not be reached till the exposure had extended over many hours. He adds that it takes about three times the exposure to obtain a star one magnitude fainter. From the data here supplied it seems certain that stars as faint as 21.0 magnitude may be photographed at Mt. Wilson, with the 60-inch reflector, and that by prolonging the exposure several additional hours or through whole nights, stars of 22.0 magnitude probably could be obtained.

It is therefore well established that stars 17 magnitudes fainter than the 225 helium stars, with average magnitude of 4.14, recently investigated at Lick Observatory, may now be photographed with more than one instrument; and the value of $\Delta = 2{,}512$ used in our calculations is amply justified. In fact it seems probable that instead of 2,512 as our distance multiplier for stars 17 magnitudes fainter, we might have used the larger value 3,981, corresponding to stars 18 magnitudes fainter than our 225 helium stars with average magnitude of 4.14. This would almost have doubled the calculated depths of the Milky Way throughout the foregoing discussion, and given us over two million light-years, exceeding the profundity originally concluded by Herschel in 1802. In the *Phil. Trans.* for 1800, pp. 83–4, Herschel finds by a different process that a cluster of 5,000 stars visible in his 40-foot telescope is distant 11,765,475,948,678,-678,679 miles, "a number which exceeds the distance of the nearest fixed star at least three hundred thousand times." With modern data this proves to be 460,355 times the distance of Alpha Centauri, or 2,001,120 light-years.

§ 10. Summary of the Chief Results of the Determination of the Depth of the Milky Way.

From the several independent and mutually confirmatory arguments here adduced it follows that the depth of the Milky Way decidedly exceeds a million light-years, and substantially accords with the profundity concluded by the illustrious Herschel one hundred and ten years ago.

1. Herschel concluded that with his forty-foot reflector he perceived stars whose light had occupied two million years in reaching the earth; and he justly remarked that he had seen further into space than any human being before him. The visual power or light grasp of Herschel's telescope is somewhat surpassed by modern instruments; and much additional power is given to the modern instrument by the use of photography.

2. But if, on the one hand, the modern instruments surpass Herschel's in power, there is on the other some increased need for this in that we now attempt to take account of the extinction of light by cosmical dust in space. Neglecting this loss of light, Herschel may have slightly overestimated the distances to which his telescope could penetrate, but the error was scarcely of sensible importance.

3. With our greatest modern instruments and the use of photography it is certain that we can observe stars[2] at a distance of over

[2] In *Astron Nachr.*, No. 4,536, Nov. 13, 1911, Professor F. W. Very concludes that the *White Nebulæ* may be galaxies at a distance of a million light-

two million light-years, and it is very probable that we can penetrate to a depth of about five million light-years. A modern silver-on-glass reflector of twelve feet aperture would give about six times as much light as the 60-inch reflector at Pasadena, and with this gain of two magnitudes in light power it is probable that we could penetrate into space at least twice this distance (theoretically 2.512 is the factor) or *to a depth from which the light would take ten million years to reach the earth.*

At the present time a 12-foot reflector is possible, and the depth to which we can penetrate is simply a question of telescopic power, which can be vastly but not indefinitely increased. And this is true in spite of the extinction of light by cosmical dust in space. There is a limit to the distance to which any given telescope can penetrate, but it increases steadily with the aperture, since the only question involved is one of enormous light grasp.

It is to be hoped that a telescope of not less than 12 feet aperture may be built for use on the Milky Way. With such a giant instrument discoveries of the highest order might confidently be anticipated. A modern expansion of our views of the sidereal universe analogous to that which marked the great epoch of Herschel would follow, with the most beneficial effects upon every branch of astronomical science. Recent developments in many lines show that the epoch of great discoveries has not passed, but is in fact just beginning: and the estimates here laid down, as to the depth and magnificent extent of the Milky Way, convey to us but a dim outline of the discoveries which await the builders of the giant telescopes of the future. In this great advance America may naturally be expected to take the leading part.

Starlight, on Loutre,
Montgomery City, Missouri,
November 4, 1911.

years. The view adopted in my "Researches," Vol. II., 1910, however, is much more probable, since it gives continuity to the various types of bodies observed to constitute the sidereal universe. Note added Dec. 16, 1911.

CONTRABAND OF WAR.

BY JOHN BASSETT MOORE.

(*Read February 2, 1912.*)

The word contraband (Italian, *contrabbando;* Spanish, *contrabando*) signifies something prohibited—a trade carried on, or an article imported or dealt in, in violation of some inhibition. Thus, smuggled goods are often spoken of as contraband.

The term contraband of war denotes commodities which it is unlawful to carry to the country, or to the military or naval forces, of a belligerent. By a "belligerent" is meant one of the parties to a war. Often the word "enemy" is used instead of "belligerent." Writers constantly speak of an "enemy" or "enemy's" country, an "enemy" ship, or "enemy" goods, meaning thereby merely that the country, or the ship, or the merchandise, is that of a party to a war, that is to say, of a belligerent government or of one of its citizens. Sometimes the word "*hostile*" is used instead of "enemy."

When war breaks out between two countries, the carrying on of trade by the citizens of the one country with those of the other becomes unlawful; but the same general interruption does not extend to the commercial intercourse between the parties to the war and third parties, called neutrals. The intercourse between the belligerents and neutrals continues. This continuance is regarded not as a favor granted to the belligerents but as a right belonging to neutrals. As between the belligerents, neither is required to grant to the other any privilege in respect of trade. On the contrary, they endeavor to subdue each other by attacks upon persons and upon property. This is their acknowledged right. But the rest of the world, composed of neutral powers, having no part in the quarrel and perhaps little concern in the issue, also has its rights. Its interests and convenience are not to be wholly subordinated and sacrificed to the exigencies of the one or the other of the belligerents, each of whom, while desirous to preserve its own trade, would of course be glad to cut off altogether that of its enemy; and it is therefore acknowledged to be the right of neutrals to continue their commerce with the belligerents, subject only to the restrictions imposed by the law of contraband and of blockade.

In proceeding to the discussion of the particular subject of contraband, it is proper to advert to the confusion which seems so widely to prevail as to the legal position of the prohibited trade. The statement is frequently made that the trade in contraband of war is lawful, even though this broad affirmation be immediately followed by the admission that the trade is carried on subject to the risk of capture and confiscation of the goods, and of the detention, loss of freight and perhaps even the confiscation of the ship. This admission should alone suffice to put us on our guard. Merchandise is not confiscated, voyages are not broken up, ships are not condemned, for acts that are innocent; these severe and destructive inflictions are penalties imposed for acts that are unlawful. The confusion so often exhibited on this subject is due to the neglect of certain simple but fundamental truths, namely, that, in the international sphere, and particularly in matters of neutrality, the criterion of lawfulness is primarily furnished by international law and not by municipal law, lawfulness according to the latter by no means implying lawfulness according to the former; that, between the acts which neutral governments and their citizens are forbidden to commit and the acts which neutral governments are obliged to prevent, there is a wide distinction; that, by international law, acts that are unneutral in the sense of being unlawful are, from the point of view of their prevention and punishment, divided into two classes, (1) those which neutral governments are bound to prevent and punish, and (2) those which neutral governments are not bound to prevent and punish; that municipal law is supposed to prohibit, not all the unneutral acts which international law forbids, but only that part of them which neutral governments are bound to repress, the prevention and punishment of the rest being left to the belligerents as the parties primarily interested. Obviously, the determination of the question whether an act is lawful or unlawful depends not upon the circumstance that the right or duty to punish it is committed to one agency or another, but upon the fact that it is or is not punishable. The proof that it is unlawful is found in the fact that its commission is penalized. All acts for the commission of which international law prescribes a penalty are in the sense of that law unlawful. That there are various acts of this kind, such as the supplying of contraband of war to a belligerent, which neutrals are not obliged to prohibit and punish by their municipal law, merely signifies that the interests of neutrals have not been regarded as negligible, and that there are limits to the burdens which they have been required to assume and to the exertions which they are required to make. Should a neutral government itself supply contraband of war to a belligerent it would clearly depart from its position of neutrality. The private citizen undertakes the business at his own risk, and against this risk his government can not assure him protection without making itself a party to his unneutral act.

These propositions are abundantly established by authority.

Maritime states, says Heffter, have adopted,

> in a common and reciprocal interest, the rule that belligerents have the right to restrict the freedom of neutral commerce so far as concerns contraband of war, and to punish violations of the law in that regard. . . . This right has never been seriously denied to belligerents.[1]

Says Kent:

> The principal restriction which the law of nations imposes on the trade of neutrals is the prohibition to furnish the belligerent parties with warlike stores and other articles which are directly auxiliary to warlike purposes.[2]

Says Woolsey:

> If the neutral [government] should send powder or balls, cannon or rifles, this would be a direct encouragement of the war, and so a departure from the neutral position. . . . Now, the same wrong is committed when a private trader, without the privity of his government, furnishes the means of war to either of the warring parties. It may be made a question whether such conduct on the part of the private citizen ought not to be prevented by his government, even as enlistments for foreign armies on neutral soil are made penal. But it is difficult for a government to watch narrowly the operations of trade, and it is annoying for the innocent trader. Moreover,

[1] Heffter, "Droit Int.," Bergson's ed., by Geffcken, 1883, p. 384.

[2] Kent, "Int. Law," 2d ed., by Abdy, 330.

the neutral ought not to be subjected by the quarrels of others to additional care and expense. Hence by the practice of nations he is passive in regard to violations of the rules concerning contraband, blockade, and the like, and leaves the police of the sea and the punishing or reprisal power in the hands of those who are most interested, the limits being fixed for the punishment by common usage or law. . . . It is admitted that the act of carrying to the enemy articles directly useful in war is a wrong, for which the injured party may punish the neutral taken in the act.[3]

Says Manning:

The right of belligerents to prevent neutrals from carrying to an enemy articles that may serve him in the direct prosecution of his hostile purposes has been acknowledged by all authorities, and is obvious to plain reason. . . . The nonrecognition of this right . . . would place it in the power of neutrals to interfere directly in the issue of wars—those who, by definition, are not parties in the contest thus receiving a power to injure a belligerent, which even if direct enemies they would not possess.[4]

Says Creasy:

A belligerent has by international law a right to seize at sea, and to appropriate or destroy, articles, to whomsoever they may belong, which are calculated to aid the belligerent's enemy in the war, and which are being conveyed by sea to that enemy's territory.[5]

Says Holland:

The neutral power is under no obligation to prevent its subjects from engaging in the running of blockades, in shipping or carrying contraband, or in carrying troops or dispatches from one of the belligerents; but, on the other hand, neutral subjects so engaged can expect no protection from their own government against such customary penalties as may be imposed upon their conduct by the belligerent who is aggrieved by it.[6]

The fact that the supplying of contraband of war is considered as a participation in the hostilities is shown not only by the authority of writers, but also by numerous state papers.

Washington, in his famous neutrality proclamation of April 22, 1793, countersigned by Jefferson, as Secretary of State, announced

that whosoever of the citizens of the United States shall render himself liable to punishment or forfeiture under the law of nations, by committing, aiding, or abetting hostilities against any of the said powers, or by carrying

[3] Woolsey, "Int. Law," §§ 178, 179.

[4] Manning's "Law of Nations," Amos's edition, 352.

[5] Creasy, "First Platform of Int. Law," 604.

[6] Holland, "Studies in Int. Law," 124–125. See, also, Moore, *Digest of Int. Law*, VII., 972–973.

to any of them those articles which are deemed contraband by the modern usage of nations, will not receive the protection of the United States against such punishment or forfeiture.[7]

Jefferson, in his subsequent note to the British minister, May 15, 1793, observes that in the case of contraband the law of nations is satisfied with the "external penalty" pronouncecd in the President's proclamation.[8]

President Grant, in the proclamation issued by him August 22, 1870, during the Franco-German war, declares, in the most precise terms:

While all persons may lawfully, and without restriction, by reason of the aforesaid state of war, manufacture and sell within the United States arms and munitions of war, and other articles ordinarily known as "contraband of war," yet they can not carry such articles upon the high seas for the use or service of either belligerent, . . . without incurring the risk of hostile capture and the penalties denounced by the law of nations in that behalf. And I do hereby give notice that all citizens of the United States, and others who may claim the protection of this Government who may misconduct themselves in the premises, will do so at their peril, and that they can in no wise obtain any protection from the Government of the United States against the consequences of their misconduct.[9]

In the neutrality proclamations, issued during the war between the United States and Spain, the following provisions are found, in which the furnishing of arms and munitions of war to either party to the conflict is expressly treated as an act of unneutrality.

The Brazilian government, by a circular of April 29, 1898, declared to be "absolutely prohibited" the "exportation of material of war from the ports of Brazil to those of either of the belligerent powers, under the Brazilian flag or that of any other nation."[10]

The King of Denmark issued April 29, 1898, a proclamation prohibiting Danish subjects "to transport contraband of war for any of the belligerent powers."[11]

Great Britain's proclamation of April 23, 1898, warned British subjects against doing any act "in derogation of their duty as sub-

[7] Am. State Papers, For. Rel., I., 140.
[8] Moore, "Digest of Int. Law," VII., 955.
[9] Moore, "Digest of Int. Law," VII., 751.
[10] Proclamations and Decrees during the War with Spain, 13.
[11] Proclamations, etc., 22.

jects of a neutral power," or "in violation or contravention of the law of nations," among which was enumerated the carrying of "arms, ammunition, military stores or materials"; and declared that "all persons so offending, together with their ships and goods, will rightfully incur and be justly liable to hostile capture, and to the penalties denounced by the law of nations."[12]

The governor of Curaçao, acting under instructions of the minister of the colonies of the Netherlands, issued a decree prohibiting "the exportation of arms, ammunition, or other war materials to the belligerents."[13]

Portugal, while stating, in Article IV. of her neutrality decree of April 29, 1898, that "all articles of lawful commerce" belonging to subjects of the belligerent powers might be carried under the Portuguese flag, and that such articles belonging to Portuguese subjects might be carried under the flag of either belligerent, yet declared: "Articles that may be considered as contraband of war are expressly excluded from the provisions of this article."[14]

Were further proof needed of the unneutral and noxious character of contraband trade, it might be found in the doctrine of infection, under which innocent cargo is condemned when associated with contraband merchandise of the same proprietor, and the transportation penalized by loss of freight and expenses, and, under various circumstances, by confiscation of the ship.

Bearing in mind that the subject which we are considering is one of universal interest, directly affecting the world's trade and involving the imposition of heavy pecuniary penalties upon individuals, one ventures little in saying that among present-day questions of maritime law, touching intercourse between belligerents and neutrals, the most important is that of contraband. This may be affirmed in spite of the fact that, partly because of the lack of great maritime wars in recent times, its gravity may not at the moment be generally or popularly appreciated. The question of

[12] Id., 35.

[13] Id., 27.

[14] Id., 61. See, also, the proclamation of the taotai of Shanghai, id., 20, and the instructions of the Haitian Government, id., 39.

blockade, although it once assumed immense proportions, to a great extent lost its importance when the principle was established that blockades in order to be legally valid must be effective, that is to say, maintained by a force sufficient to prevent access to the blockaded port or at least to render such access dangerous. Since the definite and universal acceptance of this principle, by which neutral commerce was relieved of the hazards to which it was formerly exposed from measures generically designated by the evil name of "paper blockades," the conflict between belligerent right and neutral right has been carried on chiefly in the domain of contraband, to which it may be said that all the legal uncertainties that formerly attended the subject of blockade have been transferred, with many additions and aggravations.

In order to demonstrate the paramount importance of the question of contraband, it is unnecessary to do more than point out that, if the claim of capture on this ground be not properly limited, the two great safeguards of neutral rights established after generations of conflict become utterly worthless. I refer to the rule that free ships make free goods and the rule that blockades must be effectively maintained.

First, let us consider the rule that free ships make free goods. By what has been called the common law of the sea, the goods of an enemy were subject to capture and confiscation without regard to the character of the ship in which they were borne. The enforcement of this rule necessarily involved the capture and bringing in of neutral vessels whose cargoes were alleged to be composed even in small part of the goods of a belligerent. The breaking up of the voyages of neutral vessels in this manner, with all the resultant losses, involved so much hardship to carriers in no way concerned in the conflict that, as early as the seventeenth century, there sprang up an agitation for the exemption of neutral vessels from molestation for carrying goods which happened to belong to a citizen of a belligerent country. Such an exemption gradually came to be embodied in treaties; and when on February 28, 1780, the Empress Catherine of Russia issued her celebrated manifesto, which formed the basis of the Armed Neutrality, she announced this principle:

2. Goods belonging to the subjects of the said nations at war are, with the exception of contraband articles, free [from capture] on board neutral vessels.

This definite enunciation of the rule that free ships make free goods was incorporated in the Declaration of Paris of 1856 in the following term:

2. The neutral flag covers the enemy's goods, with the exception of contraband of war.

The United States, Spain and Mexico (Mexico acting under the direct influence of the United States) did not adhere to the Declaration of Paris, because it undertook to abolish privateering; but the United States and Spain expressly accepted the rule that free ships make free goods, and this was proclaimed by the United States in 1898 as a principle of international law and was so accepted by Spain in the war between the two countries in that year. Moreover, Spain has since adhered to the Declaration of Paris in its entirety. But, note the exception to the rule. Enemy's goods are exempt from capture under the neutral flag, "with the exception of contraband of war." In other words, the operation of this rule and the protection intended to be afforded by it are wholly dependent upon the definition of contraband. Make the list of contraband long enough, and the rule becomes a farce.

Secondly, take the present law of blockade. At one time fictitious blockades were the bane of neutral commerce. In the twelve years that followed the breach of the Peace of Amiens—the days of the so-called Napoleonic wars—millions upon millions of neutral property were unlawfully confiscated for the alleged violation of or attempt to violate blockades which existed only on paper.

The declaration of the Empress Catherine above referred to contained the following rule:

4. To determine what constitutes a blockaded port, this denomination is confined to those the entrance into which is manifestly rendered dangerous in consequence of the dispositions made by the attacking power with ships stationed sufficiently near.

The Declaration of Paris of 1856 provided:

4. Blockades, in order to be binding, must be effective: that is to say, maintained by a force sufficient really to prevent access to the coast of the enemy.

The world accepted this principle with joyful unanimity. We may, however, pertinently inquire, What is it worth, if the definition of contraband be not properly limited? The answer is not difficult. If the definition of contraband be so extended as to embrace in some form, positively or conditionally, practically all articles of commerce, the question of blockade ceases to be important. The security intended to be afforded to the neutral, by requiring the belligerent to make his blockade effective, becomes a mockery; the belligerent is practically relieved of the burden of maintaining blockades, for, instead of keeping his ships at certain points and hampering his offensive use of them, he can roam the seas at will and seize all articles destined to any belligerent port under the claim of contraband.

Let us consider the significance of the question of contraband in yet another relation. It is creditable to our humanity that proposals having a benevolent sound usually evoke a prompt and generous response, but it sometimes happens that the substance upon examination turns out to be less benevolent than the sound. We have lately heard much of the proposed immunity of private property at sea from capture. The United States is said to have advocated such a measure at both Hague Conferences. What has happened is actually this: Some of our earlier statesmen, notably Franklin, did in reality advocate a very wide exemption not only of property but also of persons, on land as well as on the sea, from the operations of war; and their example was followed by some of their successors. In 1857 the government of the United States, being embarrassed by its refusal to accede to the Declaration of Paris on account of the clause abolishing privateering, offered to adhere on condition that the powers go farther and exempt private property at sea from capture; but this offer was expressly subject to the exceptions of contraband and blockade. In 1907 Mr. Choate, on behalf of the Delegation of the United States, submitted to the second Peace Conferences at The Hague the following resolution:

The private property of all citizens or subjects of the signatory powers, with the exception of contraband of war, shall be exempt from capture or seizure on the sea by the armed vessels or by the military forces of any of the said signatory powers. But nothing herein contained shall extend exemption from seizure to vessels and their cargoes which may attempt to enter a port blockaded by the naval forces of any of the said powers.

What therefore the United States since 1850 has proposed is, not that private property at sea shall be exempt from capture, but that it shall be so exempt, subject to the exceptions of contraband and blockade. The proposal, as thus qualified, no doubt had a substantial character in 1857, since the government of the United States at that day still recalled the limitations upon contraband for which it had traditionally contended. The case was the same when, by the treaty of commerce between the United States and Italy of February 26, 1871, it was actually agreed (Article XII.) that, in the event of war between the two countries, the private property of their citizens and subjects should be exempt from capture on the high seas or elsewhere, subject to the exceptions of contraband and blockade; for the treaty then proceeded (Article XV.) precisely to limit the scope of contraband, confining it to arms and munitions of war, and declaring that those articles "and no others" should be comprehended under that denomination.[15] But at The Hague, in 1907, the importance of the exceptions was greatly enhanced by the separate presentation on the part of the United States of an extremely vague and sweeping proposition on contraband of war, in which provisions appear, no doubt for the first time in American diplomacy, in the category of absolute as well as in that of conditional contraband.[16] Taking into consideration the objects of war, opinions will necessarily differ as to the merits and value of a proposal to exempt enemy ships and enemy goods as such from capture, while leaving in force the law of blockade and of contraband, without any precise definition or limitation of the latter. Such a proposal holds out no advantage to neutrals, but offers to belligerents the favor of placing them on the same footing as neutrals commercially. And even the extent of this favor would depend upon the definition and scope of contraband. Is there not, indeed, a certain incongruity in exempting from capture such an obviously important

[15] Note *A*, infra, p. 42.
[16] Note *B*, infra, p. 43.

auxiliary to military and naval operations as the ships of an enemy, while subjecting to seizure and confiscation the agricultural products of a neutral?

The question of contraband may now be considered in its historical and experimental aspects. It is unnecessary for this purpose to enter minutely into the origin of the subject. It suffices to say that in the sixteenth and the early part of the seventeenth century, the law of contraband and of blockade both being unsettled, belligerents often assumed the right to capture all neutral ships and merchandise bound to an enemy's port, thus in effect denying the existence of any right of neutral trade as opposed to belligerent exigencies. The neutral, if he differed with the belligerent as to the necessity of the inhibition or the propriety of the capture, would resort to reprisals. The conflicts that resulted and the constant interruptions of trade, rendering it impossible to carry on international commerce without risk of ruinous losses, induced governments in the latter half of the seventeenth century to concert a decided change in practice.

Grotius, in his *De Jure Belli ac Pacis* (1625), perhaps recording the transition in thought, divided articles, with reference to the question of contraband, into three classes, (1) those that were of use only in war, (2) those that were of no use in war, but served only for pleasure, and (3) those that were useful both in war and in peace (*i. e.,* things of double use, *ancipitis usus*), as money, provisions, ships and their appurtenances. The first he held to be prohibited; the second, to be free. As to the third, the circumstances of the war must, he said, be considered; and if the belligerent could not protect himself unless he intercepted it, necessity would give him the right to intercept it, "but under the obligation of restitution, except there be cause to the contrary." As an example of "cause to the contrary," he instanced the case of the supplying of a besieged town or a blockaded port, when a surrender or a peace was daily expected.[17]

By a treaty between France and the Hanse Towns, signed at Paris May 10, 1655, contraband was confined to munitions of war,

[17] Grotius, "De Jure Belli ac Pacis," Lib. III., c. I., v, 1–3.

and it was expressly declared that wheat and grains of all sorts, vegetables and other things serving to sustain life, might be carried to the enemy, provided that they were not transported to towns and places actually under attack and were taken voluntarily and not under compulsion of the enemy, in which case they might be seized and retained on paying their just value.

November 7, 1659, there was concluded between France and Spain the famous Treaty of the Pyrenees. Articles XII. and XIII. dealt with the subject of contraband, including therein only such things as were distinctly of warlike character, and excluding therefrom wheat, corn and other grains, pulse, oils, wines, salt, and generally all things useful to sustain life, unless destined to towns and places "besieged, blocked up, or surrounded."[18]

The Dutch agreed to these categories in 1662, and were soon followed by Great Britain, in treaties made with the United Provinces and Spain in 1667, and with France in 1677.

In 1713 came the Peace of Utrecht. By the treaties concluded between France and the other powers on that occasion, the subject of contraband was definitely regulated on the most advanced lines. For example, in the treaty of commerce with Great Britain signed April 11 (1713), while contraband was limited to certain enumerated articles of warlike character, the non-contraband list, which embraced wheat, barley and other grains, pulse, tobacco, spices, salt and smoked fish, cheese and butter, beer, oils, wines, sugars, salt, "and in general all provisions which serve for the nourishment of mankind and the sustenance of life," was extended to many other articles, all of which were declared to be free except when transported to places "besieged, blocked up round about, or invested."[19]

Similar stipulations were incorporated in the British-French commercial treaty signed at Versailles September 26, 1786.

In the manifesto of the Empress Catherine of Russia of 1780, which formed, as heretofore stated, the basis of the Armed Neutrality, it was declared that her Imperial Majesty adhered to Articles X. and XI. of her treaty of commerce with Great Britain, and ex-

[18] Note *C*, infra, p. 43.
[19] Note *D*, infra, p. 44.

tended their provisions to all the nations at war. This treaty was concluded June 20, 1766. With the "single exception" of certain enumerated articles, which were "accounted ammunition or military stores," it was agreed that the subjects of the one party might transport "all sorts of commodities" to places belonging to the enemy of the other that were not "actually blocked up, or besieged, as well by sea as by land."[20]

Such was the condition of things when the wars growing out of the French Revolution began. The enthusiastic devotion of the French on the one hand to the principles which they had espoused, and the frenzied resistance of monarchical governments on the other hand to what they regarded as an anarchical propagandism threatening thrones everywhere by force of example if not by force of arms, imparted to these struggles a peculiarly intense and lawless character. Three months after the war between France and Great Britain was declared, the National Convention, May 9, 1793, there being a scarcity of food in France, adopted a decree authorizing the seizure of vessels laden wholly or in part with provisions, which, if found to be neutral property, were to be paid for at the price which they would have fetched at the port of destination, together with an allowance for freight and for the vessel's detention. This was a claim not of contraband but of preemption. Nevertheless, the United States protested against it, and it was not uniformly enforced against American vessels. Great Britain on the other hand, wishing not only to supply her own wants but to increase the pressure on France, advanced a claim compounded of contraband and preemption. By an order in council of June 8, 1793, which was communicated to the Admiralty on the 28th of the same month, the commanders of British ships of war and privateers were authorized to seize all vessels laden wholly or in part with corn (*i. e.*, cereals generally, as wheat, barley, rye and oats, but more especially wheat), flour, or meal, bound to any port in France, or any port occupied by the armies of France, in order that such provisions might be purchased on behalf of the government, with an allowance to the vessel for freight, or in order that the master might be required to give

[20] Note *E*, infra, p. 44.

security to dispose of such cargo in a country in amity with Great Britain. The British government assumed to justify this order on the ground that by the law of nations, as laid down by the most modern writers, and particularly by Vattel, all provisions were to be considered as contraband, and as such liable to confiscation, where the depriving an enemy of them was one of the means intended to be employed for reducing him to reasonable terms of peace; and that the actual situation of France rendered this reasoning peculiarly applicable, not only because the scarcity there was caused by the unusual measure of arming almost the whole laboring class of the nation, but also because the trade was to be regarded, not as a mercantile speculation of individuals, but as an immediate operation of the very persons who had declared war and were carrying it on against Great Britain. On these considerations, said the British government, the powers at war would have been perfectly justifiable if they had considered all provisions as contraband and had directed them as such to be brought in for confiscation, but they had only sought to prevent the French from being supplied with corn, omitting all mention of other provisions, and even in respect of corn, instead of confiscating the cargoes, had secured to the proprietors, if neutral, a full indemnity for any loss they might sustain.

The United States on the other hand declared that the position that provisions were contraband in the case where the depriving an enemy of them was one of the means intended to be employed for reducing him to reasonable terms of peace, or in any case but that of a place actually blockaded, was entirely new; that reason and usage had established that, when two nations went to war, those who chose to live in peace retained their natural right to pursue their agriculture, manufactures, and other ordinary vocations, and to carry the produce of their industry, for exchange, to all nations, belligerent or neutral, except that they must not furnish implements of war to the belligerents or send anything to a blockaded place. Implements of war destined to a belligerent were treated as contraband, and were subject to seizure and confiscation. Corn, flour, and meal were not, said the United States, of the class of contraband, and consequently remained articles of free commerce. The state of ar between Great Britain and France furnished neither belligerent with the right to interrupt the agriculture of the United States, or the peaceable exchange of its produce with all nations. Such an act of interference tended directly to draw the United States from the state of peace in which they wished to remain. If the United States permitted corn to be sent to Great Britain and her friends, and refused it to France, such an act of partiality might lead to war with the latter power. If they withheld supplies of provisions from France, they should in like manner be bound to withhold them from her enemies also, and thus to close to themselves all the ports of Europe where corn was in demand, or else make themselves a party to the war. This was a dilemma into which no pretext for forcing the United States could be found. Great Britain might, indeed, feel the desire of starving an enemy nation; but she could have no right to do it at the cost of the United States, or to make the latter the instrument of it.[21]

Such was the position maintained by the United States; and when John Jay was sent on a special mission to England in 1794 to negotiate a settlement of differences, the first topic discussed in his instructions was that of the vexations inflicted on commerce under orders in council. By the treaty which he signed on November 19, 1794, a precise enumeration was made (Article XVIII.) of the things which were admitted to be contraband, and it was stipulated that when cases arose in which "provisions and other articles not generally contraband" might, according to the existing law of nations, be regarded as becoming such, they should not, even though seized on that ground, be confiscated, but should be paid for at their full value, together with a reasonable mercantile profit, freight and demurrage.[22] Nor was this all. A mixed commission was established under the treaty (Article VII.) to adjudicate complaints on account of seizures. The British authorities, where they made compensation for cargoes of provisions, adopted as a basis the invoice price plus a mercantile profit of ten per cent. The claimants contended that this was inadequate. The commission allowed the net

[21] For a full narrative of this incident and the text of the orders in council, see Moore's "History and Digest of International Arbitrations," I., 299–306.

[22] Note *F*, infra, p. 45.

value of the cargo at its port of destination at the time at which it probably would have arrived there, had it not been seized. The awards of the commission in the case of captured vessels laden with provisions and bound to France are estimated to have amounted to £720,000, or approximately $3,500,000.[23]

The position successfully maintained by the United States in the case of Great Britain was altogether in accord with that which was reciprocally acted upon in its relations with other powers. The commercial treaty with France of 1778—the first treaty concluded by the United States—substantially incorporated the Utrecht clause on the subject of contraband,[24] as also did the later convention of 1800. A similar stipulation may be found in the treaty with Sweden of 1783, and in that with Spain of 1795. In the treaties of 1785 and 1799 the United States and Prussia went so far as to agree that even arms and munitions of war, when seized as contraband, should not be confiscated, but that the captor should pay for them if he converted them to his own use, or pay damages if he merely detained them.[25] In the treaty between the United States and Colombia of 1824 a clause on contraband was inserted which furnished the model followed by the United States with practical uniformity in its subsequent treaties.[26] It is substantially reproduced in the contraband articles of the treaty with Italy of 1871. It may also be found in identical or nearly identical terms in the treaties between the United States and the following powers: Central America, 1825; Brazil, 1828; Mexico, 1831; Chile, 1832; Peru-Bolivia, 1836; Venezuela, 1836 and 1860; Ecuador, 1839; New Granada, 1846; Salvador, 1850 and 1870; Peru, 1851 and 1870; Two Sicilies, 1855; Bolivia, 1858; Haiti, 1864; Dominican Republic, 1867.

During the war with Spain, in 1898, the subject of contraband was dealt with by the United States in General Orders No. 492, which specified certain articles as "absolutely contraband" and others as "conditionally contraband." The former included arms

[23] Moore, "History and Digest of International Arbitrations," I., 343–344.

[24] Note *G*, infra, p. 46.

[25] Note *H*, infra, pp. 47–48.

[26] Note *I*, infra, p. 48.

and munitions of war and machinery for their manufacture, saltpeter, military accoutrements and equipments, and horses. The "conditionally contraband" were:

> Coal, when destined for a naval station, a port of call, or a ship or ships of the enemy; materials for the construction of railways or telegraphs, and money, when such materials or money are destined for the enemy's forces; provisions, when destined for an enemy's ship or ships, or for a place that is besieged.

In the early stages of the Boer war a question arose between the United States and Great Britain as to the seizure of various articles shipped at New York, some of them on regular monthly orders, by American merchants and manufacturers on the vessels *Beatrice, Maria,* and *Mashona,* which were seized by British cruisers while on the way to Delagoa Bay. These articles consisted chiefly of flour, canned meats, and other foodstuffs, but also embraced lumber, hardware, and various miscellaneous articles, as well as quantities of lubricating oil, which were consigned partly to the Netherlands South African Railway, in the Transvaal, and partly to the Lourenço Marques Railway, a Portuguese concern. It was at first supposed that the seizures were made on the ground of contraband, and with reference to this possibility the government of the United States, on January 2, 1900, declared that it could not recognize their validity "under any belligerent right of capture of provisions and other goods shipped by American citizens in ordinary course of trade to a neutral port." It soon transpired, however, that the *Beatrice* and *Mashona,* which were British ships, and the *Maria,* which, though a Dutch ship, was at first supposed to be British, were arrested for violating a municipal regulation forbidding British subjects to trade with the enemy, the alleged offense consisting in the transportation of goods destined to the enemy's territory. The seizure of the cargoes was declared to be only incidental to the seizure of the ships. As to certain articles, however (particularly the oil consigned to the Netherlands South African Railway in the Transvaal), an allegation of enemy's property was made; but no question of contraband was raised, and it was eventually agreed that the United States consul-general at Cape Town should arrange with Sir Alfred Milner, the British high commissioner, for the release or purchase by the British government of any American-owned goods, which, if purchased, were to be paid for at the price they would have brought at the port of destination at the time they would have arrived there in case the voyage had not been interrupted. In the course of the correspondence, Lord Salisbury thus defined the position of the British government on the question of contraband:

> Food stuffs, with a hostile destination, can be considered contraband of war only if they are supplies for the enemy's forces. It is not sufficient that they are capable of being so used; it must be shown that this was in fact their destination at the time of the seizure.

This statement by Lord Salisbury was in harmony with what is laid down in Holland's Manual of Naval Prize Law, issued by the British Admiralty in 1888. In this Manual conditional contraband embraces provisions and liquors fit for consumption of army or navy; money; telegraphic materials, such as wire, porous cups, platina, sulphuric acid, and zinc; materials for railway construction, as iron bars and sleepers; coals, hay, horses, rosin, tallow, and timber. But these articles, it is stated, "are contraband only in case it may be presumed that they are intended to be used for the purposes of war," and "this presumption arises when such hostile destination of the vessel is either the enemy's fleet at sea, or a hostile port used exclusively or mainly for naval or military equipment."

On the outbreak of the war with Japan, the Russian government, in March, 1904, published instructions to its naval commanders which forbade the conveyance of contraband "to Japan or to Japanese armed forces," and denounced as contraband "foodstuffs," including all kinds of grain, fish, fish products of various kinds, beans, bean oil, and oil cakes. The British government protesting expressed "great concern" that "rice and provisions" should be treated as unconditionally contraband, this being regarded "as inconsistent with the law and practice of nations." The British government, it was declared, did not contest "that, in particular circumstances, provisions may acquire a contraband character, as for instance, if they should be consigned direct to the army or fleet of a belligerent, or to a port where such fleet may be lying"; but it could not admit "that if such provisions were consigned to the port of a belligerent (even though it should be a port of naval equipment) they should therefore be necessarily regarded as contraband of war." The true test appeared to be "whether there are circumstances relating to any particular cargo to show it that it is destined for military or naval use."

The United States was obliged to deal with the same question in the case of the steamer *Arabia,* whose cargo, composed of railway material and flour, destined to Japanese ports and consigned to various commercial houses there, was condemned by the Russian prize court at Vladivostok as contraband, on the strength of its destination. The United States protested against this judgment as involving a "disregard of the settled law of nations." The United States declared that it was "vital to the legitimate maritime commerce of neutral states" that there should be "no relaxation" of the distinctions with regard to contraband; that there was and could be "no middle ground"; that "the criterion of warlike usefulness and destination" had "been adopted by the common consent of civilized nations, after centuries of struggle in which each belligerent made indiscriminate warfare upon all commerce of all neutral states with the people of the other belligerent, and which led to reprisals as the mildest available remedy"; that, while articles such as arms and ammunition, self-evidently of war-like use, were contraband if destined to enemy territory, yet articles such as coal, cotton, and provisions, which, though ordinarily innocent, were capable of warlike use, were "not subject to capture and confiscation unless shown by evidence to be actually destined for the military or naval forces of a belligerent"; that "this substantive principle of the law of nations" could "not be overridden by a technical rule of the prize court that the owners of the captured cargo must prove that no part of it" might reach the enemy forces; and that, such proof being "of an impossible nature," its exaction would render neutral commerce impossible and result in the condemnation of the innocent with the guilty. In conclusion the ambassador of the United States at St. Petersburg was instructed to express "the deep regret and grave concern" with which his government had received the unqualified communication of the decision of the prize court, and was directed to "make earnest protest against it" and to say that his government regretted "its complete inability to recognize the principle of that decision and still less to acquiesce in it as a policy."

In consequence of the British and American protests the Russian government appointed a commission to consider the question of contraband, and on October 22, 1904, announced that, while horses and beasts of burden would continue to be treated as contraband of war, yet various other articles, including rice and foodstuffs, would be considered as contraband if destined for a belligerent government, its administration, army, navy, fortresses, naval ports, or purveyors, but not if "addressed to private individuals."

Since the war between Russia and Japan, the subject of contraband has been dealt with in the Declaration of London, signed February 26, 1909, by representatives of Germany, the United States, Austria-Hungary, Spain, France, Great Britain, Italy, Japan, the Netherlands, and Russia, with the object of laying down rules of maritime law, embracing blockade, contraband, unneutral service, destruction of neutral prizes, and various other subjects, for the government of the International Prize Court which Germany proposed to the Second Peace Conference at The Hague, and for the constitution of which provision was made by the convention signed on October 18, 1907. As the House of Lords has lately rejected a bill, which had passed the Commons, to carry this convention into effect, the fate of the Declaration must, so far as Great Britain is concerned, be regarded as at least doubtful. It has been fiercely assailed in England, but has been ably defended by eminent persons, among whom Westlake may be particularly mentioned, who, although they naturally do not pronounce it perfect, consider that its adoption would on the whole be advantageous. Into this general question it is beyond my province now to enter, my subject being simply contraband.

The Declaration (Article 24), following the Grotian classification, divides articles into (1) absolutely contraband, (2) conditionally contraband, and (3) absolutely noncontraband. The second category—the conditionally contraband—includes fourteen general heads, namely, foodstuffs; forage and grain, suitable for feeding animals; clothing, fabrics for clothing, and boots and shoes, suitable for use in war; gold and silver in coin or bullion, and paper money; vehicles of all kinds available for use in war, and their component parts; vessels, craft, and boats of all kinds,[27] floating docks, parts of docks and their component parts; railway material, both fixed and rolling-stock, and materials for telegraphs, wireless telegraphs, and telephones; balloons and flying machines and their distinctive component parts, together with accessories and articles recognizable as intended for use in connection with balloons and flying machines; fuel, and lubricants; powder and explosives not specially prepared for use in war; barbed wire and implements for fixing and cutting it; horseshoes and shoeing materials; harness and saddlery; field glasses, telescopes, chronometers, and all kinds of nautical instruments. And to this list belligerents are (Article 25) allowed to add by declarations notified to other powers.

For all contraband the Declaration preserves (Article 39) the penalty of condemnation; and it provides (Article 33) that "conditional contraband" shall be liable to capture if "destined for the use of the armed forces or of a government department of the enemy state, unless in this latter case the circumstances show that the articles cannot in fact be used for the purposes of the war in progress." As to proof of destination, the provisions of the Declaration are two-fold. The doctrine of continuous voyage, though declared to be applicable to absolute contraband, is not applied to conditional, so that cargoes of the latter are not put in jeopardy when sent to a neutral port. This is a desirable and important safeguard. A hostile destination is, on the other hand, presumed (Article 34) "if the consignment is addressed to enemy authorities, or to a merchant, established in the enemy country, and when it is well

[27] This provision that vessels, craft and boats shown to be intended for belligerent use may be seized and confiscated as contraband evidently is not intended to alter or modify the law according to which the fitting out, arming, or equipping in neutral jurisdiction of a vessel to cruise or carry on war against one of the belligerents constitutes, not a mere transaction in contraband, but the setting on foot of a hostile expedition, which the neutral is bound to use due diligence to prevent.

known that this merchant supplies articles and material of this kind to the enemy," or "is destined to a fortified place of the enemy, or to another place serving as a base for the armed forces of the enemy." These grounds of inference are so vague and general that they would seem to justify in almost any case the presumption that the cargo, if bound to an enemy port, was "destined for the use of the armed forces or of a government department of the enemy state." Any merchant established in the enemy country, who deals in the things described, will sell them to the government; and if it becomes public that he does so, it will be "well known" that he supplies them. Again, practically every important port is a "fortified place"; and yet the existence of fortifications would usually bear no relation whatever to the eventual use of provisions and various other articles mentioned. Nor can it be denied that, in this age of railways, almost any place may serve as a "base" for supplying the armed forces of the enemy. And of what interest or advantage is it to a belligerent to prevent the enemy from obtaining supplies from a "base," from a "fortified place," or from a merchant "well known" to deal with him, in his own country, if he is permitted freely to obtain them from other places and persons, and especially, as countries having land boundaries can for the most part easily do, through a neutral port? No doubt the advantage of such prevention may readily become greater, if the enemy be, like Great Britain or Japan, an insular country.

The attempt to establish an international prize court constitutes one of the most remarkable advances ever proposed towards the founding of an international jurisdiction, and the effort made in the Declaration of London to furnish a universal law is a step in the right direction. The able framers of the Declaration may be assumed to have made the best compromise that was at the time obtainable. But the question of contraband remains unsolved; and it will so remain either until, by an inconceivable relapse into primitive sixteenth-century conditions, all commerce with belligerents is forbidden, or until innocent articles of universal use, such as provisions, which, even when consumed by military men, are consumed by them as human beings rather than as soldiers, are, in conformity with the traditional contention of the United States, put beyond reach of capture on loose and interested surmises.

While seizures of articles commonly classed as conditional contraband have inflicted upon neutrals enormous losses, the effect of such seizures upon the fortunes of the belligerents has by no means been so appreciable as it is often hastily assumed to have been. Lawless, unrestrained and successful as were the depredations on neutral commerce during the wars following the French Revolution, not only did the struggle persist through more than twenty years, but its end was scarcely hastened by the spoliations, which indeed seem rather to have supplied the means of its prolongation. The reduction of the South, during the American Civil War, was sensibly accelerated by the cutting off of its commerce, but this result was achieved chiefly by means of blockade.

At the Second Peace Conference at The Hague, in 1907, the British government, with a view to diminish the difficulties which neutral commerce encounters in case of war, proposed that the powers should enter into an agreement to abandon the principle of contraband altogether, and to confine the right of visit to the ascertainment of the merchant vessel's neutral character. Such a measure was justified on the ground that, while it had in spite of all efforts been found to be impossible to prevent belligerents from obtaining the munitions which they needed, the attempt to do so had, by reason of the increase in the tonnage of ships, the carrying of mixed cargoes, the lack of any single destination of ship or cargo, the multiplication of the number of articles used in war, and the development of railways and other means of transportation by land, become more and more futile on the part of belligerents and more and more injurious to neutrals. The circumstance that the radical proposal of Great Britain, although it was not eventually adopted by the Conference, received the support of twenty-six of the powers represented therein, while only five voted against it,[28] alone suffices

[28] For: Argentine Republic, Austria-Hungary, Belgium, Brazil, Bulgaria, Chile, China, Cuba, Denmark, Dominican Republic, Great Britain, Greece, Italy, Mexico, Netherlands, Norway, Paraguay, Peru, Persia, Portugal, Salvador, Servia, Siam, Spain, Sweden, Switzerland.—26.

Against: France, Germany, Montenegro, Russia, United States.—5.

to demonstrate the existence of a general conviction that the present state of things is altogether unsatisfactory.

Recalling the treaties between Prussia and the United States of 1785 and 1799 for the virtual abolition of contraband, it is curious to find the United States and Germany acting together as two of the five powers that voted against its abolition in 1907; but, although the United States voted against the British proposal, it is gratifying to note that Admiral Sperry, on behalf of the United States delegation, after the British proposal had failed to secure the unanimous approval of the conference, maintained the historic American position that the right of capture should be confined to articles agreed to be absolutely contraband. In this relation it may be observed that the Institute of International Law, in 1896, after much deliberation, voted that the category of conditional contraband should be abolished, the belligerent, however, to have the right, at his pleasure and subject to an equitable indemnity, to sequester or to preempt, when on their way to an enemy port, articles serving equally for war and for peace.[29] Rather than allow existing conditions to continue, it might be advisable to add to the present duties of neutrals the obligation to prohibit the exportation of arms and munitions of war to belligerents, it being agreed that commerce in all other articles should be free. Under the more efficient administrative methods now in vogue, the enforcement of a measure of this kind probably would not prove to be so difficult as it was once supposed to be. Several examples of such a prohibition have already been given.[30] By a joint resolution of the Congress of the United States of April 22, 1898, passed at the opening of the war with Spain, the President was "authorized, in his discretion and with such limitations and exceptions as shall seem to him expedient, to prohibit the export of coal or other material used in war from any seaport of the United States until otherwise ordered" by himself or by Congress. Not only was this law en-

Abstaining: Japan, Panama, Rumania, Turkey.—4.

See Deuxième Conférence de la Paix, Actes et Documents, I., 259; III., 881, 890.

[29] *Annuaire de l'Institut de Droit International,* Vol. 15 (1896), 231. See Westlake's comments, Int. Law, II., 249.

[30] Supra, pp. 22–23.

forced during the war with Spain,[30] but the President, by a proclamation of October 14, 1905, prohibited, without limitation or exception, till it should be otherwise ordered, the export of arms and munitions of war to the Dominican Republic. This prohibition, as the proclamation recites, was established for what appeared to the President to be "good and sufficient reasons." It was not founded upon any legal obligation. The fact that the American supervision of the Dominican customs administration had then in effect begun furnished a special justification for preventing acts that tended to disturb the public peace of the island. Nevertheless, the interest of the United States in the collection of the Dominican customs can hardly be considered as more important than its interest in the adjustment and preservation of the rights of neutral commerce in time of war, or as rendering proper in the former case a precaution which would not be admissible in the latter. It is not, however, my purpose to lay undue stress upon the method of dealing with absolute contraband; nor do I wish to intimate that the general abolition of conditional contraband should await the adoption of further measures in respect of absolute contraband.

APPENDIX.

Note *A*.

Treaty of Commerce between the United States and Italy, February 26, 1871, Articles XII. and XV.

Art. XII. The high contracting parties agree that, in the unfortunate event of a war between them, the private property of their respective citizens and subjects, with the exception of contraband of war, shall be exempt from capture or seizure, on the high seas or elsewhere, by the armed vessels or by the military forces of either party; it being understood that this exemption shall not extend to vessels and their cargoes which may attempt to enter a port blockaded by the naval forces of either party.

Art. XV. The liberty of navigation and commerce secured to neutrals by the stipulations of this treaty shall extend to all kinds of merchandise, excepting those only which are distinguished by the name of contraband of war. And, in order to remove all causes of doubt and misunderstanding upon this subject, the contracting parties expressly agree and declare that the following articles, and no others, shall be considered as comprehended under this denomination:

[30] Moore, "Digest of International Law," VII., 194.

1. Cannons, mortars, howitzers, swivels, blunderbusses, muskets, fuses, rifles, carbines, pistols, pikes, swords, sabers, lances, spears, halberds, bombs, grenades, powder, matches, balls, and all other things belonging to, and expressly manufactured for, the use of these arms.

2. Infantry belts, implements of war and defensive weapons, clothes cut or made up in a military form and for a military use.

3. Cavalry belts, war saddles and holsters.

4. And generally all kinds of arms and instruments of iron, steel, brass, and copper, or of any other materials manufactured, prepared, and formed expressly to make war by sea or land.

Note *B*.

Proposition (translated) of the Delegation of the United States at The Hague Conference of 1907 on Contraband of War:

1. Absolute contraband shall consist of arms, munitions of war, provisions, and articles employed solely for a military purpose or for military establishments.

2. Conditional contraband shall consist of provisions, materials and articles which are employed for the double purpose of peace and of war, but which by reason of their nature or special qualities, or their quantity, or by their nature, quality and quantity are suitable and necessary for a military purpose, and which are destined for the use of the armed forces or the military establishments of the enemy.

3. The list of articles and of provisions which shall be included in each of the aforesaid classes must be duly published and notified to neutral governments, or to their diplomatic agents, by the belligerents, and no article shall be seized or confiscated under the head of conditional contraband as to which such advice has not been given. (" Deuxième Conférence de la Paix," Actes et Documents, III., 1160.)

Note *C*.

Treaty of the Pyrenees, November 7, 1759.

XII. By . . . Contraband-Goods, are only understood all sorts of Fire-Arms, and all things belonging to them; as Cannons, Muskets, Mortar-pieces, Petards, Bombs, Granadoes, Saucidges, Pitch'd-circles, Carriages, Forks, Bandaliers, Gunpowder, Cords, Saltpeter, Bullets, Pikes, Swords, Casks, Head-pieces, Cuirasses, Halberts, Javelins, Horses, Saddles for Horses, Holsters for Pistols, Belts, or any other warlike Furnitures.

XIII. In that kind of Contraband-Goods, shall not be comprehended Wheat, Corn, or other Grains, Pulse, Oils, Wines, Salt, nor generally anything belonging to the nourishment and sustentation of Life; but they shall remain free, as all other Merchandizes and Commoditys, not comprehended in the foregoing Article: And the transportation of them shall be free, even to Places in enmity with the Crown of Spain, except Portugal, as aforesaid, and the Towns and Places besieged, block'd up, or surrounded. (Treaty of the

Pyrenees, concluded between France and Spain, November 7, 1659: Vol. 1, pp. 45–46, of "A General Collection of Treatys, Declarations of War, Manifestos, and other Publick Papers, relating to Peace and War," 2d edition, London, 1732.)

NOTE *D*.

Treaty of Commerce between Great Britain and France, Signed at Utrecht, March 31–April 11, 1713, Arts. XIX., XX.

Article XIX. Under this name of contraband, or prohibited goods, shall be comprehended arms, great guns, bombs, with their fusees and other things belonging to them; fire-balls, gunpowder, match, cannon-ball, pikes, swords, lances, spears, halberds, mortars, petards, granadoes, saltpetre, muskets, musket-ball, helmets, head-pieces, breast-plates, coats of mail, and the like kinds of arms, proper for arming soldiers, musket-rests, belts, horses with their furniture, and all other warlike instruments whatever.

Article XX. These merchandizes which follow shall not be reckoned among prohibited goods, that is to say, all sorts of clothes, and all other manufactures woven of any wool, flax, silk, cotton, or any other materials whatever; all kinds of clothes and wearing apparel, together with the species whereof they are used to be made; gold and silver, as well coined as uncoined, tin, iron, lead, copper, brass, coals; as also wheat and barley, and any other kind of corn, and pulse; tobacco, and likewise all manner of spices, salted and smoked flesh, salted fish, cheese and butter, beer, oils, wines, sugars, and all sorts of salt, and, in general, all provisions which serve for the nourishment of mankind, and the sustenance of life. Furthermore, all kinds of cotton, hemp, flax, tar, pitch, ropes, cables, sails, sailcloths, anchors, and any parts of anchors; also shipmasts, planks, boards and beams of what trees soever; and all other things proper either for building or repairing ships; and all other goods whatever, which have not been worked into the form of any instrument, or thing prepared for war, by land or by sea, shall not be reputed contraband, much less such as have been already wrought and made up for any other use; all which shall wholly be reckoned among free goods, as likewise all other merchandizes and things which are not comprehended, and particularly mentioned in the preceding article, so that they may be transported, and carried in the freest manner by the subjects of both confederates, even to places belonging to an enemy, such towns or places being only excepted, as are at that time besieged, blocked up round about, or invested. (Jenkinson's "Treaties," II., 51.)

NOTE *E*.

Treaty of Commerce and Navigation between Great Britain and Russia, June 20, 1766, Arts. X. and XI., referred to in the third article of the declaration of the Empress Catherine of Feb. 28, 1780.

X. Permission shall be granted to the subjects of the two contracting parties to go, come, and trade freely with those states, with which one or other of the parties shall at that time, or at any future period, be engaged in war, provided they do not carry military stores to the enemy. From this permission, however, are excepted places actually blocked up, or besieged, as well by sea as by land; but at all other times, and with the single exception of military stores, the above-said subjects may transport to these places all sorts of commodities, as well as passengers without the least impediment. With regard to the searching of merchant ships, men of war and privateers shall behave as favourably as the reason of the war, at that time existing, can possibly permit towards the most friendly powers that shall remain neuter; observing, as far as may be, the principles and maxims of the law of nations, that are generally acknowledged.

XI. All cannon, mortars, muskets, pistols, bombs, grenades, bullets, balls, fusees, flint-stones, matches, powder, saltpetre, sulphur, breast-plates, pikes, swords, belts, cartouch-bags, saddles, and bridles, beyond the quantity that may be necessary for the use of the ship, or beyond what every man serving on board the ship, and every passenger, ought to have, shall be accounted ammunition or military stores; and, if found, shall be confiscated, according to law, as contraband goods or prohibited commodities; but neither the ships nor passengers, nor the other commodities found at the same time, shall be detained or hindered to prosecute their voyage. (Chalmers, I., 7.)

Note *F.*

Treaty between the United States and Great Britain, November 19, 1794, Art. XVIII.

Article XVIII. In order to regulate what is in future to be esteemed contraband of war, it is agreed that under the said denomination shall be comprised all arms and implements serving for the purposes of war, by land or sea, such as cannon, muskets, mortars, petards, bombs, grenades, carcasses, saucisses, carriages for cannon, musket-rests, bandoliers, gun-powder, match, saltpetre, ball, pikes, swords, head-pieces, cuirasses, halberts, lances, javelins, horse-furniture, holsters, belts, and generally all other implements of war, as also timber for ship-building, tar or rosin, copper in sheets, sails, hemp, and cordage, and generally whatever may serve directly to the equipment of vessels, unwrought iron and fir planks only excepted; and all the above articles are hereby declared to be just objects of confiscation whenever they are attempted to be carried to an enemy.

And whereas the difficulty of agreeing on the precise cases in which alone provisions and other articles not generally contraband may be regarded as such, renders it expedient to provide against the inconveniences and misunderstandings which might thence arise: It is further agreed that whenever any such articles so becoming contraband, according to the existing laws of nations, shall for that reason be seized, the same shall not be confiscated, but the owners thereof shall be speedily and completely indemnified; and the captors, or, in their default, the Government under whose authority they act, shall pay to the masters or owners of such vessels the full value of all such articles, with a reasonable mercantile profit thereon, together with the freight, and also the demurrage incident to such detention.

And whereas it frequently happens that vessels sail for a port or place belonging to an enemy without knowing that the same is either besieged, blockaded or invested, it is agreed that every vessel so circumstanced may be turned away from such port or place; but she shall not be detained, nor her cargo, if not contraband, be confiscated, unless after notice she shall again attempt to enter, but she shall be permitted to go to any other port or place she may think proper; nor shall any vessel or goods of either party that may have entered into such port or place before the same was besieged, blockaded, or invested by the other, and be found therein after the reduction or surrender of such place, be liable to confiscation, but shall be restored to the owners or proprietors thereof.

Note *G.*

Treaty of Commerce between the United States and France, February 6, 1778, Arts. XXIII., XXIV.

Art. XXIII. It shall be lawful for all and singular the subjects of the Most Christian King, and the citizens, people and inhabitants of the said United States, to sail with their ships with all manner of liberty and security, no distinction being made who are the proprietors of the merchandizes laden thereon, from any port to the places of those who now are or hereafter shall be at enmity with the Most Christian King or the United States. It shall likewise be lawful for the subjects and inhabitants aforesaid to sail with the ships and merchandizes aforementioned, and to trade with the same liberty and security from the places, ports and havens of those who are enemies of both or either party, without any opposition or disturbance whatsoever, not only directly from the places of the enemy aforementioned to neutral places, but also from one place belonging to an enemy to another place belonging to an enemy, whether they be under the jurisdiction of the same Prince or under several. And it is hereby stipulated that free ships shall also give a freedom to goods, and that everything shall be deemed to be free and exempt which shall be found on board the ships belonging to the subjects of either of the confederates, although the whole lading or any part thereof should appertain to the enemies of either, contraband goods being always excepted. It is also agreed in like manner that the same liberty be extended to persons who are on board a free ship, with this effect, that although they be enemies to both or either party, they are not to be taken out of that free ship, unless they are soldiers and in actual service of the enemies.

Art. XXIV. This liberty of navigation and commerce shall extend to all kinds of merchandizes, excepting those only which are distinguished by the name of contraband; and under this name of contraband or prohibited goods shall be comprehended arms, great guns, bombs with the fuzes, and other things belonging to them, cannon-ball, gunpowder, match, pikes, swords, lances, spears, halberds, mortars, petards, granades, saltpetre, muskets, musket-ball, bucklers, helmets, breast-plates, coats of mail, and the like kinds of arms proper for arming soldiers, musket-rests, belts, horses with their furniture, and all other warlike instruments whatever. These merchandizes which follow shall not be reckoned among contraband or prohibited goods; that is to say, all sorts of cloths, and all other manufactures woven of any wool, flax, silk, cotton or any other materials whatever; all kinds of wearing apparel, together with the species whereof they are used to be made; gold and silver, as well coined as uncoined, tin, iron, latten, copper, brass, coals; as also wheat and barley, and any other kind of corn and pulse; tobacco, and likewise all manner of spices; salted and smoked flesh, salted fish, cheese and butter, beer, oils, wines, sugars, and all sorts of salts; and in general all provisions which serve for the nourishment of mankind and the sustenance of life; furthermore, all kinds of cotton, hemp, flax, tar, pitch, ropes, cables, sails, sail-cloths, anchors and any parts of anchors, also ships' masts, planks, boards and beams of what trees soever; and all other things proper either for building or repairing ships, and all other goods whatever which have not been worked into the form of any instrument or thing prepared for war by land or by sea, shall not be reputed contraband, much less such as have been already wrought and made up for any other use; all which shall be wholly reckoned among free goods; as likewise all other merchandizes and things which are not comprehended and particularly mentioned in the foregoing enumeration of contraband goods; so that they may be transported and carried in the freest manner by the subjects of both confederates, even to places belonging to an enemy, such towns or places being only excepted as are at that time besieged, blocked up, or invested.

Note *H*.

Treaty between the United States and Prussia, September 10, 1785 (signed on the part of the United States by Franklin, Jefferson, and Adams), Art. XIII.

Article XIII. And in the same case of one of the contracting parties being engaged in war with any other Power, to prevent all the difficulties and misunderstandings that usually arise respecting the merchandize heretofore called contraband, such as arms, ammunition, and military stores of every kind, no such articles carried in the vessels, or by the subjects or citizens of one of the parties to the enemies of the other, shall be deemed contraband, so as to induce confiscation or condemnation and a loss of property to individuals. Nevertheless, it shall be lawful to stop such vessels and articles, and to detain them for such length of time as the captors may think necessary to prevent the inconvenience or damage that might ensue from their proceeding, paying, however, a reasonable compensation for the loss such arrest shall occasion to the proprietors: And it shall further be allowed to use in the service of the captors the whole or any part of the military stores so detained, paying the owners the full value of the same, to be ascertained by the current price at the place of its destination. But in the case supposed, of a vessel stopped for articles heretofore deemed contraband, if the master of the vessel stopped will deliver out the goods supposed to be of contraband nature, he shall be admitted to do it, and the vessel shall not in that case be carried into any port, nor further detained, but shall be allowed to proceed on her voyage.

Treaty between the United States and Prussia, July 11, 1799 (signed on the part of the United States by John Quincy Adams), Art. XIII.

Article XIII. And in the same case of one of the contracting parties being engaged in war with any other Power, to prevent all the difficulties and misunderstandings that usually arise respecting merchandise of contraband, such as arms, ammunition, and military stores of every kind, no such articles carried in the vessels, or by the subjects or citizens of either party, to the enemies of the other, shall be deemed contraband, so as to induce confiscation or condemnation and a loss of property to individuals. Nevertheless, it shall be lawful to stop such vessels and articles, and to detain them for such length of time as the captors may think necessary to prevent the inconvenience or damage that might ensue from their proceeding, paying, however, a reasonable compensation for the loss such arrest shall occasion to the proprietors; and it shall further be allowed to use in the service of the captors the whole or any part of the military stores so detained, paying the owners the full value of the same, to be ascertained by the current price at the place of its destination. But in the case supposed of a vessel stopped for articles of contraband, if the master of the vessel stopped will deliver out the goods supposed to be of contraband nature, he shall be admitted to do it, and the vessel shall not in that case be carried into any port, nor further detained, but shall be allowed to proceed on her voyage.

All cannons, mortars, fire-arms, pistols, bombs, grenades, bullets, balls, muskets, flints, matches, powder, saltpetre, sulphur, cuirasses, pikes, swords, belts, cartouch boxes, saddles and bridles, beyond the quantity necessary for the use of the ship, or beyond that which every man serving on board the vessel, or passenger, ought to have; and in general whatever is comprised under the denomination of arms and military stores, of what description soever, shall be deemed objects of contraband.

Note *I.*

Treaty between the United States and Colombia, October 3, 1824, Arts. XIV., XV.

Art. XIV. This liberty of navigation and commerce shall extend to all kinds of merchandises, excepting those only which are distinguished by the name of contraband; and under this name of contraband or prohibited goods shall be comprehended—

First. Cannons, mortars, howitzers, swivels, blunderbusses, muskets, fusees, rifles, carbines, pistols, pikes, swords, sabres, lances, spears, halberds and grenades, bombs, powder, matches, balls and all other things belonging to the use of these arms;

Secondly. Bucklers, helmets, breast-plates, coats of mail, infantry belts, and clothes made up in the form and for a military use;

Thirdly. Cavalry belts and horses with their furniture;

Fourthly. And generally all kinds of arms and instruments of iron, steel, brass and copper, or of any other materials manufactured, prepared and formed expressly to make war by sea or land.

Art. XV. All other merchandises and things not comprehended in the articles of contraband explicitly enumerated and classified as above, shall be held and considered as free, and subjects of free and lawful commerce, so that they may be carried and transported in the freest manner by both the contracting parties, even to places belonging to an enemy, excepting only those places which are at that time besieged or blocked up; and, to avoid all doubt in this particular, it is declared that those places only are besieged or blockaded which are actually attacked by a belligerent force capable of preventing the entry of the neutral.

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THE LEGENDARY AND MYTH-MAKING PROCESS IN HISTORIES OF THE AMERICAN REVOLUTION.

BY SYDNEY G. FISHER.

(Read April 18, 1912.)

Having taken the trouble some years ago to examine the great mass of original evidence relating to the American Revolution, the contemporary documents, pamphlets, letters, memoirs, diaries, the debates in parliament and the evidence obtained by its committees, I found that very little use of it had been made in writing our standard histories, works like those of Bancroft, Hildreth, Fiske, which have been the general guides and from which school books and other compilations, as well as public orations are prepared.

Others have made the same discovery and have been overwhelmed with the same astonishment. About fifteen years ago Mr. Charles Kendall Adams, astonished at what he found in the original evidence, wrote an article on the subject published in the *Atlantic Monthly* (Vol. 82, page 174), ridiculing the standard histories for having abandoned the actualities and the original evidence. Our whole conception of the Revolution, he said, would have to be altered and the history of it rewritten. Within the last year or two Mr. Charles Francis Adams has made the same discovery and in his recent volume "Studies Military and Diplomatic" has attacked the historians with even greater severity and rewritten in his usual trenchant, luminous and captivating style, a considerable portion of that history. His essays on the military strategy of the Revolution are contributions of permanent value, refreshing and ennobling, because they substitute truth and actuality for the mawkish sentimentality and nonsense with which we have been so long nauseated.

Minor investigations like the recent works on the Loyalists by Flick, Van Tyne, Ryerson and Stark, Bartlett's "Destruction of the Gaspee," Judge Horace Gray's essay on the "Writs of Assistance," publications like the Hutchinson Letters, the Clinton-Cornwallis Controversy, have of course helped to bring about this change. The general improvement in public libraries, in accessibility to the old pamphlets and original evidence of all sorts, has also helped and led to a desire for knowledge of the actual events. Lapse of time, too, is no doubt having its effect in lessening the supposed inadvisability of letting all about the Revolution be known.

Within the last two years in writing a life of Daniel Webster I had occasion to examine the original evidence of our history from the War of 1812 to the Compromise of 1850; and I found that it had substantially all been used in our histories of that period. There was no ignoring of it or concealment of it such as I had found when I investigated the original evidence of the Revolution. It is strange at first sight, that the history of our Civil War of 1861 should have all its phases so openly and thoroughly exhibited, the side of the South as well as the side of the North, both fully displayed to the public, and that the greater part of the evidence of the Revolution should be concealed. But the circumstances of the Revolution were quite different.

In the first place, the large loyalist party in this country in some places a majority, were so completely defeated, hunted down, terrorized, driven out of the country and scattered in Canada and various British possessions, that to use a vulgarism they never "opened their heads" again. It is only in recent times that any one has had the face to collect their evidence and arguments from the original sources and publish it. For more than half a century after the Revolution no writer could gain anything but condemnation and contempt for mentioning anything about them. The successful party in America would not even vilify them, but ignored them and their doings as if they had had no existence. The object of this was to make it appear that the Revolution had been a great spontaneous uprising of the whole American people without faction or disagreement among themselves. In England, strangely enough, the loyalists were also ignored and nothing said about them. They were often suspected of being half rebels, "whitewashed rebels" as they were sometimes called. Those who fled to England were apt to be treated with more or less contempt. They were often regarded as mere objects of charity, "lick pennies" as one of them complained, or at best as mere provincials of neither social nor political importance.

But at the close of our Civil War, the people of the Southern States remained in the country, were respected by the North as well as by the rest of the world, published their side of the controversy and again sent their representatives to Congress as they had done before the war. No one has as yet dared to falsify or conceal the facts of that history or turn it into myths and legends.

In the second place, after the close of the Revolution, we were for a long time a very disunited country. It was very doubtful whether the States would be able to come together and form a national government. Many thought that some of them might go back under British control. When a national constitution was at last adopted, it was regarded by the rest of the world and even by ourselves, as an experiment which very likely might not in the end succeed. In Europe, it was largely regarded as a ridiculous experiment. Our democratic ideas and manners were despised and our newness and crudeness contrasted with the settled comfort and refinement of the old nations. We felt all this keenly. Our writers and able men struggled might and main to unite our people and build up a nation. They strove to give dignity and respect to everything; to make no damaging admissions, to let not the smallest fact creep out, that might be taken advantage of. It was, therefore, perhaps too much to expect that they would describe the factions and turmoil of the Revolution as they really were, the military absurdity of the British General Howe letting it go by default, the cruelty and persecution inflicted on the loyalists and their large numbers. So they described a Revolution that never happened and never could happen. A whoop and hurrah boys! All spontaneous, all united; merciful noble, perfect; all virtue and grand ideas on one side, all vice, wickedness, effeteness and degeneration on the other.

That feeling, the boasting and the exaggeration were proper enough in one sense. It was certainly right to strive to build up the nation, and protect and dignify it. But one of the most curious instances of the way the feeling worked was Jared Sparks' edition of the letters of Washington. Sparks was the President of Harvard College, a man of intellect and learning, the author of an interesting collection of biographies of American worthies. He felt that he must exalt Washington, and so he rewrote quite a number of the Washington letters, struck out such expressions as such and such a thing would "not amount to a flea bite," altered some statements about religion and God, left out whole passages, especially those in which Washington told of cashiering officers for cowardice. Sparks was an interesting instance of the myth-making process used for pious purposes, for by magnifying Washington in this way he, no doubt, sincerely believed that he was helping religion and the youth of the country by setting up an example of perfection. Even Washington Irving, as Mr. Adams points out ("Studies Military and Diplomatic," pp. 166–168), was not a little inclined to myth-making. Irving gave us some excellent historical work, for which we should be grateful; but he could not altogether escape the taint of his time.

Jared Sparks was unquestionably a man of integrity; but he was carried away by the feeling of making a good showing by manufacturing Washington into theoretical perfection. I do not suppose that he for one moment realized that he was doing what very closely resembled some things for which persons in lower walks of life are sent to jail. He had a rude awakening when W. B. Reed discovered the whole imposture and published the original letters with the Sparks improvements side by side. But the exposure did little good; for similar methods, and evidence-ignoring on a much larger scale, were used through whole volumes of so-called history.

It is interesting in this connection to remember that Charles Thomson, the Secretary of the Continental Congress during the Revolution, wrote a history of that event; and his position and acquaintance with leading characters must certainly have given him valuable information. But he burnt the manuscript, giving as a reason that its publication would give too much offense to persons still living. He wished to quiet down everything, forget the horrible scenes, controversies and factions, and build up the country. Certainly a most laudable motive; but we must not now in these days be misled by it and accept as history all those standard volumes which when analyzed are nothing but concealment of actual facts for the sake of helping the nation.

We must, hasten, however, to the third cause of the trouble, and that was that the first history of the Revolution which all the others have followed and copied was an English whig partisan argument.

The English whig party were in a peculiar position during the Revolution, with a rebellion on hand that seemed likely to rend the British empire asunder. They were in a very small minority, overwhelmingly outvoted on every subject. They adopted as their policy for the American War, the principle, or rather supposition, that if the troops were all withdrawn from the colonies and no attempt made to coerce them, the Americans would voluntarily submit to be ruled by England and form an ideal spectacle of uncoerced colonies willingly and gladly remaining under the tutelage of their mother.

It was a beautiful ideal as developed by the great whig orators, Burke, Chatham and Barré, illustrated from history and art, and dignified by passionate appeals to sentiment and manhood. Their speeches have become classics of the English language and have been recited for a hundred years by our school boys. Those orations with others by the lesser whig lights to be found in the parliamentary debates, together with the whole whig policy, were of course, very acceptable to our people. The whigs were continually asserting that our people did not want independence; they besought mild and conciliatory measures for us; they attacked the tory measures; and so far as they succeeded in checking in this way the tory policy of coercion, they aided us in obtaining independence.

This history of the Revolution from the whig point of view was written almost as rapidly as the events occurred, not only in the whig speeches, but in the *Annual Register,* an important publication of that time, still in existence, which summed up the political and diplomatic occurrences of the year both at home and abroad as they affected England. After the Revolution was ended and people began to think of writing an account of it, they found that it was the easiest thing in the world to do. Just get down the volumes of the *Annual Register* and there it all was for each of the seventeen years of the long controversy; each year by itself clearly and cogently written; for the *Annual Register* had employed the great whig orator Edmund Burke to write these summaries every year. Burke was very careful with his dates, facts and statements so far as he chose to go and the *Register* enjoyed a high reputation in that respect. But the statements were all whig statements; no others were admitted; no facts unfavorable to the whig line of policy were admitted; and every fact and statement was given the tinge and leaning of the whig policy.

Those summaries running for seventeen years in the *Register* and the speeches of the whig orators were the material that the early historians of the Revolution used. Gordon, who wrote the first important and widely read history of the Revolution, copied page after page of the *Register* verbatim and says so in his preface to the first English edition. Those whig speeches and summaries gave the tone, the point of view and the limitations, and fixed them so rigidly that the great mass of evidence outside of those limitations has always been rejected; and when now obtruded on the public in even the mildest form, is received with staring and sometimes indignant incredulity.

I am certainly very glad that the whigs adopted the line of policy that has been described. It was a great help to our cause; and it may have been good for the whig party or at any rate the best they could do under the circumstances. But to make that mere partisan position the basis and limitation for writing history is the rankest absurdity that was ever heard of. Even as a political policy, the whig plan was a mere dream that could never be carried out in practice. It was a legal and political impossibility and contrary to common sense. There was no such thing, there never was and there never will be such a thing as a community of Americans voluntarily submitting to the absolute supremacy of a parliament three thousand miles across the Atlantic. The tory majority tried a large part of the whig plan without success. They tried conciliation and found it a failure. They repealed the stamp act and the paint, paper and glass act very early in the controversy. They made no attempt to enforce either act with troops and had scarcely any troops in the country at that time. But the colonists, instead of becoming more submissive, felt more conscious of their power and became more independent. In 1778 the tories offered to repeal practically all objectionable legislation and make a compromise that would be just short of absolute independence; but the American patriots rejected this offer as they had rejected all other attempts at conciliation that did not offer absolute independence.

If the whigs had been in power during the revolution there is no reason to suppose they would have been any more successful in conciliating the Americans than were the tories; and it is probable that they would not even have attempted to put their idealism into practice. In the Canadian rebellion of 1837 they were in power, but they suppressed that rebellion with a high hand, hanged and banished the ringleaders, did not withdraw troops, and did not rely on voluntary submission. Their idealism in the Revolution was mere minority eloquence. It is one thing to advocate an ideal theory when you are in a hopeless minority and not responsible for results, and quite another thing to put such a theory in force when you are in the majority and in power which you wish to retain.

The whig partisan policy is such a narrow point of view for writing history, that in order to maintain it and stay within it you must leave out of consideration and either conceal or ignore more than half the evidence and testimony of the eye witnesses and contemporary documents of the Revolution. You must write the Revolution merely as the English whigs saw it, or professed to see it for party purposes. You must omit large masses of evidence that have been found in both America and England. You must ignore the testimony and arguments of the tories who from the point of view of impartial history are entitled to exactly the same consideration as witnesses as the whigs and patriots. You must ignore and vilify the testimony and arguments of the loyalists, who, if history is to be anything more than falsehood agreed upon, are entitled to exactly the same consideration as witnesses as the patriots, whigs and tories.

The whig point of view ignores completely the whole mass of evidence coming from the tories and the loyalists and does not accept all the evidence coming from the patriots. As the whigs were always trying to show that the patriot party in America did not really want independence, but would be content with a compromise, they accepted no evidence that did not accord with that view.

All through the Revolution the English whigs sneered at the loyalists, rejected all their statements, and were only a step behind the patriots in condemnation of them. It seems now a little contemptible, this merciless whig condemnation of the loyalists who were trying to save the same empire which the whigs professed to have a remedy for saving. At the close of the Revolution, when the treaty of peace was signed, a section of the whig party shifted their ground, took up the cause of the loyalists and attacked the ministry for making a treaty of peace which abandoned the loyalists to the mercy of the patriots.

If you confine yourself to the whig limitation, you must not only ignore the great mass of information about the loyalists, but you must also ignore the military strategy of the war, scarcely noticed in our histories, but, as Mr. Adams shows, almost as important and interesting as the campaigns of Napoleon.

The great controversy over General Howe's motives and military conduct fills the first three years of the evidence of the war appearing in pamphlets, letters and charges against him and finally, in the voluminous evidence of his trial or investigation by Parliament. This great mass of evidence about Howe, very familiar to the people of that time, but unnoticed in our histories, gives us entirely new views and ideas of the situation. Another controversy carried on with the greatest acrimony between Clinton and Lord Cornwallis and also unnoticed in our histories, gives us an entirely new understanding of the last three years of the war and its final issue.

Then there is much unused evidence about the actual position and services of France, not to mention Spain, and Holland. There are scores of old pamphlets which show the actual arguments exchanged between the two countries on the constitutional power of Parliament in the argumentative period of the contest 1764–1774. There is the evidence about the violation of the navigation and trade laws, and about the admiralty courts. All this evidence our standard histories fail to bring to light and explain.

They give us no adequate understanding of the dozen acts of Parliament which the patriot colonists wished repealed. They never explain the full meaning of that demand of the colonists that England should never keep soldiers in a colony in time of peace, except by the consent of the colony, that England should not change or amend a colonial charter except by the consent of the colony. They do not even explain, they hardly even notice the demand by the patriots that Parliament should have no authority in the colonies or in relation to them except to regulate ocean commerce. They do not explain what the colonists meant when they said that they were willing to be ruled by the king alone. They do not compare these demands with the modern British colonial system to see whether any of them have, in modern times, been accepted by England as proper methods of colonial government.

The most curious fact about the whig and *Annual Register* method of writing our history is that in the end the English tories accepted it as the safest and best way of describing the old controversy. Most of the evidence relating to the Revolution was a very serious matter for Englishmen to handle, no matter whether their political views were tory or whig. England still had colonies, expected to have more and to go on building up a great and obedient imperial empire. The whigs in their way believed in that empire as much as the tories and gladly accepted all the profits and advantages of it. Would it be wise for English writers, whether tory, whig or "impartial," to tell the English people that the American patriot party had from the beginning hated and detested what is to this day the foundation principle of the British empire, namely, the supremacy of Parliament as absolute and omnipotent in every colony as it is in London; that they despised colonialism from the bottom of their hearts; that they believed it to be unmanly and degrading political slavery, and that the only definition of a colony that they accepted, was one which described a community like the old Greek colonies, sent out by a mother country with the intention that it should become absolutely independent, and that the mother country's only duty towards it would be to protect it from other nations and guarantee its independence.

That an English writer should describe the Revolution in this way and be compelled to admit that the American patriots had broken away from the British empire because they despised its foundation principle, was, and is, a great deal to expect of English nature or of human nature. Neither English tories nor whigs care to describe the Revolution as it occurred; and it is hardly fair to expect them to do it. Why should they deliberately excite their present colonies and their great and profitable East Indian empire to rebel and justify their rebellion. Is it not evidently much better to say with the whigs that the American patriots dearly loved England and the British empire; that they were contented, dutiful and obedient colonists; that they were not only perfectly willing but anxious to remain in the empire and share its profits and glory of world wide conquest; that their leaving the empire was a mere accident brought about by the blindness, stupidity, and wickedness of a certain tory ministry, or, as some later writers have put it, by the blindness, stupidity and self-will of the King, George III., who of himself, against the wishes of his ministry, parliament, and the English people, drove the Americans out of the empire, when they were perfectly willing to stay within it.

The first important history of the Revolution after Burke's annual summaries in the *Register*, was a four-volume work by John Andrews, LL.D., published in 1786. It followed the same lines as Burke's essays in the *Annual Register*, except that it gives much space to stating both sides of the arguments in Parliament, but in such a tiresome, verbose way, that it is almost unreadable. Andrews had no historic ability, no interpretative power; was a mere dull chronicler and summarizer. He cites no evidence or authorities, and keeps on the safe side of mere ordinary dates and events. The great mass of actual evidence; the position, the doings, the arguments of the loyalists, the causes which led to the Revolution, the real conditions in America, the navigation and trade laws, the strategy of battles, the controversy over General Howe's conduct of the war, his trial before Parliament, the Clinton-Cornwallis controversy over the final strategy—these and a host of other actualities, one would never learn anything about from the pages of John Andrews, LL.D.

In 1787 a very ambitious and laborious account of the Revolution appeared by the Rev. William Gordon, an English whig, and Congregationalist minister, who had come out to Massachusetts early in the difficulties and remained with us all through the Revolution, interviewing generals and prominent men, visiting battlefields, examining private papers and public records and collecting notes and materials. When the war ended he returned to England and wrote his history.

He was not altogether liked in America. John Adams said he talked too much, and that his history in attempting to favor both sides was a failure. But he seems to have been trusted with important papers and he was unquestionably very painstaking and accurate. Many of the papers which he examined in manuscript, notably in the year 1775, have been published in the American Archives and confirm his statements. No one has given us a better detailed contemporary account of the Battles of Fort Mifflin and Red Bank. But he had no historic ability. He follows the *Annual Register* as a basis for a great part of his information, copying from it without changing the language, and announces in his preface that he has done so. He stays cautiously within the whig limits of safety already described. The remaining British colonies would not be stirred to rebellion by anything he says. But as a chronicler who lived amidst the events of the Revolution, his work is of some value as a piece of original partisan evidence.

In 1789 Dr. Ramsay of South Carolina, who had written about the Revolution, in his own State, brought out a general history of the Revolution, which strange to say, rejected in some respects the guidance of the whigs and the *Annual Register* and in this respect stands alone. He seems to understand that the dispute between America and England was irreconcilable and could never have been settled by conciliation. He does not regard England's conduct toward the colonies as a mere mistake of a ministry, nor did he regard it as the affair of the king, but as a deliberate movement of an overwhelming majority in Parliament heartily supported by the aristocracy, the county gentry and the ruling classes, to consolidate the empire and bring the colonies under stricter regulations. He showed that under the old system the colonists had grown accustomed to semi-independence and now were bent on absolute independence. But his method of writing was so obscure and tedious and he gave himself so little room, that his book could never have much effect.

Any influence he might have had was soon overwhelmed and forgotten by the historical works of a writer of the highest order of popularity, and in that sense and influence the ablest historian we have ever produced. Prescott, Motley and Parkman are mere children when compared with him.

The truth is that Americans had no book about their great political event that was easy to read until 1800 when the Reverend Mason L. Weems came to their rescue with his "Life of Washington," followed by lives of Franklin and Marion. Parson Weems, as he was called, was, it is said, a preacher of large family and slender means, who had charge of a church in Virginia near Mount Vernon. To support his family he became a traveling book agent for Matthew Carey, of Philadelphia. He wrote books of his own and sold them in his wagon journeys through the country. He was ready with a sermon, an harangue, or a stump speech, wherever he could draw a crowd; and he would then recommend his wares and sell them from his wagon. He played well on the fiddle and was in demand at social gatherings and dances. He must have been an entertaining fellow in his way and I should like to have seen him on some of his tours through the south.

For a generation and more, his books, especially his "Life of Washington," had an enormous sale and went through over forty editions. They were necessarily histories of the revolution. His ideas on that event reached every corner of the country and every class of life; and the publishers tell me his "Life of Washington" still sells. Reckless in statement, indifferent to facts and research, his books are full of popular heroism, religion and morality, which you at first call trash and cant and then, finding it extremely entertaining, you declare with a laugh, as you lay down the book, what a clever rogue.

It is impossible to refrain from quoting from him. He is a most delightful mixture of the Scriptures, Homer, Virgil and the back woods. Everything rages and storms, slashes and tears. At the passage of the stamp act "the passion of the people flew up 500 degrees above blood heat." In battle Americans and English plunge their bayonets into one another's breasts and "fall forward together faint, shrieking in death and mingling their smoking blood." Here is his description of Morgan at the last battle of Saratoga.

> "The face of Morgan was like the full moon in a stormy night when she looks down red and fiery on the raging deep, amidst foundering wrecks and cries of drowning seamen; while his voice like thunder on the hills was heard loud shouting his cavalry to the charge."

"Far-famed Brittanica," Weems says, "was sitting alone and tearful on her Western cliff, while, with downcast looks, her faithful lion lay roaring at her feet." And we must have one more from his description of the Battle of the Cowpens.

> "As when a mammoth suddenly dashes in among a thousand buffaloes. feeding at large on the vast plains of Missouri; all at once the innumerous herd, with wildly rolling eyes and hideous bellowings, break forth into flight, while close at their heels the roaring monster follows. Earth trembles as they fly. Such was the noise in the chase of Tarleton, when the swords of Washington's cavalry pursued his troops from the famous fields of the Cowpens."

It is in vain that the historians, the exhaustive investigators, the learned, and the accurate rail at him or ignore him. He is inimitable. He will live forever. He captured the American people. He was the first to catch their ear. He said exactly what they wanted to hear. He has been read a hundred times more than all the other historians and biographers of the Revolution put together.

He fastened his methods so firmly upon the country that the learned historians must, in their own dull and lifeless way, conform as far as possible to his ideas or they will be neither read nor tolerated.

Out of the social, genial, card-playing, fox-hunting Washington, Weems manufactured the sanctimonious wooden image, the Sunday school lay figure, which Washington still remains for most of us, in spite of all the learned efforts of Owen Wister, Senator Lodge and Paul Leicester Ford. Weems was a myth-maker of the highest rank and skill and the greatest practical success. Of the Revolution itself he made a Homeric and Biblical combat of giants, titans and mammoths against the unfathomable corruption and wickedness of about a dozen dragons and fiends calling themselves King and Ministry in England.

He goes back wholly to the whigs and the *Annual Register*. The people of England, everyone on that blessed island, except the dozen ministerial fiends, were, he assures us, a noble, kindly, gentle race. He knew them well; he had lived among them when he studied theology; and they did not make war on the Americans. They would not have thought of such a thing; they disapproved of the war. As for the American colonists, though giants and mammoths when aroused, they were also a gentle people, most loving and obedient to the mother country, anxious to remain with her, had not war been cruelly made upon them.

And why then was cruel war made upon them? Simply, says Parson Weems, because "the king wanted money for his hungry relations and the ministers stakes for their gaming tables or diamond necklaces for their mistresses."

There it is in its crudest form, the ministerial explanation of the Revolution, the most popular, short, easy and practical explanation of the great event that could be devised. It reveals nothing about the real issue at stake between the two countries; nothing about the question of the supremacy of Parliament or the other great principles involved. But it pleased vast numbers of people because as expressed by Weems, they could grasp it instantly; it appealed to their suspicions of what the effete monarchies across the Atlantic really were. Expressed in different language with a few political and more refined ideas substituted for the diamond necklaces and hungry relations, it pleased the half loyalist element which still remained in the country, and it pleased a certain class among the patriots who wanted to be able to admire England, her literature, her laws, her social customs, the charming lives of her country gentry, the hedge rows and green fields, and the fashion of London. They could admire and love all these things, have social pleasures with distinguished Englishmen, talk about the Anglo-Saxon race, its glories and conquests, and yet remain true Americans, because the Revolution had been a mere ministerial war, a ministerial accident, unconnected with the rest of England and such an accident could never happen again.

We might dispose of all the subsequent histories of the Revolution by simply saying that they followed along in this short and easy method. Even Chief Justice Marshall in his Life of Washington published in 1804, though once or twice disposed to break away, trots along in the same old rut.

In 1809 quite a popular history of the Revolution appeared in French, which went through twenty editions in Europe. It was written by Charles Botta of Northern Italy, who had been a surgeon in the French army, and was appointed by Napoleon on the commission to govern the Italian republic he established. It was made up, the author himself tells us, from the *Annual Register,* other histories, the parliamentary debates and pamphlets. But it is all *Annual Register* and so dull that a modern reader has difficulty in getting through a single chapter. The American translation went through ten editions. Adams and Jefferson, who were still alive, praised it highly. The popularity of such a tedious compilation is hard to understand, unless it was that our people were pleased because it was a French and Italian defence of our Revolution and institutions.

Hildreth's "History of the United States," published in 1849, devoted parts of the third and fourth volumes to the Revolution. It was a carefully written work, in much better style than its predecessors, and is still pleasant to read, but was a conventional chronicle within the established lines.

It was quickly followed by two other histories, one by Lord

Mahon and one by George Bancroft. Lord Mahon, afterwards Lord Stanhope, was a man of distinction in English politics and literature, founder of the National Portrait Gallery and closely associated with the amendment of the English copyright law and the Historical Manuscripts Commission. His "History of England" from 1713 to 1783 came out a volume at a time, between the years 1836 and 1853. In the last three of the seven volumes it touched upon the Revolution. It was the first account of that great event written in a style of any literary merit; and Lord Mahon's style possessed great merit. Without the slightest attempt at the eloquence or rhetoric supposed by some to be necessary for history, he relies on mere clearness and aptness of words to convey the ideas of a very cultivated and intelligent mind. Every page of it is interesting and is likely to remain so for all time. As a history of England it is full of information, especially of the prominent characters of the time; but as an account of our Revolution, it touches only the surface. He goes no deeper than to say that the loss of the colonies was a mere accidental piece of foolishness on the part of the ministry; and having started with that position his pleasing narrative keeps within the lines of safety.

In 1852 Bancroft's "History of the United States" reached the Revolutionary period. It had been coming out a volume at a time since 1832. Bancroft was of Massachusetts origin and studied in Germany where, perhaps, he over-educated and over-Germanized himself. He traveled extensively, met distinguished men, became Secretary of the Navy and founded the Naval Academy at Annapolis. He was also minister from the United States to England and to Germany. It was a splendid experience and one would naturally expect from him something of broader gauge than his very cramped, and bitter partisan account of the Revolution.

It was the most violently partisan and timorously defensive history of the Revolution that had appeared. It was most cautiously written, with the greatest dread of the slightest admission, and with intense straining to make out a perfect case. Entirely devoid of candor, his fierce assaults on the character of Governor Hutchinson, his assignment to him of every contemptible motive, his sweeping condemnation and ignoring of the loyalists, and his omission of everything that did not support the English whig theory, have made his work more violently and narrowly one-sided than the partisan pamphlets of the period of which he was writing.

His early volumes dealing with the discovery of the continent and the colonial period were much better than those relating to the Revolution. He restored to remembrance many important points in colonial history which, for want of an adequate account had been forgotten. But in the Revolution he became merely a scholarly Weems, carrying to exaggeration the worst features of Weems and Botta.

In his treatment of the Writs of Assistance, he declaims against the decision of the Massachusetts court allowing them, as contrary to the law and the constitution and cowardly subserviency to the British Government. But the decision was perfectly sound law as Judge Gray of the Supreme Court shows in his admirable investigation of the subject; and until we recognize it as sound and investigate from that point of view, we shall never get any farther in the history of the Revolution than mere demagogueism and declamation.

In his volumes on the colonial period, Bancroft made in footnotes a number of citations to the original evidence, and some when he reached the Revolution. But those for the Revolution were very inadequate; and in subsequent editions, for his work had a wide circulation, the citations for the Revolutionary part grew less and less until in the end they disappear almost altogether, and he gives no references for his innumerable quotations. His researches for material both in this country and in Europe are described by his friends as the most remarkable ever made. Documents and sources of information closed to all others were, we are assured, open to him. But strange to say, we see no result of this in his published work. Nor can any subsequent investigator profit by his labors; the wondrous and mysterious sources of information remain mysterious; and many of his opinions are difficult to support with the evidence which investigators are able to find.

This practice of not giving the evidence in footnote citations has been characteristic of all our histories and is indeed, quite necessary and proper when the essential principle is that the greater part of the original evidence must be ignored. The habit of citation once begun, might be carried too far.

Fiske, whose volumes on the Revolution have been published since the Civil War, makes no citations of the original evidence. Possibly he has forestalled criticism in this respect by the statement in the preface to his illustrated edition, that his work is a mere historical sketch. But it is two volumes containing some seven hundred pages, confident and positive in tone. For the sources of his material he refers us to Winsor's "Hand Book of the Revolution," and the notes of the "Narrative and Critical History of America." But he might just as well have referred us to the card catalogues of the public libraries. Such a general reference means nothing; and a very large part of the material contained in Winsor's "Hand Book" and in the "Narrative and Critical History" is made up of commentaries on the Revolution, which are becoming more and more numerous as time goes on. We have not yet learned in this country to distinguish sharply between the original evidence and the subsequent commentaries. Our histories are usually written from the commentaries which are numerous, more accessible, more full of suggestion of all sorts, and easier to write from and understand than the original evidence.

Fiske's account of the Revolution was, however, superior to all previous histories because it contains practically all that Bancroft and the rest contain much better expressed. It would be difficult to improve on Fiske's style of writing for clearness, beauty and readableness. Bancroft attempted the old-fashioned rhetorical style, which, in his hands, ran to turgidity and bombast. Oratorical dignity, the style that has been so often applied with success to Greek and Roman history, is probably inadequate, in any hands, to the economical, legal and constitutional, the prosaic, plebeian and democratic struggle, which took place in America. Lord Mahon's style was far better than the classic oratorical; and Fiske's is the best of all.

Fiske was an extreme admirer of Gladstone, the English liberal party, its predecessor the whig party, and the whole system of the British empire. At almost every step he brings in this admiration for England; "her glorious records of a thousand years," and her dominion "on which the sun shall never set." If Gladstone had been alive in 1776 he and Washington would have settled the whole difficulty amicably, the English speaking race would not have been divided, and the United States would in some wonderfully sweet way have remained British colonies and part of the British empire. the great civilizer of the world. That is the keynote of his history; and it is all written within that limitation. No one has so glorified and enlarged the old whig and *Annual Register* idea.

He limits himself and narrows his point of view still more by assigning the obstinacy of the king and his love of personal government as the cause of all the difficulty. The king deceived and forced the ministry, Parliament and the English people, and kept them deceived and forced during eleven years of argument and eight years of war.

This one-man explanation of great political events is a cheap and easy historical device of very wide application. It is very dramatic and from a literary point of view, very telling and interesting. Fiske varies it and makes it more dramatic by assuring us that the person who put the wickedness into the head of George III. was Charles Townshend.

That is a very pretty and interesting touch, to have Mephistopheles whispering in the ear of the one man. Botta, who also had the one-man idea, said that the devil who did the whispering was Lord Bute. And, indeed, the devil might be varied indefinitely, because there were so many people suggesting those ideas at that time. The editor of the *Boston Gazette* may have been the devil; for Townshend's main idea can be found in the pages of that journal long before Townshend promulgated it. If Mr. Fiske and his followers will admit that there were many million devils comprising the majority of the Parliament and people of England together with the loyalists in America all whispering and some talking very loud for the encouragement of George III., the one-man theory will become comparatively harmless.

If modern comprehensive investigation aided by improved libraries and collections has established anything, it is that the prominent or great individuals, while undoubtedly valuable, are more apt to be the results and outcome of political movements than the causes of them. The Revolution was a world movement forced on by the thought of millions of people. Its beginnings extend far back of 1764, and George III. merely swam in the current. In the face of all the accumulated evidence of its workings, to assign the responsibility for it to one man may do well enough for eulogistic biography or oratory; but is hardly admissible in history, if history is to be anything more serious than the latest novel.

In recent years another history of the Revolution, not yet completed, but very voluminous, by Sir George Otto Trevelyan, has been appearing in England, a volume at a time. Mr. Trevelyan is remembered for his admirable "Life and Letters of Lord Macaulay," published nearly forty years ago and for his subsequent life of his relative, Charles James Fox, the brilliant whig orator in Parliament at the time of our Revolution. The life of Fox treated only of that statesman's early years; and in his preface to the history Mr. Trevelyan explains that he finds he can write the rest of Fox's life only by writing a history of the American Revolution about which Fox so often spoke in Parliament.

It hardly accords with an American's idea of the dignity of that event to see it regarded as mere illustrative material for the biography of a very reckless and insolvent gambler, who, however able he may have been as a minority speaker in Parliament, and however interesting he may still be to his family, was by no means the most effective statesman England has produced. Our sense of proportion is somewhat outraged by the exaltation of the gambler through six volumes of the American Revolution, with more to come.

At the same time it must be confessed that from a literary point of view, and in Mr. Trevelyan's skilful hands, the sacrifice of history to an overestimate of a picturesque relative keeps his readers interested and amused. The volumes are full of anecdote, reminiscence, political and literary gossip of the intellectual sort; and the best parts of the work are the descriptions of English life and conditions in that age. The diffuseness of the style seems to an American less suitable to history than Fiske's matchless brevity and ease, and it is far inferior in intellect, keenness and humor to the style of Mr. Charles Francis Adams. But Mr. Trevelyan is a delightful master of telling idioms, and clever phrasing, which have placed him where he is in English literature.

He is a distinguished member of the English liberal party and this with his natural sympathy for that party's predecessors, the old whigs and for his picturesque relative, combined with the necessity for not saying anything to impair modern British control of colonies, forces his book into the most narrow form of the Weems ministerial explanation.

As an attack upon the tory ministry of that period, nothing probably will ever equal the accumulated force, the massing of details, the sweeping condemnation and the charm of language of Mr. Trevelyan's work. The unfortunate ministry is overwhelmed and buried under a mass of disapprobation that exceeds in weight and volume all that Fox and all that all the other whig orators ever said against them. Every fact, every inference, every delicate insinuation that lapse of time, historical perspective and the labor of years can bring together, is heaped upon them. Their depravity, malignity, and stupidity are unspeakable, especially when contrasted with the enlightened virtue and perfection of Fox and the whigs. It is perfectly obvious that the American colonies were lost merely by the peculiar circumstances of the cruelty and absurdity of this extraordinary ministry, the like of which in infamy has never been known before or since. That is all there is in the American Revolution; and it is also quite evident that if the plans of Fox and the whigs had been carried out those affectionate and long-suffering colonists who dearly loved the British empire would have remained in it in some ideal and friendly relation, which is not definitely described.

Mr. Trevelyan is not impressed by the difference between the original contemporary evidence and the subsequent innumerable commentaries or secondary authorities. He cites one as readily as the other; and his investigations into the original evidence appear to have been very moderate. He ignores the greater part of it. The secondary authorities suit him better, because they support the ministerial explanation. Except for the descriptions of English life and manners, his work is largely made up from the commentators. It is melancholy that a man of so much talent should surrender himself body and soul to this old stupidity of forever rewriting the Revolution from the accumulating opinions of commentators, which move farther and farther away from the evidence; and now Mr. Trevelyan's six or a dozen volumes must be thrown into the mass to be re-hashed for another progress away from the original evidence.

Within the last year or so, however, there has appeared an English history of the Revolution by the Rev. Mr. Belcher, which shows a most decided familiarity with the original evidence and an equally decided determination to jump out of the old whig and *Annual Register* rut. He is the first Englishman that has discovered, or has been willing to admit, that there is a great mass of loyalist evidence. He gives his book an entirely correct title and calls it "The First American Civil War." He is rather an interesting and clever phrase-maker, after the manner that has been popular in England for some time. But he runs on too much into mere political gossip, unrelated details, and his book, in consequence, lacks logical sequence; an inevitable defect, some will say, in a man of religion. But no matter about that, and no matter about his taking a very John Bull point of view, and safeguarding John's face and colonial possessions. He has jumped out of the old rut. He is in the original evidence; and for that heaven be praised even if he only flounders in it.

Since the above paragraph was written my attention has been called to an article in Blackwood's Magazine (March 1912, p. 409), attacking with very considerable severity and ridicule the absurdity of continuing to write the history of the American Revolution from the narrowness of the old whig point of view. It is mere "senseless panegyric," the writer says. As a piece of history "it belongs to the dark ages;" it represents the views of the desperate whigs which will never again be expressed by a serious historian.

Why be so scared and timorous about the original evidence, and why conceal it. After the first plunge and shock of the cold water is over, you will enjoy it. The real Revolution is more useful and interesting than the make-believe one. The actual factions, divisions, mistakes, atrocities, if you please, are far more useful to know about than the pretense that there were none. The real patriots who hated colonialism and alien rule in any form and who were determined to break from the empire no matter how well it governed them, are more worthy of admiration than those supposed "affectionate colonists," who, we are assured, if they had been a little more coddled by England, would have kept America in the empire to this day.

There has recently been some discussion in the newspapers on the hopelessness of all efforts to make good plays or even good novels out of the scenes of our struggle for independence. Why should our Revolution, it is asked, be so totally barren in dramatic incident and dramatic use and some other revolutions so rich in that use. May it not be because our Revolution has been so steadily and persistently written away from the actual occurrences, that novelists and play writers when they search for material find a scholastic, academic revolution that never happened and that is barren of all the traits of human nature.

PHYLOGENETIC ASSOCIATION IN RELATION TO THE EMOTIONS.

By GEORGE W. CRILE, M.D.

(Plates I–VIII.)

(*Read April 22, 1911.*)

To the surgeon every variety of the human emotions in the various stations of life, from infancy to senility, in health and in disease is presented. Not only does the surgeon come in intimate contact with emotions displayed by the victims of disease and accidents but he also observes those manifested by the remainder of the family circle and friends. Then, too, he is unhappily forced to notice the effects upon himself when he is waging an unequal battle against death—the strain and worry at a crisis when a life is in the balance and a single false move may be fatal is an experience unknown to others as it is to the operating surgeon.

My personal experience as a surgeon and an experimental research of my associates, Dr. H. G. Sloan, Dr. J. S. Austin, and Dr. M. L. Menten, and myself furnish data for this paper.

On this occasion I shall limit my discussion mainly to the strongest emotion, viz., *fear*. I believe that it can be shown that the emotion of fear can be elicited only in animals that utilize a motor mechanism in defense against danger or in escape from it. For example: the defense of the skunk is a diabolic odor which repels its enemies. The skunk has no adequate equipment for defence or escape by muscular exertion. The skunk has little or no fear. Again certain species of snakes are protected by venom. They possess no other means of defense nor adequate motor mechanism for escape. They show no fear. Other animals because of their prowess have but few fears. The lion, the grizzly bear, and the elephant are examples. Animals having armored protection, as the turtle, have little fear. It is therefore obvious that fear is not universal. The emotion of fear is felt only in those animals whose self-preservation is dependent upon an uncertain adequacy of their power of muscular exertion either in defense or in flight.

What are the principal phenomena of fear? They are palpitation of the heart, acceleration of the rate and alteration of the rhythm of the respiration, cold sweat, rise in body temperature, tremor, pallor, erection of the hair, suspension of the principal functions of digestion, muscular relaxation and staring of the eyes. The function of the brain is wholly suspended except that which

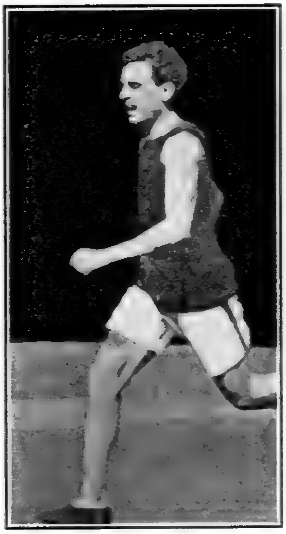

FIG. 1. The expression in this picture, copied from "Outing," shows the participation of the facial muscles in physical action—perhaps it may indicate the origin of the activity of the facial muscles in ancient fighting with teeth.

relates to the self-protective response to the object feared. Neither the brain nor any other organ of the body can respond to any other lesser stimulus during the dominance of fear.

From the foregoing it would appear that under the influence of fear, most, perhaps all of the organs of the body, are divided sharply into two classes: first, those that are stimulated, and second, those that are inhibited. Those that are stimulated are the entire muscular system, vasomotor and locomotor systems, the senses of perception, the respiration, the mechanism for erecting the hair, the sweat glands, the thyroid gland, the adrenal gland (Cannon), and the special senses. On the other hand the entire digestive and procreative functions are inhibited. What is the significance of this grouping? So far as we know the organs stimulated increase the efficiency of the animal for fight or for flight. It is through skeletal muscles that the physical attack or escape is affected; these muscles alone energize the claws, the teeth, the hoofs, and the means for flight. The increased action of muscles of the heart and the blood vessels increases the efficiency of the circulation; the secretion of the adrenal gland causes a rise in the blood pressure; the increased action of the thyroid gland causes an increased metabolic activity; there is evidence that glycogen is actively called out, it being the most immediately available substance for the production of energy; the increased activity of the respiration is needed to supply the greater requirements of oxygen and the elimination of the increased amount of waste products; the dilation of the nostrils affords a freer intake of air; the increased activity of the sweat glands is needed to regulate the rising temperature of the body from the increased metabolism. The activity of all of the organs of perception —sight, hearing, smell—are heightened for the purpose of more accurately perceiving the danger. It can not be a mere coincidence that the organs and the tissues that are stimulated in the emotion of fear are precisely those that are actually utilized in the perception of danger in a physical struggle for self-preservation.

Are there any other organs stimulated by fear except those that can or that do assist in making a defensive struggle? I know of none. On the other hand, if an animal could dispense with his bulky digestive organs, whose functions are suspended by fear, if he could, so to speak, clear his decks for battle, it would be advantageous. Although the marvelous versatility of natural selection apparently could devise no means of affording this advantage, it shut off the nervous current and saved the vital force these noncombatants ordinarily consume in the performance of their functions. Whatever the origin of fear is, its phenomena are due to a stimulation of all of the organs and tissues that add to the efficiency of the physical struggle for self-preservation through the motor mechanism and an inhibition of the function of the leading organs that do not participate—the non-combatants, so to speak. Fear arose from injury, and is one of the oldest and surely the strongest emotion. By the slow process of vast empyricism nature evolved the wonderful defensive motor mechanism of many animals and of man. Now the stimulation of this mechanism leading to a physical struggle is action, and the stimulation of this mechanism without action is emotion.

We may say that fear is a *phylogenetic fight or flight*. On this hypothesis all the organs and parts of the entire animal are integrated, connected up or correlated, for self-preservation by activity of its motor mechanism. We fear not in our hearts alone, not in our brain alone, not in our viscera alone; fear influences every organ and tissue—each organ or tissue is stimulated or inhibited according to its use or hindrance in the physical struggle for existence. In thus concentrating all or most of the nerve force on the nerve muscular mechanism for defense alone, a greater physical power is developed. Hence, it is that animals under the stimulus of fear are able to perform preternatural feats of strength. Then, too, for the same reason the exhaustion following fear will be the greater, as the powerful stimulus of fear drains the cup of nervous energy, though no visible action may result. An animal under the stimulus of fear may be likened to an automobile with the clutch thrown out but whose engine is racing at top speed. The gasoline is being consumed, the machinery is being worn, but the machine as a whole does not move, though the power of its engine may cause it to tremble.

Applying this conception to human beings of today certain mysterious phenomena are at once elucidated. It must be borne in mind that man has not been presented with any new organs to meet the requirements of his present state of civilization—indeed not only does he possess the same type of organs as his savage fellows but also the same type of organs possessed by even the lower animals. In fact the present status of civilization of man is now operated with the primary equipment of brutish organs. Perhaps the most striking difference is the greater control man has gained over his primitive instinctive reactions. Contrasted with the entire duration of organic evolution, man has come down from his arboreal abode and assumed his new rôle of increased domination over the physical world but a moment ago. And now, though sitting at his

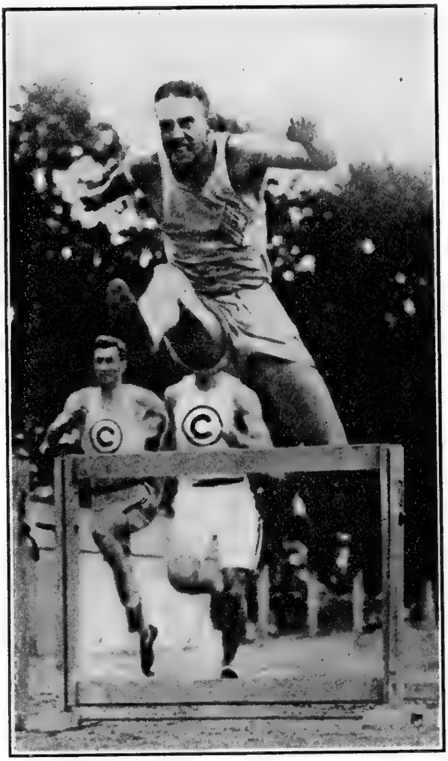

FIG. 2. Note the resemblance between the facial expression in the great efforts of the athlete and the expression of the strong emotions. The relation of motion and emotion becomes more obvious as strong motor and emotional acts are compared. From "Outing."

desk in command of a complicated machinery of civilization, when he fears a business catastrophe it is in the terms of his ancestral physical battle in the struggle for existence. He cannot fear intellectually, he cannot fear dispassionately, he fears with all of his organs, and the same organs are stimulated and the same organs are inhibited as if instead of its being a battle of credit, of position or of honor, it were a physical battle with teeth and claws. Whether the cause of acute fear is moral, financial, social, or stage fright, the heart beats wildly, the respirations are accelerated, perspiration is increased, there is a pallor, trembling, indigestion, dry mouth, etc. The phenomena are those of physical exertion in self defense or escape. There is not one group of phenomena for the acute fear of the president of a bank in a financial crash and another for the hitherto trusted official who suddenly and unexpectedly faces the naked probability of the penitentiary; or one for a patient who unexpectedly finds he has a cancer and another for the hunter when he shoots his first big game. Nature has but one means of response and whatever the cause the phenomena are always the same—always physical.

The stimulus of fear if repeated from day to day, whether it be a mother anxious on account of the illness of a child; a business man struggling against failure; a politician under contest for appointment; a broker in the daily hazard of his fortune; litigants in legal battle, or a jealous lover who fears a rival,—the countless real as well as baseless fears in daily life—all forms of fear as it seems to me, express themselves in similar terms of ancestral physical contest and on this law dominate the various organs and parts of the body. Anger and fear express opposite states. Fear expresses the evidence of a strong desire to escape from danger; anger, a strong desire to attack physically and vanquish opposition. This hypothesis is strongly supported by the outward expression of fear and anger. When the business man is conducting a struggle for existence against his rivals and when the contest is at its height, he may clench his fists, pound the table, perhaps show his teeth and he may exhibit every expression of physical combat. Fixing the jaw and showing the teeth in anger merely emphasizes the remarkable tenacity of phylogeny. Although the development of the wonderful efficiency of the hands has led to a modification of the once powerful canines of our progenitors, the ancestral use of the teeth for attack and defense is attested in the display of anger. In all stations of life differences of opinion may lead to argument and argument to physical combats, even to the point of killing. Physical violence of the savage and the brute still lies surprisingly near the surface.

There have now been presented some of the reasons based largely on gross animal behavior why fear is to be regarded as a

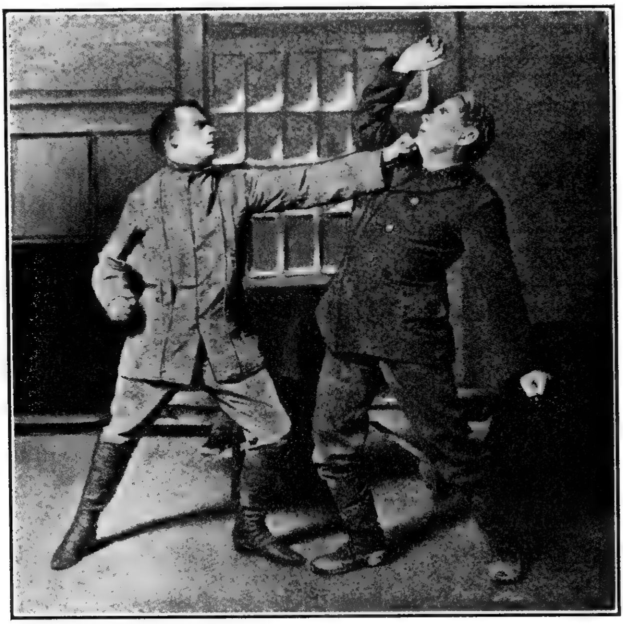

FIG. 3. The attitude and the facial expression represent anger, and the integration of the entire body for a strong aggressive action shows the extent to which the body of man has been evolved as a motor mechanism. From "Outing."

response to phylogenetic association of physical danger. I shall now present some additional evidence in support of this hypothesis from the clinical and the experimental side. Although there is not convincing proof yet there is evidence that the effect of the stimulus of fear upon the body without physical activity is more injurious than actual physical contest which results only in fatigue without gross physical injury. It is well known that the soldier lying under fire waiting in vain for orders to charge suffers more than the soldier that flings himself into the fray; that a wild animal in an open chase against capture suffers less than when cowering in captivity. An unexpressed slumbering emotion is measurably relieved by action. It is probable that the various energizing substances needful in physical combat such as the secretion of the thyroid, the adrenals, etc., but which are not consumed in action may, if frequently repeated, cause physical injury to the body. That the brain is definitely influenced, even damaged by fear has been proved by the following experiments:

Rabbits were frightened by a dog but not injured, and not chased. After various periods of time the animals were killed and their brain cells compared with the normal. Widespread changes were seen. The principal clinical phenomena expressed by the rabbit were rapid heart, accelerated respiration, prostration, tremors, and a rise in temperature.

The dog showed similar phenomena—excepting instead of muscular relaxation as in the rabbit the dog showed aggressive muscular action. Both the dog and the rabbit were exhausted and although the dog exerted himself actively and the rabbit remained physically passive, the rabbit was much more exhausted.

Further observations were made upon the brain of a fox chased for two hours by members of a hunt club, then finally overtaken by the hounds and killed. The brain cells of this fox as compared with those of a normal fox showed extensive physical changes in most of the cells.

The next line of evidence is offered with some reservation but it has seemed to me to be more than mere idle speculation. It relates to the phenomena of one of the most interesting diseases in the entire category of human ailments—I refer to exophthalmic goiter or Graves' Disease—a disease primarily involving the emotions. This disease is frequently the direct sequence of severe mental shocks or a long and intensely worrying strain. The following case is typical. A broker was in his usual health up to the panic of 1907. During this panic his fortune and that of others was for almost a year in jeopardy, failure finally occurring. During this heavy strain he became increasingly more nervous, and imperceptibly there appeared a pulsating enlargement of the thyroid gland, an increased prominence of the eyes, marked increase in perspiration, even profuse sweating, palpitation of the heart, increased respiration with frequent sighing, increase in blood pressure; there was tremor of many muscles, rapid loss of weight and strength, frequent gastro-intestinal disturbances, loss of normal control of his emotions, and marked impairment of his mental faculties. He was as completely broken in health as in fortune. These phenomena

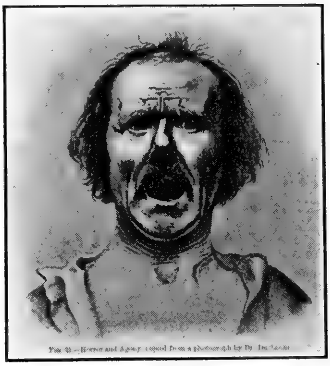

FIG. 4. This picture is taken from Darwin's "Expression of the Emotions in Man and Animals" and expresses horror and agony.

resembled closely those of fear and followed in the wake of strain due to fear.

In young women exopthalmic goiter often follows in the wake of a disappointment in love; in women, too, it frequently follows in the wake of an illness of a child or parent in which the double strain of worry and of constant care is present. Since such strains usually fall heaviest upon woman, they are the most frequent victims. Now, whatever the exciting cause of exophthalmic goiter, whether unusual business worry, disappointment in love, a tragedy, or the illness of a loved one, the symptoms are alike and closely resemble the phenomena of one of the great primitive emotions. How could disappointment in love play a rôle in the causation of Graves' Disease? If the hypothesis presented for the explanation of the genesis and the phenomena of fear is correct then it would hold for the emotion of love. If fear is a phylogenetic physical defense or escape but without resulting in muscular action then love is a phylogenetic conjugation without physical action. The quickened pulse, the leaping heart, the accelerated respiration, the sighing, the glowing eye, the crimson cheek, and many other phenomena are merely phylogenetic recapitulations of ancestral acts.

The thyroid gland is believed to participate in such physical activities. Hence, it could well follow that the disappointed maiden who is intensely integrated for a youth will at every thought of him be subjected by phylogenetic association to a specific stimulation analogous to that which attended the ancestral consummation. Moreover, a happy marriage has many times been followed by a cure of the exophthalmic goiter which appeared in the wake of such an experience. The victims of Graves' Disease present a counterpart of emotional exhaustion. The emotions in Graves' Disease are abnormally acute as illustrated by personal observation of death of a subject of this disease from fear alone. Whatever the exciting cause of this disease the symptoms of Graves' Disease are the same; just as in fear the phenomena are the same whatever the exciting cause. In Graves' Disease as illustrated by the photographs the resemblance is close to that of fear. The following phenomena fear and Graves' Disease have in common: increased heart beat, increased respiration, rising temperature, muscular tremors, protruding eyes, loss in weight; Cannon has found an increased amount of adrenalin in the blood in fear and Frankel in Graves' Disease; increased blood pressure; muscular weakness; digestive disturbances; impaired nervous control; hypersusceptibility to stimuli; in protracted intense fear the brain cells show marked physical changes; in Graves' Disease analogous changes are seen. In Graves' Disease there seems to be a composite picture of an intense expression of the great primitive emotions. If Graves' Disease is a disease of the great primitive emotions or rather of the whole motor mechanism how is the constant flow of stimulation of this complicated mechanism supplied? It would seem that at some period there must be secreted in excessive amount some substance that activates the motor mechanism; then too the nervous system in Graves' Disease is hypersusceptible to stimuli and to thyroid extract. It might follow that even a normal amount of thyroid secretion

Fig. 5. This photograph of fear closely resembles the expression of patients afflicted with Graves' disease or exophthalmic goiter.

would lead to excessive stimulation of the hypersusceptible motor mechanism.

This condition of excessive motor activity and hyperexcitability may endure for years. What is the source of this pathologic excitation?

The following facts may give a clue, viz., in suitable cases of Graves' Disease if the thyroid secretion is sufficiently diminished by a removal of a part of the gland or by interruption of the nerve and the blood supply, the phenomena of the disease are immediately diminished, and in favorable cases the patient is restored to approximately the normal condition. The heart slows, the respiration falls, the restlessness diminishes, digestive disturbances disappear, tremors decrease, there is a rapid increase in the body weight, and the patient gradually resumes his normal state. On the other hand, if to a *normal* individual extract of the thyroid gland is administered in excessive dosage over a period of time, there will develop nervousness, palpitation of the heart, sweating, loss of weight, slight protrusion of the eyes, indigestion; in short there will be produced, artificially, most of the phenomena of Graves' Disease and of the strong emotions. On discontinuing the administration of the thyroid extract these phenomena may disappear. On the other hand, when there is too little or no thyroid gland the individual becomes dull and stupid and emotionless, though he may be irritable; but if a sufficient amount of thyroid extract is given such a patient he may be brought up to the normal again.

Hence, we see that the phenomena of the emotions may be, within certain limits, increased, or may be diminished, or abolished by increasing, diminishing, or totally excluding the secretion of the thyroid gland.

Graves' Disease may be increased by giving thyroid extract, and by fear. It may be diminished by removing a part of the gland, or by tying the blood and nerve supply, or by complete rest. Finally in Graves' Disease there is at some stage an increase in the size and in the number of the secreting cells. These facts relating to the normal and the pathological supply of thyroid secretion point to this gland as one of the sources of the energizing substance or substances for the execution of the motor phenomena of animals as well as the expression of their emotions.

Anger is, of course, of similar origin and is an integration and stimulation of the motor mechanism and its accessories. Animals having no natural weapons for attack experience no emotion or anger, and the animals that have weapons for attack express anger principally by energizing the muscles used in attack. Although the efficiency of the hands of man has largely supplanted the use of the teeth, he still shows his teeth in anger and so gives support to the remote ancestral origin of this emotion and the great persistence of phylogenetic association. On this conception we can understand why it is that a patient consumed by worry—which to me signifies the state of alternation between hope and fear—interrupted stimulation, suffers so many bodily impairments and even diseases. It explains the slow dying away of animals in captivity. It explains the grave digestive and metabolic disturbance under any nerve strain—especially under the strain of fear, and the great benefits of confidence and hope; it explains the nervousness, loss of weight, indigestion—in short the comprehensive physical changes that are

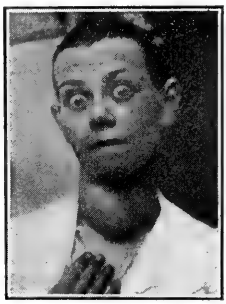

FIG. 6. This is a typical picture of exophthalmic goiter, and illustrates well its resemblance to the expression of the emotion of fear. From American Practice of Surgery.

wrought by fear and sexual love and hate, On this hypothesis we can understand the physical influence of one individual over the body and personality of another; and of the infinite factors in environment that play a rôle in the functions of many of our organs all through phylogeny and association. It is because we were evolved as motor beings on the uncompromising law of survival of the fittest, hence it is that we are not in possession of any organs or faculties which have not served our progenitors in their survival in the relentless struggle of organic forms with each other. We are now as we were then essentially motor beings and our only way of responding to the dangers in our environment is by a motor response. Such a motor response implies the integration of our entire being for action and the activity of certain glands such as the adrenals, the thyroid, the liver, etc., resulting in the throwing into the blood stream substances which help to form energy, but which if no muscular action ensues are harmful elements in the blood.

While this motor preparation is going on the entire digestive tract is inhibited. It is then clear that an emotion is more harmful than action.

If the agency that inspires sufficiently the faith—whether the agency be mystical, human, or divine—whatever dispels worry will at once stop the body-wide stimulations and inhibitions which cause lesions as truly physical as a fracture. The striking benefits of good luck, success and happiness; of the change of scenes; of hunting or fishing; of optimistic and helpful friends, are at once explained by this hypothesis. One can also understand the difference between the broken body and spirits of an animal in captivity and its buoyant return to normal condition when freed; but time will not permit following this tempting lead which has been introduced for another purpose, which I may say, is one of the principal objects sought in this paper, viz., a proposed remedy.

Worries either are or are not groundless. Of those that have a basis many are exaggerated. It has occurred to me to utilize as an antidote an appeal to the same great law that originally excites the instinctive involuntary reaction known as fear, viz., the law of self-preservation.

I have found that if an intelligent patient suffering from fear is made to see so plainly as to amount to a firm conviction that his brain, his various organs, indeed his whole being could be physically damaged by fear, this same instinct of self-preservation will to the extent of his conviction, banish fear. It is hurling threatened active militant danger, whose imperious influences are both certain and known, against an uncertain, perhaps a fancied one, or in other words fear itself is an injury which when recognized is instinctively avoided. In precisely a similar manner anger may be softened or banished by an appeal to the stronger self-preserving instinct of the fear of physical damage,—such as the physical injury of brain cells. This playing of one primitive instinct against another is comparable to the effect upon two men quarrelling when a more powerful enemy of both comes threateningly on the scene.

The acute fears of surgical operations may be banished by the use of certain drugs that depress the associational power of the brain and minimize the evidence that usually inspires fear. If in addition the entire field of operation is blocked by local anesthesia so that the associational centres are not awakened, the patient passes through the operation unscathed.

The phylogenetic origin of fear is injury, hence injury and fear cause the same phenomena—psychic shock is the same in quality and in its phenomena as traumatic shock. The perception of danger by the special senses as the sound of the opening gun of a battle, the sight of a venomous snake, cause the same effects upon the entire body and are phylogenetically the same as operations under anesthesia or a physical combat in that they all drive the motor mechanism. The use of local anesthetics in the operative field prevents the injury currents from reaching the brain and there integrating the entire body for a self-defensive struggle, though a part of the brain is asleep and the muscles paralyzed, is the same as the interception of the terrifying sound of the gun, or the sight of the dangerous reptile, because it prevents the stimulation of the motor mechanism. From both the negative and positive side we find abundant evidence which forces us to believe that the emotions are primitive instinctive reactions representing ancestral acts which utilize the complicated motor mechanism which has arisen through the forces of evolution in establishing beings best suited for their adaptation to their environment and for procreation.

The mechanism by which the motor acts are performed, and the mechanism by which the emotions are expressed are one and the same. These acts in their infinite complexity are performed by association, *i. e.,* phylogenetic association. When our progenitors came in contact with excitation in their enviromnent, action ensued then and there. There was much action—little restraint or emotion. Civilized man is really in auto-captivity. He is subjected to innumerable stimulations, but custom and convention frequently prevent physical action. When these stimulations are sufficiently strong but no action ensues, the reaction constitutes an emotion. A phylogenetic fight is anger; a phylogenetic flight is fear; a phylogenetic copulation is sexual love, and so one finds in this conception an underlying principle which may be the key to an understanding of the emotions and of certain diseases.

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THE NATURE OF THE JAPANESE VERB, SO-CALLED.

By BENJAMIN SMITH LYMAN.

(Read April 12, 1912.)

In the first place, what is properly a verb? The term was first applied to a clearly defined class of Greek and Latin words, and has ever since been supposed to belong to words of essentially similar character in those and other languages. As the old grammars undertake to describe that character, a verb is a word that signifies to be, to do, or to suffer; that is, broadly an action; but is the definition not so general that it might include even the words existence, action, experience? Is a verb not more precisely and distinctively a term that in a single word expresses not only being, doing, or suffering, but at the same time indicates personality, time, mood and voice, either all of them, or, at least, personality? Under personality, may be included an indication not merely of the person strictly speaking (whether first, second or third) of the subject, but its number, and in some languages its gender. Even the so-called impersonal verbs of Latin showed that their true subject was of the third person, either some undefined being, as in *tonuit,* it thunders, or a clause, as in *placet,* it pleases. It may be objected that many parts of the English verb do not of themselves indicate personality at all, as in: we work, you work, they work. But it can be answered, even without urging that the word work is, in reality, not a verb, that the general scheme of inflection in a language is not invalidated by the fact that in some cases the same form recurs; as, for example, the nominative, accusative and vocative of Latin and Greek neuter nouns. It is, however, preposterous to set up a scheme of inflection where all the forms throughout all the words of the whole language are the same. To the objection that may also be raised that the infinitive and certain other parts of, for instance, the Latin verb do not indicate the person of the subject, it might be answered that those parts are not strictly verbs, any more than the word action is, and that they have only been classed under verbs because they are in mode of formation closely connected with them, and have at least some semblance of voice, mood, tense, and govern any direct or indirect object in the same case as the other verbal forms. It may, however, be admitted that for these reasons, especially the last, certain forms without the distinction of person may be classed with verbs that have it; but it may well be considered extravagant to set up a class of verbs which do not have in any form whatever any indication of person.

The so-called Japanese verb is, clearly, not only lacking throughout every form in the essential feature of person (including number and gender), but it completely lacks also any true indication of time, mood, or voice; only in voice is there an approach to such an indication, which, nevertheless, is very readily explained without recourse to the device of calling the words verbs, and is no more marked an indication than is found in the very words existence, action, experience, which no one pretends to call verbs. Indeed, one of the absurdities of our foreign grammars of Japanese has been that the same particle that was called an indication of the object (the accusative) of a verb in the active voice, was necessarily called the sign of the subject of the same verb in the passive voice. If it be objected that, according to these principles, there would be strictly speaking no passive voice in English, the fact may readily be admitted; for the English passive seems really to be wholly a factitious one, the nearest translation we can give of the Latin.

The Japanese verb, then, is a word that indicates neither person, gender, number, time, mood nor voice; has, therefore, not a single distinguishing characteristic of the verbs of other languages. It is plainly nothing but a verbal noun (like working, striking, loving), with which it agrees in every respect, not only in the presence of the features which it has, but in the absence of those which it has not. Just like other nouns, it has, at times, postpositions joined to it, and is joined to other nouns as an adjective, just as nouns are used as adjectives in English.

This real character of the Japanese verb did not clearly appear to me, at field-work in Japan, in 1873, until after six or eight months of greenly groping, misled by the common grammars; but, then, the idea was of the greatest value in aiding progress in the use of the language. It seemed, however, certain that a principle so elementary, important and obvious must have been long ago perceived by professed philologists, and should have been made familiar to schoolchildren at the outset of linguistic studies. At length, after two or three months more of absence in the mountains, a return to Tokio made possible a confident and successful search for some previously published elucidation of the facts. It was, to be sure, found only in one place, in a brief and much too neglected note by the great Wm. von Humboldt on Oyanguren's Japanese Grammar, published by the Société Asiatique in the Supplément à la Grammaire Japonaise du Père Rodriguez, Paris, 1826. Notwithstanding Humboldt's knowledge of Japanese was doubtless very slight, compared with what hundreds of Americans and Europeans now possess, his acumen was sufficient to perceive that the Japanese verbal forms essentially differed from the European verb. He said (page 6):

> "Les verbes Japonais portent moins que ceux des autres langues le caractère verbal, par la circonstance que leurs inflexions ne varient jamais, quant aux personnes (gram. de Rodr., § 26); car ce qui caractérise surtout le verbe, c'est qu'il doit toujours y avoir une personne qui y soit affectée, tandisque les noms ne se rapportent aux personnes que dans certains cas, où sous certaines suppositions."

He further points out that the subject of the so-called verb is connected with the verb by the postpositions *no* and *ga,* genitive particles turning the pronominal subjects into possessive pronouns,

> "et le verbe est ainsi traité comme un nom substantif. Le Japonais n'est pas la première langue dans laquelle j'ai cru trouver ce singulier phenomène."

On my pointing out, some weeks later, this evidence of the substantive character of the verb to a fellow American exile who was beginning to talk Japanese, he said: "But what difference does it make whether you call it a verb or a verbal noun?" Certainly, the recognition of the difference by name, and in fact, aids greatly in learning the language. You, thereby, readily acquire the habit of boldly, and to the Japanese altogether intelligibly and naturally, connecting the verbal noun with other nouns or pronouns by the possessive or other particles, or of using the verbal noun simply (like any other noun) as an adjective before another substantive; and, knowing the real meaning of the verbal noun, you do not habitually attribute to it the distinctly different significance of a true verb, to the greater or less bewilderment of the Japanese hearer.

The varied forms of the verbal noun to which the names of voice, mood, and tense have been given are compounds, especially with the so-called substantive verb, more or less closely welded into single words. The passive voice is formed by compounding the verbal noun with another verbal noun, of which the root is *e*, meaning *getting*, or *receiving;* as, striking-getting, or striking-being-getting, or striking-receiving, being struck, or to be struck. The passive is sometimes used in a potential sense, and is so called; as, for example, *it is* (*to be*) *heard*. Other compounds form what have been called the indicative, imperative, conditional, conjunctive, concessive, causative and desiderative. In like manner, yet other compounds have been called tenses, present, past and future. The so-called future, with the termination *oo*, or *ou*, or *an*, *en* or *in* (so written, but really nasal vowels), derived from *amu* of the older language, is sometimes more correctly called the dubitative, but is much used as we use the future, something doubtful, or probable, being applied more particularly to future things; but often, as our so-called future with us, of present things; as, "it will be so," in the case of some probable explanation of a fact. The derivation of the termination from *amu* seems really to show that we have here a clear case of what some learned philologists would consider a shocking impossibility, a derivation pointing back even to the language, or utterances, or noises, of brute animals; though it can hardly be seriously denied that human speech must have been originally derived from the utterances of brutes, nor that it is wholly possible, and not a quite absurdly extravagant supposition, that here and there some traces; or relics, of that remote age may yet be found. The *amu* seems, in fact, to be originally the *h'm* of doubt, a nasal with the mouth closed, which is still used by lower animals in modern times, as a part of what may be called their language, the smelling of an unknown object. But a nasal made with the mouth open, commonly softened to an *n*, is essentially a mark of rejection (as regards the mouth, ejection, or a snort in the lower animals); that is, of denial.

The widespread use of these sounds with unchanged significance, in different languages, seems to point clearly to a common origin of the languages, in spite of differences of grammar, which, to be sure, indicate remoteness of affinity, yet cannot make it credible that the origin of human language was multiplex. Language can have had but a single origin, and all languages must have come eventually from one source; and distant as may be the branching from common stocks, it should not be considered incredible that occasional traces of the original source should be found in languages of unlike grammar.

Indeed, there are many resemblances, coincidences, if you please, between Japanese and European words: such as: *mushi*, an insect, and Latin *musca* and French *mouche*, a fly. But yet more striking, because more complicated, is such a resemblance as is to be seen in the demonstrative pronouns, this (near me), that (near you) and yonder (distant from both of us). In Japanese, though there are no strictly personal pronouns, these demonstratives are respectively *kore, sore, are* (the *re* appearing to mean thing), or in the adjective pronoun forms, *kono, sono, ano;* in which the distinctive syllables of at least the first two have a remarkable etymological likeness to the Latin *hic, iste* and *ille* (formerly *olle*), as well as, for the first two, the Greek **ἐγώ** and **σύ** and the Latin *ego* and *tu*. The word *so* (according to what you have heard) is almost, or quite, identical, both in meaning and sound, in Japanese and English and German; but is said to be derived from *shika*.

One fundamental way of grammatically classifying languages might be based upon the general structure of their sentences; and then, further, on the welding, or not welding into terminations. A sentence has a subject, or theme (which is not necessarily the agent of an action, the subject of the Latin verb), an agent, an object (sometimes) and a verbal word. The sentence, or thesis, is a description of either the agent, the object, or the action. In Japanese, the verbal noun, naming the action, comes last, is the goal, the thing described by the sentence; the object (indicated by the postposition *o,* or *wo,* which might be translated, in connection with) comes before the verbal noun, and the agent (sometimes indicated by the postposition *ga* or *no,* genitive particles) comes before the object; and the theme comes first, and is sometimes also the agent, and is indicated by the particle *wa*. For example: In Northampton, the landscapes are fine; "in Northampton" is the theme, or subject of discourse, and in Japanese would be followed by the particle *wa*, which might be translated, "as to," or "about"; in English, a slight pause and a comma would take the place of that particle; in Chinese, there would probably be a slight pause. In many cases, the agent of the action is also the theme, and is followed by *wa*.

In English and in Chinese, the agent of the verbal action comes first; then, the verb, or verbal noun; then, the object, if any, in connection with which the action takes place. The object is the thing aimed at by the whole sentence. In this important respect, there is a strong resemblance between these two languages, which have commonly been considered irreconcilably unlike, and which are, of course, historically extremely distant. Evidently, languages may, in the lapse of ages, through tribal vicissitudes and migrations, undergo radical grammatical changes, and pass through stages so wholly unlike their former condition, as to bring them into the same class with languages that had been widely different from them.

In Greek and Latin, the agent is the goal at the end of the sentence, the ultimate thing described by the whole thesis, or sentence, and is closely welded to the verbal noun in the form of a personal termination; while the object, in the accusative, precedes the verbal noun (for example: *Animum rege, qui nisi paret, imperat*). The agent (the so-called subject of the verb), in more precise form precedes the object; and, in general, may be considered the theme, or subject of discourse, and would in Japanese be followed by the particle *wa*.

Of course, the personal pronoun that is so welded to the verbal root, in the termination of the verb, was originally a separate word, to which that noun was, as the Japanese verbal noun frequently is, an adjective (striking-I, working-you, loving-he), and, by degrees, in time, became abbreviated and joined to that root in a single word. Of course, too, other terminations were at first separate words, and gradually, in ages of repetition, became completely joined to the root. For example, the termination of the Latin infinitive, *re*, is undoubtedly the more or less complete remains of what was originally a separate word. When, thirty years ago, it was suggested, at a meeting of the American Oriental Society, that the Latin infinitive termination *re,* not only meant *thing,* as it evidently does, but was connected with the Latin word *res,* it was scornfully and crushingly objected that the infinitive originally ended in *se,* and was much later changed to *re.* But what of that? So much the better. It makes yet more clear the close affinity between *s* and *r,* both made in the same part of the mouth, with the attitude of the tongue but slightly changed. The word *res* may, then, very likely have formerly been pronounced likewise with an initial *s,* instead of *r;* and, at any rate, the close affinity of the two sounds makes plain the true meaning and origin of the *s* in the Latin genitive and plural and nominative singular terminations, and in the English possessive and plural terminations. The plural termination may have been originally a doubling of the simple singular form. Of course, those terminations, like the verbal ones, must have been, at first, separate words with a signification of their own. The connection between the not yet united words must have been that of adjective and substantive; and the like connection, in the case of genitive, or possessive, must have existed between the yet unwelded compound and the name of the thing possessed. For instance: *Charles's box* was *Charles-thing box.* Undoubtedly, the other Latin terminations may eventually find a like rational and simple explanation, with like originally adjectival connection.

It is nothing against this simple and rational explanation of the Latin infinitive termination *re,* and the Latin case termination *s,* and the English possessive and plural *s,* that even in so grammatically distant a language as Japanese almost precisely the same sound should be similarly used. Call it a coincidence, if you will, yet, even so, it is interesting. In the ordinal numbers, *hitotsu* (one), *futatsu* (two), *mitsu* (three), etc., the syllable *tsu,* with a very short *u,* apparently meant originally thing. In bare counting, *hi, fu, mi,* etc., that syllable is omited.

Furthermore, the Japanese possessive particle, or postposition, *no,* already mentioned, and translated *of,* is evidently in reality an abbreviation of the word *mono,* which means thing, just as those

Latin and English terminations of the same significance do. The literal translation of *Saburo no katana* would, therefore be: "Saburo-thing sword," for Saburo's sword; and the expression "Saburo-thing" would be two nouns adjectivally connected, and that expression, again, would be adjectivally prefixed to "sword." The two words *tsu* and *mono,* both meaning thing, may either have originally had different origin, and been adopted into the language from different sources, perhaps at different times; or may have had at first a slightly different shade of meaning. *Tsu* may have meant a thing by itself, apart, independent, and be connected with *tatsu,* standing, Latin *stare. Mono* may have meant rather a single object, or combination, a united thing, the Latin *unus,* and the Greek *μόνος*, the English *one.* Even in English, *one* is often used in the sense of thing; as in, good ones, bad ones, little ones, big ones, young ones. The termination *ing,* also, appears to have the same original meaning; as, *loving* (Latin *amare,* or *amase*).

It is a striking coincidence, to say the least, that the German genitive and plural terminations are not only alike, as the Latin and English ones are, but, together with, likewise, the infinitive termination, are *en,* so similar to Japanese *no.* The same termination occurred in antiquated English, and less than sixty years ago, about 1854, I myself heard a countryman in Massachusetts speak of "two housen" (that is, two housing, or house-in', with still quite an intelligible meaning). Evidently, this *en* termination, as well as *ing,* and the antecedent separate word from which they were derived must have had the same meaning as the termination *s* and its antecedent word; and must have been more or less closely identical with the word one and the German *ein,* Latin *unus,* and Greek *ἕν.*

The other Japanese genitive particle, already mentioned, *ga,* appears to be a contraction from *no-ka,* the *ka* being, perhaps, an indefinite something, or somewhat, like the Latin *quid;* and probably the same as the interrogative particle *ka* placed at the end of Japanese questions, as *kya* (allied to *quid*) is placed at the beginning of Hindoostanee questions, plainly meaning *what. Ga* is defined in Hepburn's dictionary, not only as a "sign of the genitive case," but as "designating the subject of an intransitive verb, having also an indefinite sense; as: *ame ga furu,* it rains" [that is, of rain falling is]; and "sometimes as designating the object of a transitive verb, same as *wo* [the usual accusative particle]: *chichi ga nomitai,* I want to nurse, said by a child" [of milk drink-wishing is]. These strangely mixed qualities of possessive particle, verb-subject and verb-object are a result of calling a mere verbal noun a verb.

This fact of the close correspondence of the possessive, plural and infinitive terminations in Latin, English and German is certainly remarkable, even without any reference to corresponding sounds with the same meaning in a language grammatically and historically so distant as the Japanese; and should not be disregarded out of any prejudice against noticing verbal resemblances in languages not closely related grammatically. It appears, too, incontestable that the terminations are derived from what were once separate words, and that those words could have had no more appropriate meaning than the one here assigned.

In English, the word *of,* unlike the Japanese genitive particles, or postpositions, *no* and *ga,* is a preposition placed before its noun. It appears to be closely allied to the word *off,* and to indicate something off from its noun, or its offshoot, literally or metaphorically. The French and Spanish *de,* and Italian *di,* commonly translated *of,* appear, however, to be the Latin *de,* and to mean *concerning,* a meaning somewhat different from *of* and much closer to the significance implied in the adjectival relation. The adjective is a grouper, or indicator of a class, with its noun a specifier of a member or members of the group; as: a good book, high mountain, country man, spring lock, dancing school. The French say: école de danse, école des mines, a school concerning dancing, a school concerning mines, not off from dancing, or off from mines. In like manner: Département de l'Intérieur, Department concerning the Interior; not off from the Interior, but Interior Department, of the class, or group, of Interior things. So, with many other phrases that are apt to be barbarously transferred, with mistaken desire for literalness, into English.

Plainly, when the present terminations of Indo-germanic languages were in their original form of separate words, the connection between words was purely adjectival, as it still is in Japanese, and as it may still be regarded in our western languages, if we bear in mind the true original significance of the terminations; and all words should, then, be considered to be strictly nouns, and to be adjectivally connected with one another, as the parts of compound words are always connected. The oversight of this necessary connection of two parts of compound words, the first as adjective to the second, has led to some common mistakes as to the real meaning of the compounds, and to the impression that the order of the component parts made no difference in the meaning. For example, it has been supposed that the meaning of the names Theodore and Dorothy were the same; Theodore would be God-gift, and Dorothy would be Gift-goddess. Spermophile, seed-loving, Anglophile, English-loving, Russophobe, Russian-fearing, are correctly used; but Phil-hellene means friendly Greek, and Philander, not man-loving, but a loving (or friendly) man. Philadelphi means friendly brothers, and Philadelphia means friendly brotherhood, not brotherly love. Philosophy would, accordingly, appear to be, not love of wisdom, but friendly wisdom, the occupation of the philosopher, or friendly wiseman, as contrasted with that of the mere sophist; and the modern word philology (perhaps meaning properly science of loving) should have been logology, or glossology. That universal acceptance and high authority are not a wholly unimpeachable guaranty against mistranslations is evident from flagrant errors that are to be seen outside the range of our present subject. For instance, a scholar profoundly versed in the Chinese language has given currency to the translation "Middle Kingdom" for the Chinese name of China proper; but the same expression is used in Japan for the Central Provinces, or Home Provinces (or our Middle States, which would be so written in Chinese), and that appears to be the true meaning. The Japanese (or Chinese) name for Corea, Chosen, has somehow come to be translated Land of the Morning Calm; but its real meaning is Morning Earliness, *sen* meaning fresh, or new, as recently caught fish is fresh. While Japan means Sun-rising, the country next westward is appropriately called Morning-early. Evidently, we cannot put implicit faith in what has come from high sources and has been widely accepted.

In Chinese, totally without welded terminations, words are plainly connected only in the adjectival way, and as, in the writing, there are no punctuation-marks, the meaning is not always clear to a beginner. We have the same source of obscurity in English, especially in shop-signs and brief inscriptions. A Chinaman might, for example, find it difficult to know the precisely correct meaning of an inscription on a certain wagon in Philadelphia: "The largest old book store in the city"; or of the signs: "Circular Saw Mills"; "Fine Fur Felt Hats"; "North Broad Street Farmers' Market"; or the advertisement-heading: "Excelsior Straightway Back Pressure Valve"; or: "The Vare School Garden Base Ball Team." In the spoken language, the pauses and intonations indicate the grouping of the words and the consequent meaning. The grouping might well be shown in printing with the hyphen; but that would be irksome in manuscript writing, unless the hyphen should conventionally be written with a little quirk, too small to be taken for the letter *e*, and without lifting the pen: "Old-book store."

It is clear, then, that the so-called Japanese verb is in reality merely a verbal noun, and that much is to be gained by calling it by its right name, and bearing its true character in mind, and remembering that its connection with other words is precisely adjectival, either as an adjective itself, or as the substantive to an adjective. It is plain, too, that in European languages the terminations that give to words the distinctive meaning of different parts of speech were originally separate words connected in the same adjectival manner to the present roots, and that the original significance of those separate words before being welded into mere terminations was, in the case of the Latin and English genitive and plural terminations in *s* and the Latin infinitive termination in *se* (now *re*), simply *thing;* which, also, is the original meaning of the German possessive, plural and infinitive terminations in *en,* and of the antiquated English plural termination in *en;* and of the termination *ing* of English verbal nouns. The resemblance between the two western terminations in *s* and *en* and the Japanese particles *tsu* and *no* of like meaning, though not at all essential in identifying the character of the terminations, is interesting, whether regarded as merely a coincidence in languages grammatically far apart, or as possible relics, together with many others equally remarkable, from some extremely ancient common language, leading back towards the original human language and even towards the utterances of brute animals. Evidently, the earliest languages must have had their words connected purely as adjectives and substantives, as is still common in English, and is universally the case with the parts of compounds. The English language shows that the grammar of a language may within a few hundred years become radically changed; and, in spite of historical and geographical remoteness, has acquired grammatical resemblance to Chinese.

THE VALIDITY OF THE LAW OF RATIONAL INDICES, AND THE ANALOGY BETWEEN THE FUNDAMENTAL LAWS OF CHEMISTRY AND CRYSTALLOGRAPHY.

By AUSTIN F. ROGERS.

(*Read March 1, 1912.*)

Some fundamental law of nature governs the position of the faces of a crystal and limits in number the faces which occur on the crystals of any one substance. Crystal faces are designated by intercepts on coördinate axes, which are chosen so as to yield simple relations. Now it is found that the intercepts of the various crystal faces of a given substance, on each coördinate axis taken separately,

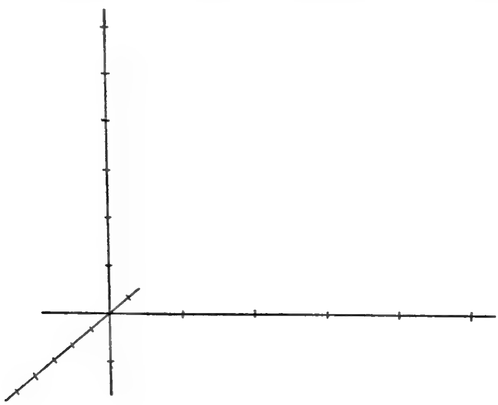

FIG. 1. The coördinate axes of a crystal.

usually bear a simple ratio to each other such as $1:\infty$, $1:2$, $1:3$, $2:3$, $3:1$, etc. A selected face chosen because of its prominence is taken as a standard and the other faces are expressed in terms of it. The selected face is called the unit face, as its intercepts on the three axes establish a unit which, in general, is different for each axis, as represented in Fig. 1. The intercepts of the unit face which are, in general, irrational constitute the axial ratios which are constants for each crystallized substance. For convenience in calculation the reciprocal ratios of the intercepts are used. These reciprocals are called indices or Miller indices, as Miller, an English crystallographer, was the first to make extensive use of this method. The indices are usually simple numbers such as (110), (210), (130), (211), (321), (441), etc., the unit face being (111).

If we examine the statements concerning the rationality of the indices of crystal faces in text-books and treatises we find a difference of opinion as to the exact definition of the law. Some authors insist that the indices are small whole numbers, while others simply state the fact that the indices are whole numbers, usually, but not necessarily small. One crystallographer, Viola,[1] goes so far as to doubt the validity of the law of rational indices. Another investigator, G. H. F. Smith,[2] believes that the law of simple rational indices is valid except in one particular instance, that of calaverite from Cripple Creek, Colorado. But, as he shows, by assuming several interpenetrant space-lattices it may be valid even in this case.

Thus there are three possibilities to consider: (1) The indices are always small rational numbers. (2) The indices are rational numbers, but not necessarily small. (3) The indices are not always rational and the law has no meaning. This subject is such a fundamental one in both theoretical and practical crystallography that it seems advisable to enquire into the history and status of the law. Such is the object of this paper.

The credit of the discovery of the rationality of the indices is due to Haüy,[3] professor of the humanities in the University of Paris, who developed it from his theory of crystal structure based upon cleavage observations. Haüy believed that crystals are composed of minute cleavage fragments which he called *molécules intégrantes*. Primary faces, according to his view, are due to the association of the *molécules* in parallel position, while secondary faces are due to the omission of *molécules* on the exterior of the crystal in step-like

[1] *Zeitschrift für Krystallographie und Mineralogie*, Vol. 34, pp. 353–388 (1901).

[2] *Mineralogical Magazine*, Vol. 13, p. 122 (1902).

[3] "Essai d'une Theorie sur la Structure des Crystaux." Paris, 1784.

arrangement. According to Haüy the omission is usually of one, two or three, rarely of four or five rows of *molécules*. Fig. 2 shows the production of an (110) face in this manner. If the cubes were very minute the (110) face would appear to be smooth. This epoch-making discovery laid the foundation of crystallography as an exact science and entitles Haüy to the title "father of crystallography." With some modification it has been the guiding principle in crystallography since that time and should not be abandoned unless the evidence is clearly against it.

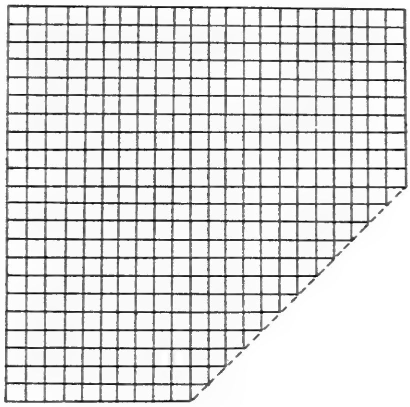

FIG. 2. The production of an (110) face.

Some authors express the fundamental law of crystallography as the law of simple mathematical ratio. Thus Williams[4] says: "Experience has shown that only those planes occur on any crystal whose axial intercepts are either infinite or small even multiples of unity." Tutton[5] also says: "The indices of any and every face on a crystal are three small numbers." Small in these quotations is usually interpreted as not more than six. Faces with indices larger than six, according to this view, are accidental and are usually relegated to the list of uncertain forms. There is a tendency to consider forms

[4] "Elements of Crystallography," 3rd ed., p. 26 (1901). Similar statements are also made in the text-books of Bayley, Brush-Penfield, Moses and Parsons, Patton, and Van Horn.

[5] "Crystallography and Practical Crystal Measurement," p. 70, 1911.

with indices at all complex as doubtful even when the measurements indicate the form.[6]

The law of simple mathematical ratio is untenable. There are

LIST OF CRYSTAL FACES WITH COMPLEX INDICES.

	Angle.	Meas.	Calc.	
Octahedrite	$1.1.28 \wedge 001$	5° 8½′	5° 8′	Robinson, *A. J. S.* (4), 12, 180.
Baumhauerite...	$13.0.12 \wedge 100$	48 31	48 31½	Solly, *Min. Mag.*, 13, 154.
Barite	$1.44.0 \wedge 120$	40 58	40 57	Brunlechner, *Min. Mitth.*, 12, 73.
Apophyllite	$51.51.50 \wedge 001$	61 3	61 1	Ploner, *Zs. Kr.*, 18, 351.
Fluorite	$19.1.1 \wedge 100$	4 13	4 15	Whitlock, Bull. 140, N. Y. St. Mus., 198.
Pyrite	$24.15.10 \wedge 111$	19 30	19 32	Mauritz, *Zs. Kr.*, 39, 363.
	$24.15.10 \wedge 100$	36 55	36 55	
Tetrahedrite.....	$35.35.1 \wedge 110$	1 9	1 9	Ungemach, *Bull. fr. soc. min.*, 29, 251.
Tourmaline	$20.19.\bar{39}.1 \wedge 10\bar{1}1$	63 0	63 1½	Worobieff, *Zs. Kr.*, 33, 263.
Vanadinite	$43.0.\bar{43}.40\ (\rho)$	41 29	41 29	Schaller, Bull. 262, U. S. G. S., 138.
Millerite	$31.13.\bar{44}.0\ (\phi)$	13 17	13 17	Palache and Wood, *A. J. S.* (4), 18, 355.
Pectolite.........	$1.0.25\ (\rho)$	7 29	7 32½	Moses, *A. J. S.* (4), 12, 98.
Natrolite.........	$16.\bar{16}.17 \wedge 110$	64 32	64 33	Zambonini, *Zs. Kr.*, 34, 581.
Whewellite......	$14.26.1 \wedge 010$	32 48½	32 48½	Ježek, *Bull. int. l'acad. Sci. Bohême*, '09, 9.
	$14.26.1 \wedge \bar{1}01$	63 17	63 18	
Iodyrite	$33.0.\bar{33}.2 \wedge 0001$	86 20	86 21	Kraus, *A. J. S.* (4), 27, 218.
Chrysoberyl	$11.20.20 \wedge \bar{11}.20.20$	60 54½	60 54¼	Liffa, *Zs. Kr.*, 36, 611.
Quartz............	$1.30.\bar{29}.29 \wedge 01\bar{1}1$	1 26	1 25	Gonnard, *Zs. Kr.*, 29, 323.
Strontianite......	$36.36.1 \wedge 001$	1 9	1 9	Beykirch, *N. Jb. Min. Beil. Bd.*, 13, 423.
Danburite	$0.50.1 \wedge 001$	87 36	87 37	Weber, *Zs. Kr.*, 37, 620.
Epidote..........	$29.0.1 \wedge 001$	63 27	63 27	Zambonini, *Zs. Kr.*, 37, 13.
Calcite..........	$49.41.\bar{90}.8 \wedge 49.90.\bar{41}.8$	65 29	65 29	Rogers, *A. J. S.* (4), 12, 43.
	$49.41.90.8 \wedge 90.41.\bar{49}.8$	53 49	53 48½	

hundreds of measurements to prove this statement. The accompanying tabulated list gives faces with complex indices for a number of minerals, which list could be greatly extended if space permitted.

[6] Palache and Wood, *American Journal of Science*, Vol. 18, p. 355, 1904.

These are selected because of the good agreement between the measured and calculated angles. Outside of its position in certain zones the only proof of a face lies in this agreement. Ordinarily an agreement as close as ten to thirty minutes of arc is sufficient to establish a face. For the common form-rich minerals, such as orthoclase, tourmaline, fluorite, magnetite, pyrite, barite, anglesite, calcite, aragonite, cerussite, stibnite, hematite, etc., it is certain that some of the faces have complex indices. To be convinced of this fact let one look over the list of forms of the above mentioned minerals in Goldschmidt's "Krystallographische Winkeltabellen."[7] For calcite one half of the forms (162 out of 325) have indices greater than 10. The law of simple mathematical ratio is hardly compatible with this fact.

Many crystals have what are called vicinal faces. These are faces with very high indices which replace faces with very simple indices. Thus apparent cubic crystals of fluorite from the north of England are in reality bounded by faces of a tetrahexahedron with the symbol (32·1·0). Here each cube face is replaced by a very low four-faced pyramid. Vicinal faces are often regarded as accidental or in some way irregular and are usually excluded from the law of rational indices as they are of course inconsistent with the law of simple mathematical ratio. As they lie in prominent zones and as their arrangement conforms to the symmetry of the crystal on which they occur, they can hardly be excluded from the list of faces, though their origin is not clearly understood. The only possible argument for excluding them is that the exact indices of such faces can not always be determined, for the agreement between measured and calculated angles must be exceptionally good to establish the face. Miers[8] found that on alum very flat trisoctahedral faces replace the octahedral faces. In one case the measurements indicated the symbol (251·251·250). As Miers says, this form can not be regarded as established. It may be some other form with a little different

[7] For recent additions to these lists see Whitlock, *School of Mines Quarterly*, Vol. 31, p. 320; Vol. 32, p. 51 (1910).

[8] *Philosophical Transactions of the Royal Society*, A, Vol. 202, pp. 459–523 (1903).

symbol. But according to Miers[9] these vicinal faces on alum probably have rational indices.

If we decide to exclude vicinal faces where shall we draw the line? In the zone of (*hk*0) faces, for example, we have a large series of possible faces. (32·1·0) is undoubtedly vicinal and so perhaps are (25·1·0) and (20·1·0). The faces (12·1·0) and (10·1·0) are probably not vicinal, but what of the intermediate faces? Such faces as (12·9·1), (3·5·11) and (11·4·7) can hardly be considered as vicinal, yet they are comparatively complex. There is no exact definition of a vicinal face. As a matter of fact there are all gradations between very simple indices and very complex ones, the limit in complexity apparently being determined by the limits of measurement. There seems to be proof of indices at least as high as 50 (see in the tabulated list apophyllite, danburite and calcite of forms on page 106).

Finding that the indices of crystal faces are often very large numbers a few authors, notably Viola,[10] express the opinion that the law of rational indices has no meaning. For of course if we take the indices large enough any plane can be expressed by whole numbers. It is manifestly impossible to prove by direct measurement that the indices of all crystal faces are rational, for measurements are subject to certain errors, the measured angle rarely ever coinciding with the theoretical angle.

But, as I shall show, *there is indirect proof that the indices of crystal faces are rational numbers.* Since the time of Haüy thousands of crystals have been measured and among all these crystals, which include both minerals and prepared compounds of the laboratory, only axes of 2-fold, 3-fold, 4-fold, and 6-fold symmetry have

[9] *Philosophical Transactions of the Royal Society*, A, Vol. 202, p. 476.

"One reason why I am led to believe that they are really referable to rational, although not to simple, indices is the following: During the growth of the crystal, one set of vicinal faces is being continually replaced by another along certain zones; . . . but the change is not gradual, neither are the surfaces curved; one plane reflecting surface is replaced by another plane; and although the images may for a time be multiple and confused, sharply defined images emerge successively by the substitution of one image for another *per saltum.*"

[10] *Loc. cit.*, p. 363, "Also kann das allgemeine Gesetz der rationalen Indices keine Bedeutung für die Krystallographie haben."

ever been found. Assuming that these are the only possible symmetry-axes it may be proved[11] that crystals consist of regularly arranged particles at small finite distances apart, the arrangement about any particle being the same as about any other. In a regular arrangement of particles of indefinite extent, there is an infinite number of symmetry-axes, some of which are parallel to each other. Let A_1 and A_2 be two parallel symmetry-axes with the minimum distance A_1A_2 between them. A revolution about A_1 brings A_2 to A_3 and a similar revolution about A_2 brings A_1 to A_4. By hypothesis the distance A_3A_4 can not be less than A_1A_2. Therefore the angles of revolution, $A_2A_1A_3$ and $A_1A_2A_4$, can not be less than 60° and therefore no symmetry-axis greater than six is possible. Axes of 2-, 3-, 4-, 5-, and 6-fold symmetry remain to be considered. A revolution of 72° ($\frac{1}{5}$ of 360°) around A_1 and A_2 brings two particles A_3 and A_4 a smaller distance apart than the original minimum distance A_1A_2. If we take A_3 and A_4 as the original particle a still smaller distance A_5A_6 would result and so on *ad infinitum*. Revolutions of 60°, 90°, 120°, and 180° are not contrary to the hypothesis of a minimum distance. Therefore only axes of 2-, 3-, 4-, and 6-fold symmetry are consistent with a regular molecular structure. While the rationality of the indices may not be subject to direct proof, the symmetry of crystals can be determined by measurement. The fact that only the types of symmetry mentioned have been discovered makes it practically certain that crystals are made up of regularly arranged particles of some kind. Other facts point to the same conclusion.

Assuming homogeneity or regular arrangement of the particles of crystals Barlow[12] has proved that only thirty-two crystal classes or combinations of symmetry elements are possible. It is remarkable that all but one of these classes, viz., the trigonal bipyramidal class (one plane of symmetry and one axis of 3-fold symmetry),

[11] Lewis, "A Treatise on Crystallography," pp. 136–137 (1899). Barlow, *Philosophical Magazine* (6th series), Vol. 1, pp. 1–36 (1901).

[12] *Philosophical Magazine* (6th series), Vol. 1, pp. 1–36 (1901). The thirty-two possible crystal classes were also deduced by Hessel in 1830 and independently by Gadolin in 1867. Both of these authors base their work upon the law of rational indices but Barlow's work is based upon homogeneity of structure.

have been found either among minerals or prepared compounds. Moreover, every crystal that has been carefully investigated can be assigned to one of thirty-one out of the thirty-two possible crystal classes.

Physicists in general assume the coarse-grainedness of matter.[13] It is only fair to assume that in crystals the molecules or particles are arranged in a definite and regular manner. The most comprehensive definition of a crystal is the following: "A crystal is a homogeneous solid, the physical properties of which are the same in parallel directions but, in general, are different in non-parallel directions."

It is necessary to assume a regular arrangement of particles in order to explain many of the physical properties of crystals. On account of the correlation between the geometrical and physical (especially the optical) properties of crystals it is practically certain that the crystal form is an outward expression of a regular internal structure. A regular internal structure accounts at the same time for the constancy of interfacial angles and for diversity in crystal habit. It also seems impossible to explain cleavage in any other way.

If crystals are made up of regularly arranged particles,[14] *the centers of which are at small, finite distances apart, all crystal faces necessarily have rational indices* for the faces are due to the alignment of particles in parallel position but with the omission of particles in step-like arrangement. A whole number of particles is always omitted.

The indices are not necessarily small numbers but may often be large numbers. Even the highest indices ever assigned to crystal faces such as the vicinal faces of adularia (500·527·0), (250·249·0), and (200·157·0) are simple compared with the number of particles or molecules in a crystal.

[13] Rücker, Report British Association for the Advancement of Science, 1901, p. 12.

[14] The size, shape, and nature of the particles are immaterial. It is also immaterial whether they are contact as Haüy believed or widely spaced as modern physicists are inclined to believe. So stripped is the structure-theory of all hypothesis that it becomes a mere geometrical abstraction. It is only necessary to assume that crystals are made up of parts.

The intimate connection between rational indices, molecular structure, and symmetry-axes with periods of 2, 3, 4, and 6 can not be denied. If one is true, it is pretty certain that the others are true. There is direct proof of only one of these facts, viz., symmetry-axes of the kinds mentioned. This is the empirical basis upon which my argument rests. It is absolutely true that only axes of 2-, 3-, 4-, and 6-fold symmetry have ever been found and it is very probable that these are the only ones that ever will be found. Suppose crystals with an axis of 5-fold symmetry should be included as possible. If five-fold axes are possible, axes of 7-, 8-, 9-, 10-fold, etc., would also be possible, for the minimum possible distance between two particles excludes axes with periods greater than 6 for the same reason that it excludes those with a period of 5. Then instead of 32 crystal classes with one gap to be filled, we should have an indefinite number of crystal classes but with only 31 of them yet found in nature.

Even if we grant that the indices are rational numbers, crystallography would still be very complicated for the number of possible rational ratios is very large. In the orthorhombic system, for example, there are 1,037 possible forms with indices not over 10. Yet for the mineral topaz, which leads all orthorhombic minerals in the number of forms there are only about 125 known forms. For all orthorhombic minerals taken together there are only about 386 known forms with indices not over 10. Of all known substances calcite has the greatest number of crystal forms, about 325 well-established ones with about 140 uncertain ones. Only about a half (162) of the forms have indices greater than 10,[15] yet the possible number of forms in the calcite class with indices not greater than 10 is 876.

We need an explanation that will reconcile the observed fact that the indices are usually simple with the fact that they are occasionally complex, the complexity, in general, increasing with the rarity. Such an explanation is furnished by the structure-theory of Bravais.[16] Bravais assumes that the centers of molecules occupy the points of a space-lattice. Fourteen kinds of space-lattices, con-

[15] That is, h, k, and l in the symbol $hk\bar{i}l$ are not greater than 10.

[16] "Etudes Cristallographiques," Paris (1866).

stituting various styles of crystal architecture, are necessary to account for the crystals of various systems.

The crystal faces of most frequent occurrence are, according to Bravais, those planes in which the points of the space-lattice are most closely packed. These are faces with simple indices as can be seen from Fig. 3. Faces with complex or high indices are planes with the points relatively far apart (Fig. 3). It is a well-known fact

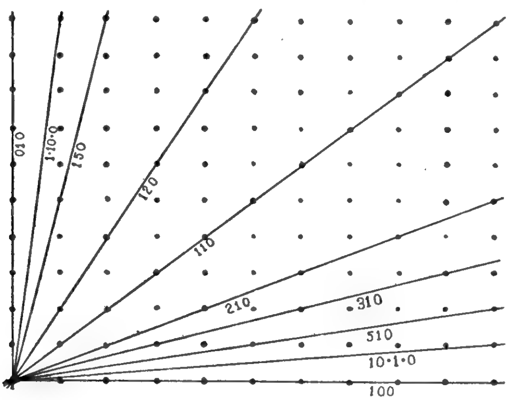

FIG. 3. The relative frequency of occurrence of crystal faces.

that the same forms are not common for every crystal even of the same system. The space-lattice is distinctive for every crystal except those of the isometric system and even in this system there are three kinds of space-lattice possible. The following statistics, compiled from Goldschidt's "Krystallographische Winkeltabellen," will give an idea of the relative abundance of the various forms. Taking the (*hk*o) zone for 206 orthorhombic minerals, thus eliminating individual peculiarities, (010) occurs on 134, (100) on 111, (110) on 144, (120) on 66, (210) on 48, (130) on 43, (230) on 29, (320) on 22, (310) on 20, (150) on 17, (430) on 10, (340), (530), and (410) on 9 each, (540) on 8, (610) on 7, (560) and (350) on 6 each, (160), (250), (520), and (10·9·0) on 5 each (650) and (750) on 4 each, (170), (710), and (740) on 3 each, (510) (970), (1·11·0), (1·12·0), on 2 each, and many forms including (7·11·0), (10·7·0), (1·12·0), (16·1·0), (19·20·0), etc., on one each.

Goldschmidt[17] attempts to explain the relative frequency of crystal forms by a different method from that of Bravais. Assuming (100) and (010) as the primary faces in the zone [100:*hk*0:010] secondary faces result by the addition of the indices. Thus adding 100 and 010, index by index, we have as the first complication, 110. Adding 100 and 110, also 110 and 010, we have 210 and 120 as the second complication and so on. The relative frequencies of crystal forms for the *hk*0 zone are, according to Goldschmidt's law of complication, in the following order.

100 010

<table>
<tr><td colspan="16">110</td></tr>
<tr><td colspan="8">210</td><td colspan="8">120</td></tr>
<tr><td colspan="4">310</td><td colspan="4">320</td><td colspan="4">230</td><td colspan="4">130</td></tr>
<tr><td colspan="2">410</td><td colspan="2">520</td><td colspan="2">530</td><td colspan="2">430</td><td colspan="2">340</td><td colspan="2">350</td><td colspan="2">250</td><td colspan="2">140</td></tr>
<tr><td>510</td><td>720</td><td>830</td><td>730</td><td>740</td><td>850</td><td>750</td><td>540</td><td>450</td><td>570</td><td>580</td><td>470</td><td>370</td><td>380</td><td>270</td><td>150</td></tr>
</table>

Although Goldschmidt's law of complication accounts in a general way for the relative frequency of crystal forms it does not fully explain the observed facts. According to Goldschmidt (210) and (120) should be of equal frequency as should also (310), (320), (230), and (130). Yet (120) occurs on 66 orthorhombic minerals while (210) occurs on only 48. The form (130) occurs on 43 orthorhombic minerals while the other three forms mentioned occur on only 29, 22, and 20 minerals respectively. Out of 206 combinations of anglesite[18] (120) occurs 34 times and (210) only twice. The explanation of these apparent discrepancies is that in the orthorhombic system the *a*-axis is shorter than the *b*-axis and consequently molecules are more closely packed along (120) than along (210). Hence (120) is more frequent than (210). With many orthorhombic crystals, for example cordierite, chalcocite, chrysoberyl, columbite, and witherite (130) occurs to the exclusion of (120).

In the monoclinic system the *a*-axis is either shorter or longer

[17] *Zeitschrift für Krystallographie und Mineralogie*, Vol. 28, pp. 1–35, 414–451 (1897). Abstract by Moses, *School of Mines Quarterly*, Vol. 25, pp. 415–420 (1904).

[18] Hermann, *Zeitschrift für Mineralogie*, Vol. 39, p. 478 (1904).

than the *b*-axis. Out of 59 monoclinic minerals with *a* less than unity, (010) occurs on 56, but (100) on only 46 while (120) occurs on 23, but (210) on only 13. Out of 64 monoclinic minerals with *a* greater than unity, (100) occurs on 60, but (010) on only 43 while (210) occurs on 16, but (120) on only 13. If *a* is shorter than *b*, the molecules are more closely packed along (010) and (120) than along (100) and (210), but if *a* is longer than *b* the reverse is true.

Out of 168 combinations of orthoclase (including microcline) crystals given in Hintze's "Handbuch der Mineralogie," (010)

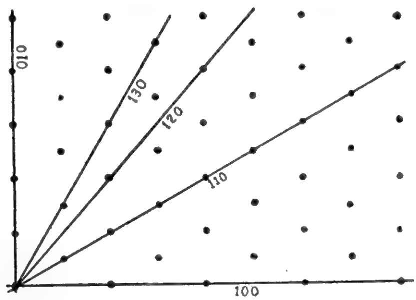

FIG. 4. The probable structure of orthoclase.

occurs on 133, but (100) on only 22. The form (130) occurs 70 times but (120) occurs only once! This remarkable case is explained by assuming the structure to be that of the monoclinic or clinorhombic prism, one of the space-lattices of Bravais. It can be seen from Fig. 4 that the molecules are more closely spaced along (130) than along (120).

It is certainly true that the form-series differs for various crystals, but according to the law of complication the form-series should be alike for all crystals and all systems.[19]

For those who are familiar with chemistry, the whole matter of indices, rationality, crystal structure, and relative frequency of crystal faces may be cleared up by considering the analogy between the fundamental laws and theories of chemistry and those of crystallography.

[19] Goldschmidt (*loc. cit.*) explains the differences in the form-series by assuming outer disturbing influences. These undoubtedly have an effect but certain discrepancies are more easily explained by the law of maximum reticulate density.

For the crystals of any one substance the angles between corresponding faces are constant. This law is known as the law of constancy of interfacial angles. It corresponds to the law of definite proportions in chemistry.

The proportions in which two elements combine determines the atomic weight of the elements. In an analogous way the intercepts, which are determined by certain constant interfacial angles, establish the axial ratio which, like the atomic weight, is a constant.

Crystal measurement corresponds to quantitative analysis in chemistry. Exact measurements establish the axial ratio of a crystal just as exact analyses establish the atomic weight of an element.

Two chemical elements A and B unite not only to form the compound AB but also the compounds AB_2, A_2B_3, A_3B, etc. This fact is known as the law of multiple proportions. These proportions for most chemical compounds are usually simple but in many compounds, especially those containing silicon or carbon, they are often far from simple. Among silicate minerals we have such compounds as $Mg_5Al_{12}Si_2O_{27}$ and $H_{20}Mg_{11}Al_8Si_6O_{45}$. Among organic compounds we have $C_{60}H_{122}$, $C_{17}H_{23}NO_3$, $C_{27}H_{46}O_{14}$, and many others with fifty or more carbon atoms in the molecule. In spite of these complex formulæ all chemists accept the law of multiple proportions as an established fact. Without it chemistry would scarcely deserve to be called a science. The law of rational indices in crystallography corresponds to the law of multiple proportions in chemistry. The same difficulties are encountered in crystal measurement as in quantitative analysis. That is, there are certain errors which usually render it impossible to prove absolutely the law of rational indices or the law of multiple proportions.[20] According to Jaquet the formula of hemoglobin (of the dog) is $C_{758}H_{1203}N_{195}S_3FeO_{218}$. This formula can hardly be regarded as established. It may be a little different but it is very probable that these elements unite in definite proportions. This is exactly analogous to vicinal faces such as (251·250·250) observed on alum by Miers.

The law of multiple proportions was deduced by Dalton from his atomic theory before there were accurate analyses to prove it,

[20] Organic chemistry has an advantage over inorganic chemistry in that the formulæ may usually be determined by the method of formation.

just as the law of rational indices was deduced by Haüy from his theory of crystal structure. If chemical compounds are made up of atoms they must necessarily unite in definite proportions. This it will be recalled is precisely analogous to the argument used for proof of the rationality of the indices. If crystals are made up of particles or molecules, the crystal faces necessarily have rational indices.

Two or more given elements do not unite in all possible proportions but in a comparatively few, usually simple, proportions which we explain by the term valence. There are but two oxids of mercury Hg_2O, and HgO which we explain by saying that the valence of mercury is one and two. This is analogous to the limitation imposed by the law of complication of Goldschmidt or the law of maximum reticulate density of Bravais.

To complete the analogy between the laws and theories of crystallography and chemistry let us consider the periodic law and its analogue. Mendeléef, the Russian chemist, predicted the existence of several chemical elements, scandium and gallium, which he called ekaboron and eka-aluminum, before they were discovered. Not less remarkable was the deduction by Hessel, a German mathematician, of the thirty-two possible types of symmetry in crystals, assuming 2-, 3-, 4-, and 6-fold symmetry-axes, in 1830, at a time when only about half of them were known. Of the thirty-two possible types of symmetry, only one remains to be found.

Summary.

Judging from various text-books and articles a difference of opinion exists as to the exact meaning of the law of rational indices. Some authors limit the indices to simple numbers while others admit that occasionally the indices are large numbers. Unfortunately this question can not be decided by direct measurement of the angles on account of errors in measurement. As crystals possess axes of only 2-, 3-, 4-, and 6-fold symmetry they must consist of regularly arranged molecules, or particles of some sort, whatever their nature may be. Crystal faces, then, necessarily have rational indices. The indices are usually small numbers but may also be

complex, the complexity in general increasing with the rarity of the face. The structure theory of Bravais offers a satisfactory explanation of the abundance of faces with simple indices and the rarity of faces with complex indices. There is a remarkable analogy between the fundamental laws of chemistry and crystallography.

STANFORD UNIVERSITY,
CALIFORNIA,
Feb., 1912.

DYNAMICAL THEORY OF THE GLOBULAR CLUSTERS AND OF THE CLUSTERING POWER INFERRED BY HERSCHEL FROM THE OBSERVED FIGURES OF SIDEREAL SYSTEMS OF HIGH ORDER.

By T. J. J. SEE.

(*Read April 19, 1912.*)

(Plates VIII (bis) and IX.)

I. Introductory Remarks.

More than a century and a quarter have elapsed since it was confidently announced by Sir William Herschel that sidereal systems made up of thousands of stars exhibit the effects of a clustering power which is everywhere moulding these systems into symmetrical figures, as if by the continued action of central forces (*Phil. Trans.*, 1785, p. 255, and 1789, pp. 218–226). In support of this view he cited especially the figures of the planetary nebulæ, and the globular clusters, as well as the more expanded and irregular swarms and clouds of stars visible to the naked eye along the course of the Milky Way, which thus appears to traverse the heavens as a *clustering stream*. And yet notwithstanding the early date of this announcement and the unrivaled eminence of Herschel, it is only very recently that astronomers have begun to consider the origin of sidereal systems of the highest order.

The historical difficulty of solving the problem of *n*-bodies, when *n* exceeds 2, which dates from the establishment of the law of universal gravitation by Newton in 1687, will sufficiently account for the restriction of the researches of mathematicians to the planetary system, where the central masses always are very predominant, the orbits almost circular and nearly in a common plane, and to other simple systems such as the double and multiple stars: but owing to the general prevalence of the clustering tendency pointed out by Herschel and now found to be at work throughout the sidereal universe, it becomes necessary for the modern investigator to consider also the higher orders of sidereal systems, including those made up of thousands and even millions of stars. It is only by such a comprehensive view of nature, which embraces and unites all types of systems under one common principle, that we may hope to establish the most general laws governing the evolution of the sidereal universe.

Accordingly, although the strict mathematical treatment of the great historical problem of *n*-bodies is but little advanced by the recent researches of geometers, yet if we could arrive at the general secular tendency in nature, from the observational study of the phenomena presented by highly complex systems of stars, operating under known laws of attractive and repulsive forces, the former for gathering the matter into large masses, the latter for redistributing it in the form of fine dust, the result of such an investigation would guide us towards a grasp of problems too complex for rigorous treatment by any known method of analysis.

Now it happens that in the second volume of the "Researches on the Evolution of the Stellar System," 1910, the writer was able to establish great generality in the processes of cosmogony, and to show that the universal tendency in nature is for the large bodies to drift towards the most powerful centers of attraction, while the only throwing off of masses that ever takes place is that of small particles expelled from the stars under the action of repulsive forces and driven away for the formation of new nebulæ. The repulsive forces thus operate to counteract the clustering tendency noticed by the elder Herschel, and so clearly foreseen by Newton as an inevitable effect of universal gravitation upon the motions of the solar system that he believed the intervention of the Deity eventually would become necessary for the restoration of the order of the world (cf. Newton's "Letters to Bentley," Brewster's "Life of Newton," Vol. II., and Chapter XVII., and Appendix X).

But whilst the argument developed in the second volume of my "Researches" gives unexpected simplicity, uniformity and continuity to the processes of cosmogony, there has not yet been developed, so far as I know, any precise investigation of the attractive forces operating in globular clusters, which might disclose the nature of the clustering power noticed by Herschel to be in progress throughout the sidereal universe. Such an investigation of the central forces governing the motions in clusters is very desirable, because it might be expected to throw light on the mode of evolution of clusters as the highest type of the perfect sidereal system. If it can be shown that a clustering power is really at work, and is of such a nature as to produce these globular masses of stars, it will be less important to consider the details of those systems which have not yet reached a state of symmetry and full maturity; for the governing principle being established for the most perfect types, it must be held to be the same in all.

II. General Expressions for the Potential of an Attracting Mass.

If we have a mass M' of any figure whatever, in which the law of density is $\sigma' = f(x', y', z')$, where (x', y', z') are the coördinates of the element dm' of the attracting mass, and this element attracts a unit mass whose coördinates are (x, y, z); then the element of the attracting mass is

$$dm' = \sigma' dx' dy' dz'. \qquad (1).$$

And the expressions for the forces acting on the unit mass when resolved along the coördinate axes become

$$\begin{aligned} \frac{\partial U}{\partial x} &= X = \int\int\int \frac{x' - x}{r^3} \sigma' dx' dy' dz', \\ \frac{\partial U}{\partial y} &= Y = \int\int\int \frac{y' - y}{r^3} \sigma' dx' dy' dz', \\ \frac{\partial U}{\partial z} &= Z = \int\int\int \frac{z' - z}{r^3} \sigma' dx' dy' dz', \end{aligned} \qquad (2)$$

$$r = \sqrt{(x' - x)^2 + (y' - y)^2 + (z' - z)^2}.$$

The potential function itself obviously is

$$U = \int\int\int \frac{\sigma' dx' dy' dz'}{r}. \qquad (3)$$

In spherical coördinates we may take the angle ϕ for the longitude, θ for the latitude, and r for the radius of the sphere; and then the required expressions become

$$\begin{aligned} x'-x &= r\sin\theta\cos\phi, \\ y'-y &= r\sin\theta\sin\phi, \\ z'-z &= r\cos\theta. \end{aligned} \tag{4}$$

The element of mass dm' defined in (1) has the equivalent form

$$\sigma' dx'dy'dz' = \sigma' dr\cdot rd\theta\cdot r\sin\theta d\phi. \tag{5}$$

The element of the potential due to this differential element is

$$\frac{\sigma' r^2 \sin\theta drd\theta d\phi}{r}; \tag{6}$$

and the general expression for the potential becomes

$$U = \frac{1}{4\pi}\int_0^{2\pi} d\phi \int_0^{\pi} \sin\theta d\theta \int_0^{r} \sigma' rdr. \tag{7}$$

If we make use of the equations (1), (4), (5) in equation (2) we may obtain the corresponding expressions for the forces resolved along the coördinate axes:

$$\begin{aligned} X &= \int_0^{2\pi} \cos\phi d\phi \int_0^{\pi} \sin^2\theta d\theta \int_0^{r} \sigma' dr, \\ Y &= \int_0^{2\pi} \sin\phi d\phi \int_0^{\pi} \sin^2\theta d\theta \int_0^{r} \sigma' dr, \\ Z &= \int_0^{2\pi} d\phi \int_0^{\pi} \cos\theta\sin\theta d\theta \int_0^{r} \sigma' dr. \end{aligned} \tag{8}$$

These expressions will hold rigorously true for any law of density whatever, so long as it is finite and continuous. In the physical universe these conditions always are fulfilled; and hence if these several integrals can be evaluated, they will give the potentials and forces exerted on a unit mass by an attracting body such as a cluster of stars, or the spherical shell surrounding the nucleus of a cluster.

But before considering the attraction of a cluster in detail, we shall first examine the cumulative effect of central forces on the law of density. The problem is intricate and must be treated by methods of great generality, but as it will elucidate the subsequent procedure for determining the attraction of such a mass upon a neighboring point, we shall give the analysis with enough detail to establish clearly the secular effect of close appulses of individual stars upon the figure and internal arrangement of these wonderful masses of stars.

III. The Cumulative Effect of the Central Forces upon the Figure and Compression of a Globular Cluster of Stars.

Suppose a globular cluster of stars to be in a moderate state of compression, with density increasing towards the center. Imagine the whole of the mass at the epoch t_0 to be divided into two parts by a spherical surface of radius r, drawn about the center of gravity of the entire system; and let the external boundary of the cluster be R, so chosen that no star, from the motions existing at the initial epoch, will cross the border $r=R$. The stars in the outer shell, between the surfaces r and R, with coördinates (x', y', z'), will give rise to a potential U. Those of the nucleus or series of internal shells, between $r=0$, and $r=r$, with coördinates (x, y, z), will give rise to a potential V. Accordingly we have

$$\begin{aligned} U &= \iiint \frac{\sigma' dx' dy' dz'}{\sqrt{(x'-x)^2+(y'-y)^2+(z'-z)^2}}, \\ V &= \iiint \frac{\sigma dx dy dz}{\sqrt{(x'-x)^2+(y'-y)^2+(z'-z)^2}}. \end{aligned} \tag{9}$$

And the forces resolved along the coördinate axes are

$$\begin{aligned} \frac{\partial U}{\partial x} &= X = \iiint \frac{\sigma'(x'-x) dx' dy' dz'}{\sqrt{(x'-x)^2+(y'-y)^2+(z'-z)^2}}, \\ \frac{\partial U}{\partial y} &= Y = \iiint \frac{\sigma'(y'-y) dx' dy' dz'}{[(x'-x)^2+(y'-y)^2+(z'-z)^2]^{\frac{3}{2}}}, \\ \frac{\partial U}{\partial z} &= Z = \iiint \frac{\sigma'(z'-z) dx' dy' dz'}{[(x'-x)^2+(y'-y)^2+(z'-z)^2]^{\frac{3}{2}}}; \end{aligned} \tag{10}$$

with similar expressions for

$$\frac{\partial V}{\partial x}, \quad \frac{\partial V}{\partial y}, \quad \frac{\partial V}{\partial z}.$$

The integration for the mutual potential energy of the stars in the outer shell relative to those in the central sphere of radius r leads to a sextuple integral

$$\Omega = \int\int\int\int\int\int \frac{\sigma\sigma' dxdydzdx'dy'dz'}{\sqrt{(x'-x)^2 + (y'-y)^2 + (z'-z)^2}}. \qquad (11)$$

And the total of the mutual attractive forces resolved along the coördinate axes are

$$\frac{\partial \Omega}{\partial x} = \int\int\int\int\int\int \frac{\sigma\sigma'(x'-x) dxdydzdx'dy'dz'}{[(x'-x)^2 + (y'-y)^2 + (z'-z)^2]^{\frac{3}{2}}}, \qquad (12)$$

with similar expressions for

$$\frac{\partial \Omega}{\partial y}, \quad \frac{\partial \Omega}{\partial z}.$$

Now it is easy to prove (cf. Thomson and Tait's "Natural Philosophy," §§ 547–548) that the sextuple integral (11) can be put into the form

$$\Omega = \int\int\int \sigma U dxdydz = \int\int\int \sigma' V dx'dy'dz'. \qquad (13)$$

By actual derivation of the expressions (9) we easily find that

$$\frac{\partial U}{\partial x}\frac{\partial V}{\partial x} + \frac{\partial U}{\partial y}\frac{\partial V}{\partial y} + \frac{\partial U}{\partial z}\frac{\partial V}{\partial z}$$

is equivalent to Ω, by (11), and therefore

$$\int\int\int \left(\frac{\partial U}{\partial x}\frac{\partial V}{\partial x} + \frac{\partial U}{\partial y}\frac{\partial V}{\partial y} + \frac{\partial U}{\partial z}\frac{\partial V}{\partial z}\right) dxdydz = 4\pi\Omega, \qquad (14)$$

4π being introduced owing to the integration over the closed sphere surface (cf. Williamson's "Integral Calculus," edition of 1896, p. 330; Bertrand, "Calcul Integral," p. 480).

As the right members of (13) give the mutual potential energy of the bodies of the system, it suffices for us to deal with the integral of (14). This triple integral admits of transformation by Green's theorem ("Essay on the Application of Mathematics to Electricity and Magnetism," Nottingham, 1828). If U and V be functions of x, y, z, the rectangular coördinates of a point; then provided U and V are *finite and continuous for all points within a given closed surface S*, it is easy to show (cf. Williamson's "Integral Calculus," 7th edition, 1896, p. 328; Riemann, "Schwere, Electricität und Magnetismus," p. 73; Thomson and Tait's "Natural Philosophy," Part I., Vol., I., p. 167; Bertrand, "Calcul Integral," p. 480):

$$\iiint\left(\frac{\partial U}{\partial x}\frac{\partial V}{\partial x}+\frac{\partial U}{\partial y}\frac{\partial V}{\partial y}+\frac{\partial U}{\partial z}\frac{\partial V}{\partial z}\right)dxdydz$$

$$=\iint U\frac{\partial V}{\partial n}dS-\iiint U\left(\frac{\partial^2 V}{\partial x^2}+\frac{\partial^2 V}{\partial y^2}+\frac{\partial^2 V}{\partial z^2}\right)dxdydz \quad (15)$$

$$=\iint V\frac{\partial U}{\partial n}dS-\iiint V\left(\frac{\partial^2 U}{\partial x^2}+\frac{\partial^2 U}{\partial y^2}+\frac{\partial^2 U}{\partial z^2}\right)dxdydz.$$

The case in which one of the functions, U for example, becomes infinite within the surface S was also considered by Green, and is of prime importance in the present investigation of the theory of globular clusters. To simplify the treatment, suppose U to become infinite at one point P only; then infinitely near this point U may be taken as sensibly equal to $1/r$, where r is the distance from P. Imagine an infinitely small sphere, of radius a, described about P as a center. Equation (15) obviously is applicable to all points exterior to this little sphere. Moreover, since

$$\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+\frac{\partial^2}{\partial z^2}\right)\frac{1}{r}=0, \quad (16)$$

it is clear that the triple integral of the right members of (15) may be supposed to extend through the entire enclosed space S, since the part arising from the points within this little sphere is a small quantity of the same order as a^2, and therefore of the second order of small quantities.

Moreover, since near P the function U is sensibly equal to $1/r$, the part of $\iint U\frac{\partial V}{\partial n}dS$ due to the surface of the sphere is infinitely small of the order of the radius a, which is of the first order of small quantities, and may therefore be neglected. It only remains, then, to consider the part of $\iint V\frac{\partial U}{\partial n}dS$ due to the spherical surface.

As V is supposed to vary continuously, we may take for it the value V' which is that attained at the point P. Then, since

$$\frac{\partial U}{\partial n}=\frac{\partial U}{\partial r}=\frac{d\left(\frac{1}{r}\right)}{dr}=-\frac{1}{r^2}=-\frac{1}{a^2}, \tag{17}$$

the integral over the sphere $S=4\pi a^2$ will become

$$\iint V\frac{\partial U}{\partial n}dS=\iint V\left(-\frac{1}{a^2}\right)d(4\pi a^2)=-4\pi V'. \tag{18}$$

Accordingly, the equation (15) becomes

$$\iiint\left(\frac{\partial U}{\partial x}\frac{\partial V}{\partial x}+\frac{\partial U}{\partial y}\frac{\partial V}{\partial y}+\frac{\partial U}{\partial z}\frac{\partial V}{\partial z}\right)dxdydz$$

$$=\iint U\frac{\partial V}{\partial n}dS-\iiint U\left(\frac{\partial^2 V}{\partial x^2}+\frac{\partial^2 V}{\partial y^2}+\frac{\partial^2 V}{\partial z^2}\right)dxdydz \tag{19}$$

$$=\iint V\frac{\partial U}{\partial n}dS-\iiint V\left(\frac{\partial^2 U}{\partial x^2}+\frac{\partial^2 U}{\partial y^2}+\frac{\partial^2 U}{\partial z^2}\right)dxdydz-4\pi V'. \tag{20}$$

In these formulæ, as before, the triple integrals extend through the whole space, and the double integrals over the whole surface. If V had become infinite, instead of U, there would have been the corresponding term $-4\pi U'$ to be added to the right member of (19).

Now in a globular cluster of stars subjected to the mutual gravitation of its components over long ages, many close approaches will eventually develop: and they may depend on the wandering of stars within either the outer shell or the central sphere, or from the shell to the sphere or *vice versa*. Therefore both U and V may become infinite from the appulses of stars under the secular effects of the mutual gravitation of the stars of the cluster. If we denote by $\nabla^2 U$ and $\nabla^2 V$ the Laplacean operation indicated in (16), as applied to the functions U and V, the right members of equations (19) and (20) when modified to include the appulses accumulating in a cluster over long ages, become

$$\begin{aligned}\iint U\frac{\partial V}{\partial n}dS - \iiint U(\nabla^2 V)dxdydz - \sum_{i=1}^{i=i} 4\pi U_i'\\ = \iint V\frac{\partial U}{\partial n}dS - \iiint V(\nabla^2 U)dxdydz - \sum_{i=1}^{i=i} 4\pi V_i'.\end{aligned} \tag{21}$$

In our present problem the triple integrals may be neglected, since $\nabla^2 V$ and $\nabla^2 U$ are each zero, or evanescent, in the small spheres where the appulses occur, and even here are small quantities of the order a^2. Hence by (14) the secular equations become

$$4\pi\Omega = \iiint\left(\frac{\partial U}{\partial x}\frac{\partial V}{\partial x} + \frac{\partial U}{\partial y}\frac{\partial V}{\partial y} + \frac{\partial U}{\partial z}\frac{\partial V}{\partial z}\right)dxdydz$$

$$= \iint V\frac{\partial U}{\partial n}dS - \sum_{i=1}^{i=i} 4\pi V_i' \tag{22}$$

$$= \iint U\frac{\partial V}{\partial n}dS - \sum_{i=1}^{i=i} 4\pi U_i'. \tag{23}$$

Over very great intervals of time, to be reckoned, as Herschel believed, in "millions of ages," the number of appulses may be taken to be proportional to the time in either the original shell or the original sphere. Consequently instead of the summations in the right members of (22) and (23) we could introduce terms depending directly on the time, and thus write

$$\begin{aligned}4\pi\Omega &= \iint V\frac{\partial U}{\partial n}dS - 4\pi V'\cdot\alpha(t - t_0)\\ &= \iint U\frac{\partial V}{\partial n}dS - 4\pi U'\cdot\beta(t - t_0)\end{aligned} \tag{24}$$

where α and β are positive numerical coefficients in the form of undetermined multipliers.

Now it is significant that to the surface integrals negative terms are attached increasing at rates proportional to the time. The second members of (24) cannot therefore be constant, but must decrease with the time. As U and V depend on the coördinates at the initial epoch t_0, and the derivatives $\frac{\partial U}{\partial n}$ and $\frac{\partial V}{\partial n}$ depend on the same elements, a progressive decrease in the double integrals, to satisfy the right members of (24), implies that the coördinates of the entire system must so change that the surface S decreases. Thus the globular cluster undergoes a secular compression, owing to the accumulation of appulses, and the shrinkage of the bounding surface.

It is well known that under the operation of universal gravitation the bodies of a system, starting from any initial distribution, tend to fall together, so that the potential energy diminishes. When the number of bodies is very large it becomes impossible for the motions to be simply periodic, like that of a planet or comet moving in a Keplerian ellipse; but although the nature of the non-reëntrant orbits cannot be predicted by any known method, it is possible to say that the potential energy of the system *tends incessantly to a minimum*, while the maximum of the total energy becomes kinetic, and is expended in producing large velocities of the bodies. The left member of (24) therefore incessantly decreases, owing to the exhaustion of the potential energy. This accords with what, on purely mathematical grounds, we found to be the effect of appulses, on the right member of (24). Hence universal gravitation acts as a *clustering power*, and when the figure of a cluster is rendered globular, the dimensions of the system is further diminished under the secular effect of appulses and exchanges of velocities going on within the mass of stars.

In view of the above considerations it is evident that the right member of equations (24) should include independent negative terms to take account of the effect of *general shrinkage*, without regard to appulses due to close approach. Thus the final forms of these equations become:

$$
\begin{aligned}
4\pi\Omega &= \iint V\frac{\partial U}{\partial n}dS - 4\pi V'\cdot\alpha(t-t_0) - \alpha'(t-t_0) \\
&= \iint U\frac{\partial V}{\partial n}dS - 4\pi U'\cdot\beta(t-t_0) - \beta'(t-t_0),
\end{aligned}
\tag{25}
$$

where α' and β' are positive numerical coefficients in the form of undetermined multipliers. The first of these negative terms depends on appulses due to close approach, the second on the *general shrinkage* due to the mutual attraction of the stars of the cluster at all distances.

The action of the clustering power upon the figure of a cluster, as Herschel remarked (*Phil. Trans.*, 1789, p. 219), is analogous to that of gravity on the figure of a planet. It might be compared also to the well-known effect of surface tension on the figure of a drop of dew or a drop of mercury, etc. In these last phenomena the *surface is made a minimum,* for a given volume, by the restriction of the elastic layer constituting the outer boundary. A soap bubble is also a good illustration of such *minimal surfaces,* the mathematical theory of which has been placed on a strictly rigorous basis by the researches of the late Professor Weierstrass, one of my most revered teachers at the University of Berlin. In the case of the clusters, however, we have not only a tendency to minimal surfaces, but also for such an internal arrangement of the stars with increase of density towards the center as will reduce the potential energy of the system to a minimum. The theory of the clusters is therefore much more complex than that of simple minimal surfaces, such as we see in drops of dew or soap bubbles, to which the analysis of Weierstrass is applicable.

In the case of the minimal surfaces of the type rigorously treated by Weierstrass, the determination of the minimum is found by the usual condition in the calculus of variations,

$$\delta u = 0, \tag{26}$$

where the function $u=\chi(x, y, z)$ represents the surface.

In the more general problem of clusters, the determination of the minimum potential energy applies to every shell as well as the external surface, and thus for the i concentric shells we have

$$\delta\left(\sum_{i=1}^{i=i} u_i\right) = 0, \tag{27}$$

where $u_i = \chi_i(x, y, z)$ is the equation of any surface.

Moreover, the clusters involve two additional conditions, the first being that in each layer the density σ_i shall depend wholly on the radius, and not at all on the angles (ϕ, θ) usually used in polar coördinates. If any point in any layer be taken as a pole it suffices to regard simply the new polar angle θ; and the required condition is

$$\frac{\delta(\sigma_i)}{\delta\theta} = 0, \tag{28}$$

where $\sigma_i = \psi(r, \theta, \phi)$ is the law of density in any shell, the new angle θ alone being sufficient where there is no fixed pole. The second condition is that the law of density as respects the radius shall be suitable and the same throughout the mass; so that in every part the form of the density function does not vary as respects the radius:

$$\frac{\delta[\psi(r, \theta, \phi)]}{\delta r} = 0. \tag{29}$$

The actual arrangement in any given cluster may not be perfect, but nature always and everywhere works towards the fulfillment of these conditions.

IV. The Observed Law of Density in Globular Clusters.

In the *Monthly Notices* of the Royal Astronomical Society for March, 1911, Mr. H. C. Plummer, of Oxford, has an important paper "On the Problem of Distribution in Globular Star Clusters." For earlier data on the distribution of stars in clusters he refers to a statistical paper by Mr. W. E. Plummer (*Monthly Notices,* June, 1905, Vol. LXV., p. 810), and to the much earlier investigations by Professor E. C. Pickering (*Harvard Annals,* Vol. XXII.) and Professor Solon I. Bailey (*Astronomy and Astrophysics,* Vol. XII., p. 689).

Among the results cited from the researches of Pickering and Bailey are these:

1. The law of distribution is essentially the same for different clusters.

2. The bright stars and faint stars of a cluster obey the same law.

Mr. H. C. Plummer also availed himself of the important researches of Dr. H. von Zeipel on the cluster Messier 3 (*Annales de l'Observatoire de Paris,* Tome XXV.), in which a method was developed for finding the law of distribution of the stars in space, from the observed law of distribution in the projection as we see it. Dr. von Zeipel effected this transformation by means of a theorem due to Abel. He subsequently compared his results for Messier 13 and Omega Centauri with the densities to be expected in a spherical mass of gas in isothermal equilibrium.

In his paper of March, 1911, Mr. Plummer investigates the law of density for the clusters Omega Centauri, 47 Toucani, and the great cluster in Hercules (M. 13). By the use of von Zeipel's method he finds that in these three clusters there is a very good agreement as respects the law of density. In the accompanying table we give the ten points of Plummer's empirical curve of density, based on recent photographs. For the sake of comparison we give also the corresponding points for the laws of density and pressure for a sphere of gas following the monatomic law and in convective equilibrium, as developed in the writer's researches on the "Physical Constitution and Rigidity of the Heavenly Bodies" (*Astron. Nachr.,* Nos. 4053, 4104). The nature of these three laws is best understood from the accompanying illustration, Fig. 1.

1. The cluster density is greater near the boundary, the curve tending to become asymptotic, as there is no definite boundary to the mass of stars.

2. The cluster density also appears to be relatively greater near the center, so that the curve intersects the monatomic curves in the outer parts of the radius but again unites with them at the center, after falling and pursuing a different course between the surface and the center.

3. As the apparent density of the stars in a cluster is consider-

Part of Radius, or Distance from Center	Plummer's Law of Density in Star Clusters	See's Law of Density in Sphere of Monatomic Gas in Convective Equilibrium.	See's Law of Pressure in Sphere of Monatomic Gas in Convective Equilibrinm.
0.0	1.00	1.00	1.00
0.1	0.87	0.97	0.95
0.2	0.63	0.90	0.80
0.3	0.38	0.74	0.60
0.4	0.24	0.58	0.40
0.5	0.145	0.42	0.235
0.6	0.085	0.28	0.118
0.7	0.062	0.161	0.048
0.8	0.035	0.008	0.014
0.9	0.025	0.0025	0.002
1.0	0.020	0.0000	0.000

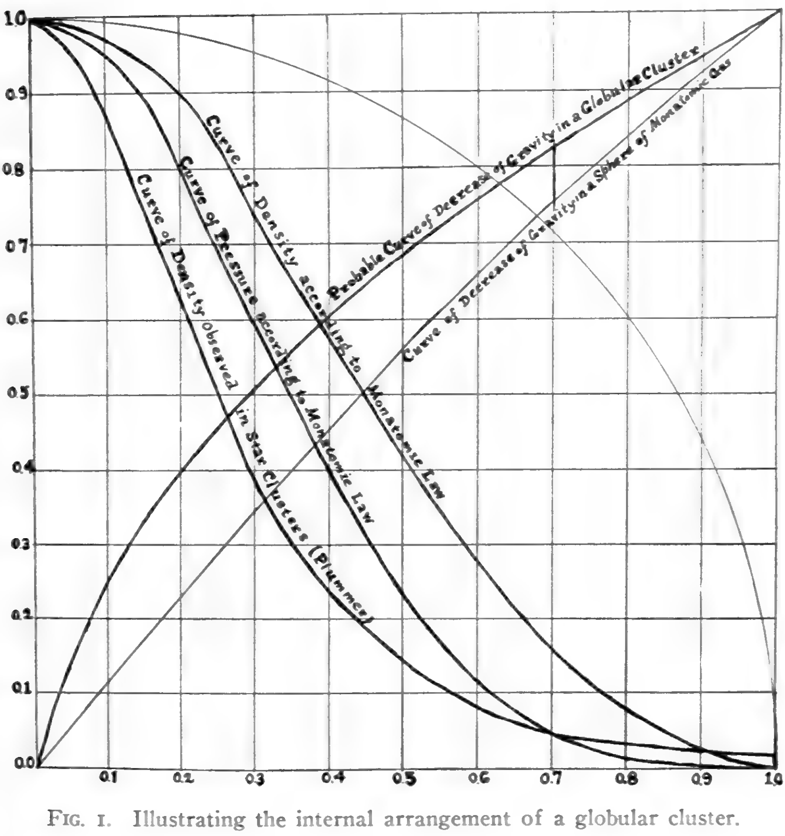

FIG. 1. Illustrating the internal arrangement of a globular cluster.

able, and the images spread somewhat on the plate, it is possible that longer photographic exposures or better plates, on which the images do not spread, would give relatively more stars in the region of the middle of the radius of the cluster, and thus bring the law of density for clusters into essential agreement with the monatomic law of density.

Further photographic observations, with the best modern instruments, alone would decide this question. A final decision can not be made yet, but in order to have the judgment of the best contemporary astronomical photographer on the subject, I have recently referred the question to Professor W. S. Adams, acting director of the solar observatory at Pasadena, who reports as follows:

> "I regret that I cannot give answers which would be at all conclusive to your questions regarding the distribution of the fainter stars in star clusters. Up to the present time only a few counts have been made upon our photographs. So far as these go, they do not appear to show any tendency on the part of the fainter stars to predominate around any particular portion of the radius of the cluster, but rather for the distribution to be tolerably uniform. The problem is made difficult by the fact that the central part of our photographs is almost always burned out, so that counting is impossible for some distance along the radius. We have begun, however, to take series of photographs of clusters, giving exposure times with a ratio of 1 to 2.5. These should help greatly in providing an answer to your questions."

On the whole the indications are that the capturing process of drawing in stars from without is still going on. This would account for the small density near the outside of the cluster, and also the great central density, the latter being an accumulative effect of the various shells in the course of millions of ages.

V. The Potential due to a Mass of Globular Figure Assumed under the Action of Central Powers.

In my "Researches," Vol. II., 1910, I have outlined the process by which the nebulæ form by the aggregation of dust from a distance; and shown that the collecting streams may often take the spiral form, and in this early stage are not of symmetrical figure. The general integrals in Section II. are required to express the attraction of these unsymmetrical masses. But in true sidereal systems as old and fully developed as the globular clusters are known to be, a state of very perfect symmetry has been attained through the oscillations of the entire mass, and the mutual adjustments of the parts of the system, and by the rounding up of the orbits under the secular action of the resisting medium, as implied in Plato's remark that the Deity always geometrizes—ὁ θέος ἀεὶ γεωμέτρει. On this latter process I have dwelt at some length in an address on "The Foundations of Cosmogony," delivered to the St. Louis Academy of Sciences, May 1, 1911, and printed in the *Memorie delle Societa degli Spettroscopisti italiani,* Rome, Vol. XL., 1911; and in another address entitled "The Evolution of the Starry Heavens," delivered to the California Academy of Sciences, Aug. 7, 1911, and printed in *Popular Astronomy* for November and December, 1911.

Herschel's theory of the spherical figures of clusters (*Phil. Trans.,* 1789, p. 217), conceived as made up of a series of concentric shells of uniform density, but with increasing accumulation towards their centers, is confirmed by modern photographs of various clusters as shown in the accompanying plates from my "Researches," Vol. II. The attraction of a mass of this kind thus becomes similar to that of a sphere made up of concentric homogeneous layers, but with the density increasing towards the center. The integration for the central attraction in these perfectly symmetrical figures thus need not involve θ or ϕ, but only the radius r.

If σ_0 be the central density of the cluster, and σ the density at any point whose distance from the origin of the coördinates at the center is x, a shell of density σ and thickness dx will have the mass

$$dm = 4\pi\sigma x^2 dx. \tag{30}$$

And the sphere enclosed by this shell will have the mass

$$m = 4\pi \int_0^x \sigma x^2 dx = \tfrac{4}{3}\pi\sigma_1 x^3, \tag{31}$$

where σ_1 is the average density of the enclosed layers included between $x = 0$ and $x = x$. Thus we have

$$\sigma_1 = \frac{3m}{4\pi x^3} = \frac{3\sigma_0}{x^3} \int_0^x \left(\frac{\sigma}{\sigma_0}\right) x^2 dx. \tag{32}$$

At the surface of the cluster the gravity of the entire mass will become

$$G = \frac{M}{x'^2}, \tag{33}$$

where M is the mass of all the stars and x' the exterior radius of the cluster. If G' be the value of the force of gravity of the cluster at any point below the surface, at a distance x from the center, we shall have

$$G' = \frac{4\pi\sigma_0}{x^2}\int_0^x \left(\frac{\sigma}{\sigma_0}\right) x^2 dx. \tag{34}$$

The outer shell of the cluster is here neglected as exerting no attraction on a point within, as was long ago established by Newton for homogeneous solid bodies (cf. "Principia," Lib. I., Prop. XCI., prob. XLV., Cor. 3).

To find the ratio of G' to G so as to give the law of central force within the cluster, we have the relation

$$\frac{G'}{G} = \frac{\dfrac{4\pi\sigma_0}{x^2}\displaystyle\int_0^x \left(\frac{\sigma}{\sigma_0}\right) x^2 dx}{\frac{4}{3}\pi\sigma_1{}' \cdot \dfrac{x'^3}{x'^2}} = \frac{3\sigma_0 \displaystyle\int_0^x \left(\frac{\sigma}{\sigma_0}\right) x^2 dx}{x' x^2 \dfrac{3\sigma_0}{x'^3}\displaystyle\int_0^{x'} \left(\frac{\sigma}{\sigma_0}\right) x^2 dx}$$

$$= \frac{x'^2 \displaystyle\int_0^x \left(\frac{\sigma}{\sigma_0}\right) x^2 dx}{x^2 \displaystyle\int_0^{x'} \left(\frac{\sigma}{\sigma_0}\right) x^2 dx}. \tag{35}$$

The evaluation of this ratio depends on the integrals between the assigned limits, one corresponding to the entire sphere of radius x', and one to the part of the sphere included within the radius x. Thus the integrals depend on the law of density in the cluster. We have already seen from the researches of Dr. H. von Zeipel, and Mr. H. C. Plummer that the accumulation of density towards the center appears to slightly exceed that of a sphere of monatomic gas in convective equilibrium and fulfilling adiabatic conditions (*A. N.*, 4053, and *A. N.*, 4104).

Although the monatomic law may not hold strictly true in clusters, yet it seems worth while to examine the results which will follow from this law. In *A. N.*, 4053, p. 327, it is shown that

$$\frac{\sigma}{\sigma_0} = \frac{1}{x^2}\frac{d\mu}{dx}, \tag{36}$$

where the expression for μ, with the correction noted in *A. N.*, 4104, p. 386, is

$$\begin{aligned}\mu = {} & \frac{x^3}{3} - \frac{x^5}{20} + \frac{x^7}{240} - \frac{x^9}{3888} + \frac{19x^{11}}{1425600} - \frac{2719x^{13}}{4447872000} \\ & + \frac{20621x^{15}}{800616960000} - \frac{193328x^{17}}{190546836480000} \\ & + \frac{39667364x^{19}}{104267228921856000} - \frac{8078124341x^{21}}{59119518798692352000000} + \cdots.\end{aligned} \tag{37}$$

Now if we substitute the value of σ/σ_0 from (36) in the integrals of (35), they are reduced to two series which may be called μ and μ', the latter having the same form as (37) but the limit x' instead of x. Accordingly (35) becomes

$$\begin{aligned}\frac{G'}{G} = \frac{x'^2\mu}{x^2\mu'} &= \frac{x'^2\left[\frac{x^3}{3} - \frac{x^5}{20} + \frac{x^7}{240} - \frac{x^9}{3888} + \cdots\right]}{x^2\left[\frac{x'^3}{3} - \frac{x'^5}{20} + \frac{x'^7}{240} - \frac{x'^9}{3888} + \cdots\right]} \\ &= \frac{x\left\{\frac{1}{3} - \frac{x^2}{20} + \frac{x^4}{240} - \frac{x^6}{3888} + \cdots\right\}}{x'\left\{\frac{1}{3} - \frac{x'^2}{20} + \frac{x'^4}{240} - \frac{x'^6}{3888} + \cdots\right\}}.\end{aligned} \tag{38}$$

As the coefficients of the series μ and μ' are the same, we may calculate from the equation (37) or (38) the value of the ratio at suitable intervals throughout the sphere, and ascertain rigorously the law of the variation. The results of my calculations are given in the following table and illustrated by the corresponding curve in Fig. 1.

Table Showing Decrease of Central Gravity in a Sphere of Monatomic Gas in Convective Equilibrium. The Decrease of Central Gravity in a Globular Cluster is Slightly Less Rapid, Owing to Greater Accumulation of Density Towards the Center.

Distance from Center. $= \frac{x}{x'}$	Ratio of Internal Gravity to Surface Gravity. $= \frac{G'}{G}$
1.0	1.00000
0.9	0.92563
0.8	0.84378
0.7	0.75495
0.6	0.65975
0.5	0.55928
0.4	0.45317
0.3	0.34769
0.2	0.23069
0.1	0.11587
0.0	0.00000

VI. Dynamical State of a Globular Cluster.

In works on the theory of potential and attraction the following theorems are demonstrated and well known:

1. That a *sphere* either homogeneous or made up of concentric spherical shells attracts an external point as if collected at its center (Newton's "Principia," Lib. I., Prop. LXXVI., Theorem XXXVI.).

2. That *homogeneous spherical shells* attract external points as if collected at their centers of figure, and exert no attraction on points within ("Principia," Lib. I., Prop. LXX., Theorem XXX.). Also a point within the sphere is attracted by a force proportional to the distance from the center ("Principia," Lib. I., Prop. LXXIII., Theorem XXXIII.); and the same theorem holds for the spheroid made up of concentric spheroidal shells ("Principia," Lib. I., Prop. XCI., Prob. XLV.).

3. That *ellipsoidal homœoids,* or ellipsoidal shells of any thickness made up of homogeneous layers, bounded by two ellipsoidal surfaces, concentric, similar and similarly placed, likewise exert no attraction on points within, as is shown by Newton in the "Principia" (Lib. I., Prop. XCI., Prob. XLV., Cor. 3) for the case of the spheroid, which corresponds to the figure and internal arrangement of density in such bodies as the planets, sun, and stars.

To illustrate the simple case of a *homogeneous sphere*, we remark that it attracts a point at its surface with a force

$$f=\frac{4}{3}\frac{\pi\sigma r^3}{r^2}=\tfrac{4}{3}\pi\sigma r=Cr, \qquad (39)$$

where σ is the density, and r the radius. This equation shows that all points within the sphere are attracted to the center by forces proportional to the radii of the shells on which they are situated, since the external shells exert no attraction on points within.

Let the solid sphere be set rotating steadily about an axis; then as the central forces at the various points are proportional to the radii described by the points, there will be no tendency arising from the central attraction for any shell to be displaced with respect to the shells within or without, once the condition of equilibrium is attained, but the central accelerations will everywhere tend to secure steady motion without relative displacement of the parts of the sphere. The same is true of the centrifugal force, after the adjustment to a suitable figure of equilibrium; for the centrifugal force is equal to v^2/r, v being the velocity of the particle and r the radius it describes; for this gives

$$f=\frac{v^2}{r}=\frac{(2\pi r)^2}{t^2 r}=\frac{4\pi r}{t^2}; \qquad (40)$$

and as it is common for all particles the force has the same form here as in equation (39).

What is here proved for the simple case of the homogeneous sphere, will obviously hold also for a sphere made up of concentric spherical shells of uniform density; for the theorem will hold for all the points within. And similarly for *ellipsoidal homœoids,* or spheroids such as the planets, sun and stars. If any of these masses have attained uniform movement as of rotation, there is no tendency to produce a relative displacement of the parts.

Now the simple equation (39) shows that a similar theorem holds for the internal dynamics of a globular cluster, the component stars of which have attained a state of equilibrium following a definite law of density depending only on the radius. But before treating of this at length, we shall recall a suggestive investigation of Sir William Herschel printed in the *Philosophical Transactions* for 1802 (pp. 477–502) under the title "Catalogue of 500 New Nebulæ, Nebulous Stars, Planetary Nebulæ, and Clusters of Stars; with Remarks on the Construction of the Heavens."

VII. Herschel's Theorem on the Motion of Multiple Stars, 1802.

In the important paper just cited Herschel first discusses "Binary Sidereal Systems or Double Stars," and then proceeds to Section "III. Of more complicated sidereal systems, or treble, quadruple, quintuple and multiple stars," where he reasons as follows:

> "In all cases where stars are supposed to move round an empty center, in equal periodical time, it may be proved that an imaginary attractive force may be supposed to be lodged in that center, which increases in a direct ratio of the distances. For since, in different circles, by the law of centripetal forces, the squares of the periodical times are as the radii divided by the central attractive forces, it follows, that when these periodical times are equal, the forces will be as the radii. Hence we conclude, that in any system of bodies, where the attractive forces of all the rest upon any one of them, when reduced to a direction as coming from the empty center, can be shown to be in a direct ratio of the distance of that body from the center, the system may revolve together without perturbation, and remain permanently connected without a central body."

This reasoning is best understood by means of simple formulæ: Let f_1 and f_2 be two centrifugal forces, which in revolving systems are always equal to the centripetal forces, and V_1 and V_2 the corresponding velocities of the bodies, and r_1 and r_2 the radii of the circles in which they are supposed to revolve. Then, by the elementary principles of mechanics, we have

$$f_1 = \frac{v_1^{\,2}}{r_1}\,;\ f_2 = \frac{v_2^{\,2}}{r_2}\,;\ \text{whence}\, f_1 = \frac{(2\pi r_1)^2}{t_1^{\,2} r_1}\,;\ f_2 = \frac{(2\pi r_2)^2}{t_2^{\,2} r_2}\,.$$

This gives

$$t_1^{\,2} = \frac{4\pi^2 r_1}{f_1}\,;\ t_2^{\,2} = \frac{4\pi^2 r_2}{f_2}\,. \tag{41}$$

Now in orbital revolution the centripetal and centrifugal motions are always exactly equal, and hence if $t_1 = t_2$, we have

$$\frac{t_1^2}{4\pi^2} = \frac{r_1}{f_1}\,;\ \frac{t_2^2}{4\pi^2} = \frac{r_2}{f_2}\,,\ \text{or}\ \frac{r_2}{f_2} = \frac{r_1}{f_1}\,,$$

whence

$$\frac{f_1}{f_2} = \frac{r_1}{r_2}, \tag{42}$$

as concluded by Herschel in the *Philosophical Transactions*, for 1802, p. 487.

To establish clearly such actual cases of motion, with the attractive force in the direct ratio of the distance from the empty center, where he says the system may revolve together without perturbation, and remain permanently convected without a central body, Herschel proceeds to deal first with two equal double stars revolving in circles about the common center of gravity of the system. He next generalizes the procedure by taking two unequal masses, then treats also the cases of motion in elliptic orbits, and finally considers certain types of triple and multiple stars, to which similar reasoning will apply. This paper of Herschel is quite remarkable, and deserving of more attention than it has received.

VIII. Theorem on the Revolutions of Stars in Clusters.

It is now obvious that the clusters which have attained a definite law of density depending wholly on the radius will conform to Herschel's Theorem of motion about empty centers, which is also the law for the central motion of particles of a rotating solid. If we imagine a heterogeneous sphere made up of concentric homogeneous layers, but with the density of the layers increasing towards the center, and take the radii of the layers to be $r_1, r_2, r_3, \ldots r_i$, and denote by $\sigma_1, \sigma_2, \sigma_3, \ldots \sigma_i$ the average density of the sphere up to the ith layer inclusive; then the attraction on points in these several layers will be $A_1, A_2, A_3, \ldots A_i$, as follows:

$$A_1 = \frac{4}{3}\frac{\pi\sigma_1 r_1^3}{r_1^2} = C_1 r_1\,;\ A_2 = C_2 r_2\,;\ A_3 = C_3 r_3\,;\ \cdots;\ A_i = C_i r_i. \tag{43}$$

Thus the constant will vary from layer to layer in a heterogeneous sphere made up of concentric homogeneous shells, but the attraction at every point, including the external surface, is proportional to the radius of the shell in question.

Now just as a sphere, either homogeneous or made up of concentric layers of uniform density, attracts all internal points, including those at the external surface, with a force proportional to the radius of the shell on which it is situated; so also will a cluster which is condensed towards the center according to any law of density depending wholly on the radius, attract all internal points, including those in the external surface, according to the same law of direct proportionality to the distance from the center.

When the attractive force varies directly as the distance from the center, the particle so attracted describes an ellipse as was first proved by Newton in the "Principia" (Lib. I., Prop. X., Prob. V.). This case of attraction depending directly on the first power of the distance is also discussed by the analytical method in Vol. II. of my "Researches," 1910, pp. 25–27, where it is shown that the time of revolution is quite independent of the dimensions of the ellipse, but depends wholly on the intensity of the central force.

For motion in a plane the coördinates of the particle are shown to be defined by the equations:

$$x = \frac{V \cos \psi}{\sqrt{\mu}} \sin \sqrt{\mu} t + a \cos \sqrt{\mu} t, \quad y = \frac{V \sin \psi}{\sqrt{\mu}} \sin \sqrt{\mu} t. \quad (44)$$

As the values of the coördinates are the same at the time t and $t + \frac{2\pi}{\sqrt{\mu}}$, it is evident that the time of revolution is $\frac{2\pi}{\sqrt{\mu}}$, or inversely as the square root of μ, where μ is the mass, and exerts the corresponding unit of force at unit distance.

In a cluster with stars arranged according to a law of density depending wholly on the radius, the value of μ or the force will depend wholly on the radius also, as shown in equation (34). And thus the time of revolution will be independent of the dimensions of the ellipse. Assuming that there is but little relative displacement of the bodies of the clusters, a star situated, therefore, in an outer shell will revolve about the common center of gravity in exactly the same time as one situated near the center; for the remoter stars revolve under a greater attractive force, while the nearer ones revolve under feebler forces, and all would therefore have a common period. The movement at the end of the period would restore the cluster to its original state, the individual bodies being exactly where they started from at the initial epoch. This is one of the most remarkable results of the dynamics of a system of n-bodies arranged in concentric shells of uniform density, depending wholly on the radius, as in our typical globular clusters, which are made up of stars of equal brightness and apparently of equal mass.

If therefore the cluster were once established with such relations among the stars that their orbits do not intersect, and the sphere of powerful attraction for each star is small compared to the spaces between the neighboring stars, the wonderful system thus arranged might oscillate in stability for millions of ages. These conditions evidently are quite fully realized in the globular clusters, as will more clearly appear from the following considerations on their mode of formation.

IX. The Symmetrical Growth of a Cluster due to a Process of Internal Compensation.

In the second volume of my "Researches," 1910, it is shown by a line of argument based on the principle of continuity, similar to that used by Herschel in the *Phil. Trans.*, 1811, p. 284, that the nebulæ are formed by the gathering together of dust expelled from the stars under the action of repulsive forces. As this dust gathers towards a center so as to form a nebula or cluster, of more or less symmetrical figure, it takes a long time for the new system to acquire an arrangement by which the density increases from the surface to the center. In the course of ages, however, the central mass increases or the central group of masses accumulate, by accretion of dust to the individual bodies, or by the capture and redistribution of interpenetrating bodies. The result, on the one hand, is that all orbits will be decreased in size and the system will contract its dimensions; and, on the other hand, this waste matter will tend to accumulate in regions of stability, and there build up the smaller into larger bodies. Thus the individual stars being supplied from such varied sources the cluster will necessarily acquire increasing symmetry, and orderly arrangement, like those actually observed.

This natural tendency to order and stability will be greatly augmented by mutual compensation among the stars of the cluster. As the stars are both gaining and losing matter incessantly, under the mutual interaction of attractive and repulsive forces, it is evident that those which gain too rapidly, will also begin at once to lose at an abnormal rate, owing to the augmented action of the repulsive forces; and the dust expelled from them will go directly or indirectly very largely to the other members of the cluster, and thus operate to restore the equilibrium of the whole group. Moreover, if any serious collision occurs, by which one star acquires predominant size, it will at the same time acquire such abnormal energy of radiation, that the balance of power will tend to become gradually restored under the action of the repulsive forces at work.

From these known causes one would expect a cluster therefore to be a mutually compensating system, producing and building up new bodies in vacant regions, where the conditions are stable, and redistributing undue accumulations of mass by the natural balance established between attractive and repulsive forces, as all the stars gain matter from surrounding space and again expel it after a certain repulsive vigor has been attained. The eventual accumulation of so many stars in a comparatively small space largely operates to retain the dust expelled from them in that region; it thus goes to other members of the group, rather than to the rest of the remote stars of the universe, so that in the course of vast time—millions of ages in Herschel's expressive phrase—the cluster accumulates to such grandeur and order as we see in such noble globular clusters as that in Hercules, 47 Toucani, and Omega Centauri.

It is worthy of note that this simple theory, based on known and established laws, explains not only the origin and growth of these wonderful masses of stars, under conditions of stability; but also the nearly perfect equality of the individual stars which has always been so bewildering to astronomers.

X. How a Star Entering a Cluster has its Oscillations Damped and is Finally Captured.

If we recall the familiar equations for an oscillation, as treated in works on physics,

$$\eta = ae^{-kt} \cos(nt + \alpha), \text{ or } \eta = ae^{-kt} \sin(nt + \beta), \qquad (45)$$

where a is the original amplitude of the harmonic oscillation, so that ae^{-kt} becomes a coefficient decreasing as t increases, $n = 2\pi/T$, T being the period; we see that as the time t increases the ordinate η will decrease, though the period T remains constant. The equation (45) thus represents a *damped vibration,* such as constantly arises where resistance is encountered by vibratory motion. Under these circumstances the harmonic curve rapidly loses amplitude and is of the form:

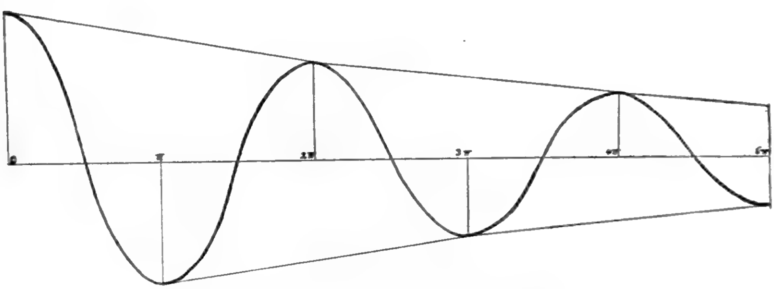

Fig. 2. Illustrating damped vibrations.

The process of damping here brought to light for oscillating particles describing simple harmonic motion has its analogies in the movements of stars in a cluster; for here too the period of the movement, as we have seen in VIII., is essentially constant, but the amplitude of the oscillation is reduced till it becomes adapted to that of the rest of the system. This is a part of the capture process, because it tends to reduce all the abnormal movements to one dead level.

Let us now examine the dynamical process by which stars tend to become entrapped in the central region of a cluster. If we consider the potential of a spherical shell of stars obeying any law of density, and having a thickness R-r, it is evident from equation (7) that

$$V' = \frac{1}{4\pi}\int_0^{2\pi} d\phi \int_0^{\pi} \sin\theta d\theta \int_r^R \sigma r dr, \tag{46}$$

and the forces along the coördinate axes will be

$$\begin{aligned} X' &= \int_0^{2\pi} \cos\phi d\phi \int_0^{\pi} \sin^2\theta d\theta \int_r^R \sigma dr, \\ Y' &= \int_0^{2\pi} \sin\phi d\phi \int_0^{\pi} \sin^2\theta d\theta \int_r^R \sigma dr, \\ Z' &= \int_0^{2\pi} d\phi \int_0^{\pi} \cos\theta \sin\theta d\theta \int_r^R \sigma dr. \end{aligned} \tag{47}$$

Now every globular cluster may be regarded as made up of a series of such shells; so that the total forces become

$$\begin{aligned} X &= \sum_{i=1}^{i=i} X_i = \sum_{i=1}^{i=i} \int_0^{2\pi} \cos\phi d\phi \int_0^{\pi} \sin^2\theta d\theta \int_r^R \sigma dr, \\ Y &= \sum_{i=1}^{i=i} Y_i = \sum_{i=1}^{i=i} \int_0^{2\pi} \sin\phi d\phi \int_0^{\pi} \sin^2\theta d\theta \int_r^R \sigma dr, \\ Z &= \sum_{i=1}^{i=i} \quad = \sum_{i=1}^{i=i} \int_0^{2\pi} d\phi \int_0^{\pi} \cos\theta \sin\theta d\theta \int_r^R \sigma dr. \end{aligned} \tag{48}$$

These expressions are so complex, that we are obliged to restrict our consideration to the action of a single shell. Accordingly, we shall suppose the single shell filled with stars to a considerable density, and the distribution uniform. An external star coming in from the distance, if otherwise undisturbed, will revolve in a Keplerian ellipse having its focus in the center of the shell. The mass acting as if collected at the center is $4\pi\sigma r^2(R$-$r)$, where the thickness R-r is not too large; and the velocity acquired at the outer border of the shell is

$$V^2 = k^2[4\pi\sigma r^2(R-r)]\left[\frac{2}{R} - \frac{1}{a}\right], \tag{49}$$

where a is the semi-axis major of the Keplerian ellipse.

As soon as a part of the shell of thickness dr has been traversed, however, the stars included in the space $4\pi r^2dr$ will cease to exert attraction on the moving star; and the further it enters the shell the less central attraction will be exerted from the original focus. As the star quits the shell and enters the hollow space within there will be no central attraction to cause it to describe a Keplerian ellipse. Thus as the radius vector decreases from R to r, the path ceases to be the arc of an ellipse, and becomes a straight line. The body thus moves uniformly across the hollow of the shell, and enters again on the opposite side, with the same velocity it had on quitting the shell. The central attraction of the shell begins to be felt as soon as a layer of thickness dr is traversed, for the space $4\pi r^2dr$ has a mass $4\pi\sigma r^2dr$, and it attracts as if collected at the center of the shell. This force grows till the star emerges from the shell on the outside, when it is equal to that operating at the moment the star first entered the shell. Consequently it will depart from the shell on a Keplerian ellipse exactly similar to that on which it first came in; and the *total external orbit* will consist of two exactly similar and similarly situated parts of ellipses, joined by straight lines in the hollow of the shell, and within each layer of the shell gradually passing from the arc of an ellipse to a straight line. This path is illustrated by the accompanying figure.

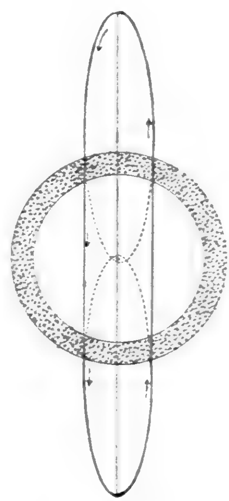

FIG. 3. Illustrating the capture of an oscillating star by the action of a spherical shell uniformly filled with stars as in a globular cluster.

The orbit here described supposes that no local perturbations have occurred during the complete revolution. Let us now consider the *average effect* of such perturbations as will occur. These may be best understood by analogy with the average effect of Jupiter on comets crossing his orbit. It is will known that many comets originally traveling in orbits almost parabolic have been thrown within Jupiter's orbit, till quite a large family has been acquired with short periods, and aphelia near Jupiter's path; and those which still overlap his orbit are being gradually worked into the more stable region within the orbit of that giant planet. In the same way the asteroids have been thrown within Jupiter's orbit, as H. A. Newton justly remarked in 1894 (cf. my "Researches," Vol. II., 1910, p. 699), by a process which Professor E. W. Brown has more fully investigated in the *Monthly Notices* for March, 1911. Professor H. A. Newton's researches and those of Callandreau and Tisserand on the capture of comets are well known, and need not be described here.

Now if for Jupiter we substitute the action of the shell of the cluster, it may be thought that Jupiter is a very large mass, while the comets are very small; whereas the stars in the shell of the clusters are not supposed to be so much larger than the star falling in. This is very true, but as the shell contains many stars in mutual adjustment to an average state of stability, the oscillating star in the course of ages will be disturbed by the many stars, and the cumulative effects will be added together, just as the actions on comets are by the massive planet Jupiter. The mass of the shell greatly exceeds that of the single oscillating star, and even if some of the individual stars in the shell are considerably disturbed, yet the disturbance in successive revolutions will not effect the same stars, owing to movements within the shell of the cluster; and thus in the long run the only possible effect of the action of the many upon the one visiting star will be to dampen its energy of oscillation, till it too will have its path reduced and take its place in the shell with the original group. Thus the visitor from without is entrapped and its movements dragged down to the dead level of the rest of the stars in the shell.

This is a general explanation of the capture process established by the more rigorous method of integration depending on Green's theorem, when some of the terms become infinite. It seemed desirable to examine the matter from both points of view.

To be sure this transformation may take many millions of years, but the average effect of the action of the shell in the long run is certain. As the stars in the shell are comparatively quiescent, the only possible average effect of their action on the visitor will be to exert a drag on its motion. Some of the quiescent stars may be slightly disturbed by the passing body, but as the effect of one appulse is likely to be comparatively small, the stars in the shell will readjust the relations among themselves easily, while the visitor will suffer a considerable retardation of its oscillation. And after many appulses the visitor will have its motion restricted to the shell like the motion of the multitude of stars composing it.

This explains in a simple manner the capture process by which clusters are built up, and given such accumulation of density towards their centers. For the clusters are made up of a series of shells, and if the effect of one shell is of this type, the effect of all the shells will be an integration of these damping effects. It is no wonder therefore that all the clusters show such pronounced accumulation of density towards their centers. It is the inevitable outcome of this capturing of foreign bodies in the course of immeasurable time.

In section III. we have admitted the possibility that defects in our photographs will account for the central density in clusters exceeding that of the atoms in a globe of monatomic gas in convective equilibrium; but in view of this capture process, it seems much more likely that the stars are accumulating in these centers beyond the normal density for a mass of monatomic gas. Thus have the clusters been built up to such extraordinary accumulation that they justly excited the wonder of Sir William Herschel.

XI. The Globular Clusters can be Explained Only by the Capture Theory.

The figures of the clusters, nebulæ and other sidereal systems impressed Herschel with the view that there is a clustering power in nature, everywhere gathering the stars into globular swarms, and moulding the nebulosity into figures of greater and greater symmetry (*Phil. Trans.*, 1789, pp. 217–219). This is the earliest outline of the modern capture theory as applied to clusters and nebulæ of symmetrical figure. It is evident that this process gives a good explanation of the origin of the clusters, and that they can be explained in no other way.

It is obvious that masses of such vast extent and perfectly round figure and symmetrical arrangement of internal density, could not possibly have arisen by any of the theories of collision formerly held but now abandoned. For collisions could not disperse the stars to such great distances over spaces measured by many thousands of light years, nor could they give rise to the observed symmetrical arrangement of the parts. Moreover, clusters embracing thousands of stars, if due to collision, would imply two equally immense masses in collision; and there would be so few of these large masses in the universe, that it is inconceivable that they would ever come into collision. The whole collision doctrine is manifestly inconsistent with the symmetry and order found in the clusters, which can therefore be explained only by the capture theory, based on the expulsion of dust from the stars, and its collection from all directions into masses of impressive symmetry.

This theory not only gives a perfectly satisfactory account of the phenomena of the clusters, which are wonderful in the extreme, and show steady and uniform processes working slowly over immeasurable ages; but also establishes the theory itself by the way the most intricate and diverse phenomena are woven into a continuous whole.

The first rule of philosophy laid down by Newton in the "Principia" is that: "*We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances.*" He explains this by adding that "philosophers say nature does nothing in vain, and more is in vain when less will serve." The next rule is that we are to ascribe the same natural effects to the same causes.

If therefore the capture theory alone will explain the clusters, where the scale of the operations is immense, and the symmetry so perfect that other causes are easily excluded; and on the other hand it will equally account for all other known phenomena of the sidereal universe, it follows from Newton's rules for philosophizing that this cause alone can be regarded as established. The definite proof of the capture theory for the formation of clusters and nebulæ thus renders its operation general throughout the sidereal universe. Everywhere the large masses drift towards the most powerful neighboring center of attraction, while fine dust is expelled from the stars to produce nebulæ in the vacant regions of the heavens; and this concentration of the large masses under gravity, and the redistribution of the fine dust by the action of repulsive forces is the great law of nature which preserves the order of the starry heavens.

XII. The Mutual Interaction of Attractive and Repulsive Forces Confirmed by a Delicate Criterion Based on the Exact Equality of Thousands of Associated Stars in a Cluster.

Elementary considerations on the principles of probability will show that the chances of even two associated stars being of equal brightness is slight; it is still smaller for three, four and higher multiples, and when the number becomes large the probability of the chance association of such equal stars totally disappears. Accordingly, it is not by accident that thousands of stars observed in a cluster, with perfectly symmetrical accumulation towards the center of the associated stars, all known to be at nearly the same distance from us, are as exactly equal in every respect as the finest coins turned out of a mint. There must be in nature a reliable process for the manufacture of these nearly equal stars, which is described above for the first time.

To prove this more conclusively we may compare clusters with double and multiple stars, which are systems of lower order. In binaries the components often are very unequal in brightness, and also in mass. The same principle, as is well known, holds for triple and quadruple stars. Now in these double and multiple star systems the ratio of the mass of the components depends on the chance division of the original nebulosity gathered from the heavens, not from the associated stars themselves; but in the clusters the *principle of redistribution* becomes largely predominant, owing to the great number of radiating centers in close association. It is not surprising, therefore, that the lower orders of stellar systems should include: *first, single stars,* with planetary systems, amounting to about four fifths of all the stars; *second, binary stars,* with unequal components; *third, multiple stars,* also with components very unequal. This inequality of the associated stars is to be expected in all sidereal systems made up of a small number of bodies, but the visual double stars, as the brighter and more easily recognized systems, appear to have components more nearly equal than the much greater number of systems,* which remain invisible at the distance of the fixed stars.

The association of *thousands of equal stars in a cluster* must therefore depend on something besides a chance distribution, or partition of the primordial nebulosity. For although the clusters are very far away, and the double stars in a cluster would thus appear single from the perspective effect of distance alone, yet the distance would not prevent fainter single stars from appearing on the background of the cluster if they were present. Perrine points out in Lick Observatory Bulletin No. 155 that in cluster there is rarely a difference of more than two magnitudes among the stars composing it. This difference probably depends on difference in the spectral types, rather than on difference in mass. The conclusion that the great equality in luster depends on the essential equality in the redistribution of dust within the system therefore seems unavoidable, as a necessary result of known laws of nature actually proved to be in operation. If therefore this argument regarding the origin of clusters, based on the equality of the stars, is admissible, the explanation may as confidently be depended on as the law of gravitation itself. For the testimony of the sidereal universe to its truth seems to be absolutely overwhelming. There are in all over one hundred globular clusters, and they include millions of stars; so that the observed order of nature obviously rests on a fundamental cause.

Accordingly, if we admit the truth of this theory of clusters, which now seems to be well established, through the evidence presented by hundreds of globular clusters, and by the analogous evidence offered by thousands of nebulæ, we have at the same time an equally satisfactory proof of the universality of the operation of repulsive forces in nature. With his usual penetration Herschel saw in the accumulation of density and brightness towards the centers of these masses an incontestible proof of the existence of a clustering power operating throughout the sidereal universe.

Now by *exactly reversing his argument* we have an equally valid proof of the operation of repulsive forces, to give the original distri-

* Resembling planetary systems.

bution of dust, out of which the clusters and nebulæ are finally built. Moreover, as already remarked, this general argument, drawn from the sidereal universe as a whole, is minutely verified in the construction of clusters, by the exact equality of thousands of closely associated stars, which thus supply a criterion of unrivaled rigor. This cluster criterion authorizes the conclusion that the theory may now be removed from the category of speculation and entered in the list of established facts relating to the physical universe. The most obvious indications of nature are plain enough; and in interpreting them all we need to do is to follow the theory of probability, which, as Laplace has remarked, is nothing but common sense reduced to calculation. This theory tells us that there is a deep underlying cause for the perfect equality of the associated stars in clusters, which can be nothing else than the mutual interaction of attractive and repulsive forces in these island universes.

XIII. The Real Dimensions of the Clusters and the Average Distances of the Stars Apart.

The question of the distances of the clusters is one which at present cannot be fully answered, owing to the lack of certain observational data; but it is well known that nearly all these masses of stars are very remote. To be sure such an outspread swarm as Coma Berenices, really is a cluster so near us as not to be suspected of belonging to the same type as the better defined Pleiades, Praesepe and Omega Centauri. But leaving out of account a few exceptions of this class we may say that the globular clusters in general, like the nebulæ considered by Dr. Max Wolf in *A. N.*, 4549, are thousands of light-years in diameter. This is proved by the comparative faintness of the component stars, and the large angular magnitude of the clusters as seen in the sky.

Accordingly, even when there are thousands of stars in a very compressed cluster, they are not really close together, but separated by great intervals, of the order of a light-year. Thus the components in a dense cluster probably are somewhat closer together than our sun is to Alpha Centauri; and yet the intervals can hardly be less than a ten thousand fold radius of the earth's orbit, the light-year being 63,275 times that distance. In fact the average distances are likely to be several light-years, and thus of the order 100,000 radii of the earth's orbit.

This great distance of the stars apart, even in the densest cluster, will enable us to realize the well-known fact that our sun is in a solar cluster, which includes Sirius, the stars of Ursa Major, and many other bright objects. It also enables us to appreciate why the motion in the clusters necessarily is slow, owing to the great intervening spaces and the feebleness of the disturbing forces acting on the individual stars. And at the same time we easily see why such a system, under the mutual gravitation of its parts, might survive for infinite ages, without sensible decay of its order or stability. Newcomb therefore was right when he remarked that there might be planets revolving about the stars in a cluster (article "Stars," Encyclopedia Americana); for we ourselves live on a planet attached to a star of the solar cluster, and the other clusters of the sidereal universe are not very different from that including our sun.

Sir William Herschel was of the opinion (*Phil. Trans.*, 1789, p. 225) that the clusters which are most compressed are drawing on towards a period of dissolution. In an earlier paper of 1785 Herschel suggested that the clusters are the laboratories of the universe where the most salutary remedies for the decay of the whole are prepared (*Phil. Trans.*, 1785, p. 217).

In my "Researches," Vol. II., 1910, I have independently pointed out that the condensation of very compressed clusters into one mass is the only logical explanation of such immense stars as Canopus and Arcturus. For it appears that with the advance of age the state of compression slowly increases, and when it has become extreme, and all the single bodies are drawn very near the center, it is quite likely that the cluster by conflagration may become the furnace of a *laboratory* of the universe for repairing through repulsive forces the ravages wrought by universal gravitation in the course of millions of ages.

If this be true someone may ask why we do not find some cluster in the stage of conflagration? But if we recall that only a little over one hundred globular clusters are known, with their internal spaces still large, and remember also the vast interval of time required to produce the *invisible state of close compression*, it will become evident that the chances of our living at the epoch of a cluster conflagration totally disappears, and the most we can hope to recognize is the resulting giant star such as Canopus.

XIV. Proof that Matter Actually is Lost from our Sun Supplied by the Very Straight Tails of Comets Developed in Close Perihelion Passage.

In view of the recent development of the doctrine of repulsive forces in nature, it becomes important to have readily at hand specific illustrations of these forces adequate to meet any demand that may be made on the new doctrine. Now the tails of comets and the streamers of the corona, as explained by Arrhenius in Lick Observatory Bulletin 58, give abundant evidence of the operation of repulsive forces directed from the sun; but every case does not show a repulsion sufficiently strong to carry the particles away from our solar system on parabolic or hyperbolic paths. The question thus arises: Are there any known cases of repulsion sufficiently powerful to carry particles away from our sun to the other stars, and thus cause a secular decrease in the sun's mass? We may answer this question in the affirmative, for the following reasons:

1. Those comets which have had a very small perihelion distance, as the great comets of 1680, 1843 and 1882, have all had also very straight tails, which were found by calculation to be of immense length near perihelion passage. It is well known that this extreme straightness of tail indicates very powerful repulsion of the particles composing it.

2. By actual calculation I have established the fact that the velocity of the particles in the tails of the above comets, at perihelion, exceeded the parabolic velocity of a body driven away from the sun. The matter in these tails therefore was not only diffused over the solar system, but also carried away to other fixed stars.

3. Now if this repulsion with more than parabolic velocity could happen for vaporous matter developing in a comet's tail near perihelion, but remaining of sufficient density and luminosity to be visible

to the eye against the background of the sky, because it is condensed into a beam, the same thing obviously could develop also for particles in the solar corona itself, even if they be not sufficiently concentrated to present at night the aspect of a ray extending from the sun. In fact such rays of charged matter are proved to emanate from the sun by Maunder's researches on the sun spots and magnetic disturbances noted at Greenwich, and published in the *Monthly Notices* of the Royal Astronomical Society for 1905.

4. The emission of charged particles from the sun being thus clearly proved, the only question remaining open to discussion is whether any of the matter thus driven away from the sun goes away to the other fixed stars. But as my calculations show this to occur for the particles of the tails of comets which graze the sun's disc in perihelion—the only case in which the beams can be distinctly seen and the velocity of the particles determined from the lack of curvature in the tails—it must, by similarity of causes and effects, be held to occur also for some of the particles in the corona, even though they be invisible, owing to the diffuseness of the streamers.

5. The sun therefore is losing matter incessantly as well as gaining it, in the form of meteorites from celestial space. And in my "Researches," Vol. II., 1910, I have shown that the secular acceleration of the earth's motion indicates that at present the gain exceeds the loss; but if the sun was hotter in past ages, the reverse tendency formerly may have been at work.

6. Thus it appears to be demonstrated, by observed phenomena in our planetary system, that the sun is both gaining and losing matter, but that at present the rate of gain exceeds that of loss, so that there is a secular acceleration of the planets of such excessively minute character that it long escaped detection. In other fixed stars, it is probable that various combinations of gain and loss are at work; and we may be sure that the masses of the stars are not strictly constant over long ages, however approximately an even balance of gain and loss may hold for shorter intervals of time.

The view held by Newton and adopted by Lagrange and Laplace that the sun's mass may be considered constant, is only approximately true, and cannot properly be applied to the secular equations for the motions of the planets; and what has been found true of our sun, as respects a growth of mass, from the records of ancient eclipses, will naturally be adopted for other solar stars, while a secular decrease in mass may be assumed for some of the Sirian stars, owing to the intensity of their radiation.

XV. The Building of Clusters and Nebulæ Condensed Towards the Center, as Illustrated by the Very Elongated Elliptic Orbits of our System of Comets.

If we seek to inquire how clusters and nebulæ much condensed towards the center are built up by the process of capture, we shall find the general mathematical treatment by Green's theorem already given very satisfactory, for large bodies of the type of stars. It is equally convincing mathematically as applied to small bodies of the type of comets, but it is perhaps well to notice how the comets descending to our sun in very elongated ellipses have served to supply material for building up the planets and sun. This remarkable system of comets, with elliptic orbits equally diffused in all directions about our sun, is a sure sign that the nebulosity now condensed into our comets came originally from the fixed stars.

But if on the one hand, this equality of distribution of the aphelia in every direction points to the original entrance of the material into our nebula from without, the other equally remarkable property of high eccentricity, on the other, points to a similar conclusion. At the same time this coming in of matter from a distance makes possible the growth of the planets near the center of the system, because near perihelion the comets often pass so close to the planets as to have their orbits transformed, and their masses disintegrated and their dust absorbed by the planets. It is by moving against the resistance due to comets, and meteor swarms that the planetary orbits have been rendered so perfectly circular that the Greeks believed that the Deity had chosen the circle for the paths of the planets, because the circle was held by the ancient geometers to be a perfect figure.

Now what takes place about our sun, in the solar cluster, may also take place, in other star clusters of the Milky Way. There are in every region systems of bodies corresponding to our comets; and as they travel in very elongated ellipses, they tend to build up the bodies near the centers about which they revolve. In this way there must be countless infinities of comets working in towards the centers of the globular clusters; and thus they build up the equality of the stars in these regions, while at the same time the increase of mass and the resistance to orbital motion thus arising tend to round up the cluster and give increasing density towards the center.

Thus the analogy of the comets revolving in very elongated orbits and being destroyed to build up the planets and the sun, will also hold in the building up of a cluster. Not only may mature stars be captured and adjusted to the average oscillation within a cluster, but also myriads of millions of comets; and it is in this way largely that the cluster augments in mass and density towards the center. This growth of central power in turn augments the condensation observed in the clusters, and tends still further to produce a secular decrease in volume; just as the planets are drawn nearer the sun by the increase of the sun's mass. The shrinkage in the volume of a cluster is thus analogous to the diminution of the dimensions of the primitive orbits of the planets. And just as the planets in time will fall into the sun, so also will the stars of a cluster eventually combine into one great central star and thus produce an Arcturus or a Canopus.

The study of the system of comets about the sun, and the way the planets have been built up near the center of the solar nebula, thus gives us much light on the central accumulations noted in globular clusters. The smaller masses drawn in from without tend to augment the central bodies of the system; and this growth of mass in turn produces a further condensation of the original group, whether it be a planetary system, or a globular cluster of the highest order of glory and magnificence.

XVI. The Projectile Forces which Set the Double and Multipple Stars Revolving in Their Orbits, Point to Origin in the Distance.

If we have a stellar system made up of several components, we may designate the masses of the individual stars by M_1, M_2, M_3 . . ., M_n. We shall first consider a binary star with masses M_1 and M_2. Then the moment of momentum of the components about the common center of gravity of the system will be

$$\frac{M_1}{M_1+M_2}\left(\frac{M_2\rho}{M_1+M_2}\right)^2\Omega\sqrt{1-e^2}$$
$$+\frac{M_2}{M_1+M_2}\left(\frac{M_1\rho}{M_1+M_2}\right)^2\Omega\sqrt{1-e^2}=\frac{M_1M_2}{M_1+M_2}\rho^2\Omega\sqrt{1-e^2}, \tag{50}$$

where e is the eccentricity of the orbit, and ρ the radius vector, and Ω the mean angular velocity in the orbit (cf. inaugural dissertation, "Die Entwickelung der Doppel-Stern Systeme," Berlin, 1892, p. 16).

When the other elements are unchanged, we find that the moment of momentum of the binary system decreases with the increase of the eccentricity. In case of a circular orbit, e vanishes, and Ω is constant. In the general equation of the planetary theory the unit of time may be so chosen that the constant of attraction (cf. Gauss, "Theoria Motus," Lib. I., § 1) becomes

$$k^2=\frac{4\pi^2}{\tau^2}\cdot\frac{a^3}{M+m}=n^2a^3=1, \quad \text{or} \quad n=\frac{1}{a^{\frac{3}{2}}}; \tag{51}$$

and we may therefore put Ω for n and ρ for a, and the second member of (50) becomes

$$\frac{M_1M_2}{M_1+M_2}\rho^2\Omega\sqrt{1-e^2}=\frac{M_1M_2}{M_1+M_2}\rho^{\frac{1}{2}}\sqrt{1-e^2}, \tag{52}$$

the radical involving e to be unity in circular orbits.

From this equation (52) it appears that with constant mass the moment of momentum of a system of double stars depends on the square root of the mean radius vector, and therefore increases rapidly with the distance.

Other conditions being equal, the maximum moment of momentum would therefore be attained by the separation of two stars to a great distance, yet a pair of such passing stars would have to have peculiar directions and velocities to enable them under mutual gravitation to form a system. If the motions of two stars were directed towards the same point in space, and with velocities which would enable one to overtake the other, before or after the point was reached, one might revolve about the other; and with proper relative velocity—to be gotten either by altering the directions of motion, or by adjusting the velocities in the converging lines of motion—the two stars might form a binary system.

This dynamical condition of formation is so difficult to realize in practice that we may be sure that it is quite rare in nature; and that the vast majority of double stars have developed from nebulæ, by the appropriate division of the elements between two leading centers of condensation. But it is now recognized that the nebulæ themselves have developed from dust expelled from the fixed stars and were originally of vast extent; and hence even if the bodies into which they condense gradually approach the center of gravity of the system, as the stars increase in mass and revolve against the nebular resisting medium and their orbits grow smaller and smaller and rounder and rounder, it will yet follow that many double stars have components so far apart that their systems have large moments of momentum of orbital motion.

The difficulty of explaining the large orbital moments of momentum of double stars first arose in completing certain calculations for my inaugural dissertation at the University of Berlin just twenty years ago. At that time I saw that a wide separation of the components of a system gave large moment of momentum, and that in order to account for the orbital moment of momentum by the hypothesis of tidal friction first developed by Sir George Darwin and afterwards extended by me to binary systems, it was necessary to endow the stars with very rapid axial rotation. Otherwise the mean distance of the components would not be greatly increased by the exhaustion of the moments of momentum of axial rotation under the secular action of tidal friction.

At this early stage in the study of the problems of cosmogony, naturally I had not exhausted the other possible modes of formation, though I had largely excluded the capture of single stars by chance approach due to difference in proper motion. The further study of this problem has occupied a part of the past twenty years, but as it has now led to the establishment of a great law of nature, one may feel that the labor has not been in vain.

From the above reasoning it will be found:

1. That if the globes of the stars of a binary be expanded till a hydrostatic connection is established between the components, the fluid will thereby become so rare that no hydrostatic pressure could be exerted to throw off a companion by rotation.

2. A rotation rapid enough to produce such a separation could not be accounted for by natural causes.

3. Hence it is clear that the premise implying a separation by rotation is false; and the true mode of formation is diametrically opposite to what was long believed. Instead of being thrown off by rapid rotation, the attendant bodies have all been formed in the distance, and added on from without, so that they have neared the centers about which they now revolve. This uniform law greatly simplifies all our conceptions of cosmical evolution.

To illustrate the relative significance of the moments of momentum of the axial rotations compared to the moment of momentum of orbital motion, it suffices to cite the case considered in my inaugural dissertation of 1892, pp. 37–38. In this case each of the two equal stars imagined expanded into a nebula has three times the mass of the sun; and the axial rotations are such as to give an oblateness of 2/5. The stars are set in motion at a mean distance of 30 astronomical units. In the special units there adopted, it turns out that the moments of momentum of the axial rotations have the numerical values 0.394, or 0.788 for the two stars; and the moment of momentum of orbital motion becomes 2.378.

Thus with the two stars so far apart as 30, it is impossible to keep the figures of equilibrium stable and yet give them rotations rapid enough to render the moments of momentum of axial rotation large compared to that of the orbital motion. Nevertheless, a double star orbit with a mean distance of 30 must be considered small compared to many orbits which exist in the heavens. For there are physically connected stars which show very little motion in a century, and others which remain quite fixed, as may be clearly established by comparing modern measures with those of Herschel and Struve.

The conclusion from this calculation is that the observed mean distance of wide double stars has not been developed by the transfer of moment of momentum of axial rotation to moment of momentum of orbital motion. By such transfer of moment of momentum the orbit may indeed be expanded, but not to many times its original size. On this tidal frictional theory the larger orbits of double stars could not be explained satisfactorily. The difficulty encountered some twenty years was therefore first overcome in developing the second volume of my "Researches," along the lines of thought resulting from the extension of Babinet's criterion in 1908.

Looking at the problem in the light of recent progress it is evident that the large and highly eccentric orbits of double stars do undoubtedly point to capture; that is, the formation of separate nuclei at a great distance, and the revolution of the two stars in narrowing orbits about the center of gravity of the system. If this process of revolution in the original nebula should continue long enough, the size and eccentricity of the orbit would be much reduced; and we should thus obtain systems of the type commonly observed to be in comparatively rapid revolution. There is thus established a real connection between the revolving visual double stars and the much larger number of physical systems which have remained nearly if not quite fixed since the epoch of Herschel and Struve.

This inference is also sustained by recent progress in double star astronomy, which shows that the longer the period the higher the eccentricity, and the same tendency holds for the rapid spectroscopic binaries, as I pointed out in 1907 (*Monthly Notices,* Roy. Astron. Soc., Nov., 1907). This unbroken continuity among all the classes of double stars shows that the cause is everywhere the same. If therefore the wider visual double stars have formed from separate nuclei, in the condensing nebulæ, the explanation becomes valid also for the spectroscopic binaries; and the law of formation is the same for all the double stars as for the planets of the solar system, where Babinet's criterion is absolutely decisive against the detachment theory generally held since the days of Laplace, but now universally abandoned.

Summary and Conclusions.

Without attempting in this closing summary to recapitulate the contents of this memoir in detail, it may yet be well to draw attention to some of the most significant conclusions at which we have arrived.

1. As intimated in the first section of this paper the problem of n-bodies, under ideal dynamical conditions, remains forever beyond the power of the most general methods of analysis; but the dynamical theory of clusters gives us the one secular solution of this problem found under actual conditions in nature. For when n is of the order of 1,000, so as to give rise to a cluster, the clustering power observed by Herschel operates to exhaust the mutual potential energy of the system, and bring about increasing accumulation in the center, so that the cluster finally unites into a single mass of enormous magnitude. Probably the giant stars of the type of Canopus and Arcturus have arisen in this way.

2. And since attendant bodies of every class—as satellites, planets, comets, double and multiple stars—tend everywhere to approach the centers about which they revolve, as an inevitable effect of the growth of the central masses and of the action of the resisting medium over long ages, it follows that the secular solution of the problem of clusters is more or less valid for all cosmical systems. They finally end by the absorption of the attendant bodies in the central masses which now govern their motions.

3. The dynamical theory of globular clusters shows that the clustering power inferred by Herschel is nothing else than the action of universal gravitation; and that it operates on all sidereal systems, but does not produce the cumulative effect which Herschel ascribed to the ravages of time inside of millions of ages.

4. The globular clusters are formed by the gathering together of stars and elements of nebulosity from all directions in space; and

this points to the expulsion of dust from the stars of the Milky Way, and its collection about the region of the formation in such manner as to give essential symmetry in the final arrangement of the cluster, which doubtless has some motion of rotation, and originally a tendency to spiral movement.

5. The stars and smaller masses are captured by the mutual action of the other members of the cluster, and worked down towards the center of the mass. This gives a central density in excess of that appropriate to a sphere of monatomic gas in convective equilibrium (*A. N.,* 4053, and *A. N.,* 4104).

6. The density of the clusters is greater on the outer border than in a globe of monatomic gas, which shows that stars are still collecting from the surrounding regions of space. The starless aspect of the remoter regions about clusters is an effect of the ravages of time, as correctly inferred by Herschel in the course of his penetrating sweeps of the starry heavens.

7. And just as clusters under the mutual gravitation of the component stars contract their dimensions, with time, chiefly owing to the growth of the central masses, so also do other systems, whether the mass-distribution be *single,* giving a system made up of a sun and planets, or *double, triple* and *multiple,* giving binary, triple or multiple stars, or sidereal systems of still higher order. The tendency everywhere is from a wider to a narrower distribution of the large bodies; while the only throwing off that ever occurs is of particles driven away from the stars by the action of repulsive forces.

8. The orbits of the stellar and planetary systems are decreased by the growth of the central masses and rounded up by the action of the nebular resisting medium. And in like manner all clusters tend to assume spherical or globular figures, so as to justify the expression of Plato, that the Deity always geometrizes; or Newton's remark that the agency operating in the construction of the solar system was "very well skilled in mechanics and geometry."

9. Newton required the intervention of the Deity to give the planets revolving motion in their orbits, because in the absence of repulsive forces he could not account for the dispersion of the matter, so as to produce the tangential motions actually observed. By means

of the theory of repulsive forces, however, it is now possible to explain these projectile motions, which Herschel likewise pointed to as the chief agency for the preservation of sidereal systems. The only assumption necessary is an unsymmetrical figure of the primordial nebula, giving a whirling motion about the center as the system develops; and since the dust gathers from all directions it is certain that this lack of perfect symmetry will nearly always develop, as we see also by the spiral nebulæ.

10. It is this unsymmetrical form of the spiral nebulæ produced by the gathering of the dust from the stars, or the slight relative tangential motion of stars formed separately but finally made to revolve together as a binary system, that gives the binary stars the projectile forces, with which they are set revolving in their orbits. In no case have they resulted from the rupture of a rotating mass of fluid under conditions of hydrostatic pressure as formerly believed by Darwin, Poincaré and See.

11. Even if the rotation could become rapid enough to produce a separation, under conditions of hydrostatic pressure, by rupture of a figure of equilibrium, there would still be the equal or greater difficulty of explaining the origin of the primitive rapid rotation. This last difficulty escaped notice till we came to assign the cause of rotations, and found that mechanical throwing off was impossible under actual conditions in nature. It is therefore recognized, from the definite proof furnished by Babinet's criterion in the solar system, that such a thing as a throwing off never takes place; but that all planetary and stellar bodies are formed in the distance, and afterwards near the centers about which they subsequently revolve.

12. *This gives us a fundamental law of the firmament—the planets being added on to the sun, the satellites added on to their planets, the moon added on to the earth, and the companions added on to the double and multiple stars—which is now found to be beautifully confirmed by the dynamical theory of the globular clusters. It is not often that such a great law of nature can be brought to light, and it is worthy of the more consideration from the circumstance that it explains all classes of stellar systems by a single general principle.*

13. As sidereal systems of lower order are conserved by projectile forces, it is probable that the clusters likewise have a spiral motion of rotation, with similar projectile forces tending to counteract simple progressive collapse. The period of the orbital revolution of the stars of a cluster is found to be common to all, without regard to the dimensions of the elliptical orbits described, and thus the whole system may have a common period of oscillation, after which the initial condition is perfectly restored. This possibility in the dynamics of a cluster is exceedingly wonderful, and results from the central attraction depending directly on the distance.

14. The equality of brightness in star clusters shows that some process of compensation between the attractive and repulsive forces has produced stars of wonderful uniformity of luster. Thus the present investigation confirms the previous researches on the evolution of the stellar systems, which have laid the foundations for a new science of the starry heavens.

15. Accordingly the capture theory of cosmical evolution being now firmly established for the clusters, where the nature of the process is entirely clear, it becomes at once a guide to us in dealing with systems of lower order; and we see that the law of nature is uniform and everywhere the same, the large bodies working in towards the centers of attraction, while the only throwing off that ever takes place is of small particles driven out of the stars by the action of repulsive forces. All planetary bodies are formed in the distance, and have their orbits reduced in size by increase of the central masses, and rounded up by moving in a resisting medium. *This is a perfectly general law of the sidereal universe. It verifies the early conjectures of Plato and Newton as to the stability of the order of the world, and shows that these illustrious philosophers were quite justified in concluding that the Deity always geometrizes.* The spiral nebulæ tend to develop systems with rounder and rounder orbits, and the clusters made up of thousands of stars assume globular figures with minimal surfaces and internal density so arranged as to give maximum exhaustion of the potential energy.

16. This is geometry of the most marvellous kind, as we find it impressed on the systems of the sidereal universe; and the perfection

of this most beautiful science of celestial geometry may be considered the ultimate object of the labors of the astronomer. The philosophic observer is not and never can be content with mere observations of details which do not disclose the living, all-pervading spirit of nature.

17. If, then, the mystery of the gathering of stars into clusters is now penetrated and traced to the clustering power of universal gravitation, so also is the mystery of the *converse problem of starless space,* which was a subject of such profound mediation by the great Herschel.

18. This incomparable astronomer likewise correctly concluded that the breaking up of the Milky Way into a *clustering stream* is an inevitable effect of the ravages of time; but we are now enabled to foresee the restorative process, under the repulsive forces of nature, by which new nebulæ, clusters and sidereal systems of high order eventually will develop in the present depopulated regions of starless space.

19. If there be an incessant expulsion of dust from the stars to form the nebulæ, with the condensation of the nebulæ into stars and stellar systems, while the gathering of stars drawn together by a clustering power operating over millions of ages gives at length a globular mass of thousands of stars accumulating to a perfect blaze of starlight in the center, but surrounded externally by a desert of starless space resulting from the ravages of time, certainly the building of these magnificent sidereal systems may well engage the attention of the natural philosopher.

20. The foremost geometers of the eighteenth century, including Lagrange, Laplace and Poisson, were greatly occupied with the problem of the stability of the solar system; and in his historical eulogy on Laplace the penetrating Fourier justly remarks that the researches of geometers prove that the law of gravitation itself operates as a preservative power, and renders all disorder impossible, so that no object is more worthy of the meditation of philosophers than the problem of the stability of these great celestial phenomena.

But if the question of the stability of our single planetary system *may so largely absorb the talents of the most illustrious geometers of the age of Herschel, how much more justly may the problem of the stability of clusters, involving many thousands of such systems, claim the attention of the modern geometer, who has witnessed the perfect unfolding of the grand phenomena first discovered by that unrivaled explorer of the heavens?*

The grandeur of the study of the origin of the greatest of sidereal systems is worthy of the philosophic penetration of a Herschel! The solution of the dynamical problem presented surpasses the powers of the most titanic geometers, and would demand the inventive genius of a Newton or an Archimedes!

Yet notwithstanding the transcendent character of the problem, and the hopelessness of a rigorous solution in our time, even an imperfect outline of nature's laws may aid the thoughtful astronomer, in penetrating the underlying workings of the sidereal universe, and thus enable him to perceive the great end subserved by the development of the cosmos. If so, he may well rejoice, and exclaim with Ptolemy:

> "Though but the being of a day,
> When I the planet-paths survey,
> My feet the dust despise;
> Up to the throne of God I mount
> And quaff from an immortal fount
> The nectar of the skies."

Starlight on Loutre,
Montgomery City, Missouri,
February 19, 1912.

THE CLASSIFICATION OF THE BLACK OAKS.

By WILLIAM TRELEASE.

(*Read April 19, 1912.*)

(PLATES X–XIII.)

Since Alphonse de Candolle[1] pointed out that the abortive ovules occupy a definite position in a mature acorn, constantly basal or nearly so in some species and as constantly apical or nearly so in others, and crystallized the knowledge that the ripening of the fruit occurs in one season in some and requires two seasons in others (attending correspondingly retarded fertilization[2]) with as great constancy,[3] so many other correlations in wood, bark, leaf, stamens and styles have been associated with these differences that the white oak and black oak groups[4] have long been recognized as presenting a natural division of our native species: the former with basal ovules, short styles with dilated stigmas, usually annual often stalked fruit essentially glabrous within and often with tuberculate or aristate cupule-scales, leaf lobes not bristle-tipped, pale often flaky bark and tough compact rather pale wood of slow growth; the latter with apical ovules, elongated slender styles, usually biennial nearly sessile fruit tomentose within and rarely with tuberculate or tapered cupule-scales, bristle-pointed leaf lobes, dark often deeply checked but not flaking bark and darker wood of twice as rapid growth on the average.

The principal doubts as to the sufficiency of these group characters may be said to rest on an occasional easily understandable but none-the-less misleading slip of the pen such as that of de Candolle's

[1] A. de Candolle, *Ann. Sci. Nat.*, Bot., IV., **18**: 51. 1862. For various other places of publication in French and English, reference may be made to the catalogue of the Royal Society.

[2] Conrad, *Bot. Gaz.*, **29**: 410. 1900.

[3] A. de Candolle, *l. c.*, 50.

[4] Engelmann, *Trans. Acad. Sci. of St. Louis*, **3**: 374, 381, 388. 1876–7; "Bot. Works," 390, 394, 397.

translator[5] and of Professor Sargent,[6] making the ovules appear to be basal in the black oaks; and on puzzling facts as well as observations on the dwarf live oaks, particularly *Q. Emoryi* which Engelmann[7] and Greene[8] have treated as a black oak on its general assemblage of characters, and Sargent[9] (as did Engelmann[10] at first) places with the white oaks because of its basal ovules.

Without attempting a critical analysis of hybrids, segregates and aberrants, the present communication offers what appears to be a natural grouping of our black oaks, which have been arranged in floras and monographs usually and diversely in sequence dictated by convenience of foliage contrast—that is, descriptively rather than taxonomically.

The classification here proposed was adopted some months since when the oaks growing about St. Louis were selected to illustrate to a university class the synthesis of generic concepts out of specific characters. This local flora is fairly rich in representation of *Quercus*, for its dozen species constitute about two-thirds of those of Missouri, half of those of the northeastern states, a fourth of those of the United States, and a twentieth of those of the world. For this reason it has been comparatively easy to extend the conclusions based on the local species so as to embrace all of those occurring east of the great plains—which are evidently of a common stock. The few species occurring between the continental divide and the desert, and the few found west of this natural barrier, appear to represent groups more properly coördinated with the entire assemblage of eastern species than with the sets into which this is divided. In them, perhaps, is to be found the key to an understanding of the history of the genus as it is now represented in North America.

Not many words are needed to indicate the striking collective differences in bud and fruit between the three groups, black oaks, scarlet oaks and swamp oaks of the eastern states, as pictured in the accom-

[5] A. de Candolle, *Trans. Edinburgh Bot. Soc.*, 7: 440. 1863.

[6] Sargent, "Manual, Trees of N. A.," 227. 1905.

[7] Engelmann, *l. c.*, 388, 394.

[8] Greene, "Ill. of W. A. Oaks," 45. 1889.

[9] Sargent, *l. c.*, 230, 286.

[10] Engelmann, *l. c.*, 381–2.

panying plates: the first (Pl. X.) with large hairy buds and rather large fruit with coarse cup-scales, the second (Pl. XI.) with medium-sized nearly smooth buds and moderate or large fruit with rather closer or finer scales, and the third (Pl. XII.) with still smaller buds and acorns, these with still closer and finer cupule-scales. That the groups are closely allied is to be expected, and in bud and cup characters *Q. coccinea* connects the first two; but a glance at the plates will show how distinct the collective impression produced by each group is, and how far from natural it is to place *Q. marilandica* (Pl. X., f. 1) next *Q. nigra* (Pl. XII., f. 2) because of a comparability in leaf shape that has worked mischief in the names both have borne, or *Q. palustris* (Pl. XII., f. 1) next *Q. rubra* (Pl. XI., f. 5) or *Q. velutina* (Pl. X., f. 4), or to separate *Q. Catesbæi* (Pl. X., f. 2) far from *Q. digitata* (Pl. X., f. 3) or even *Q. marilandica*, as is commonly done. An interesting feature in the cup of these latter species is that the scales are inflexed around its margin—commonly in the first, occasionally in the others—a character to be connected with Engelmann's observation[11] that the tips of the leaf lobes are bent in in vernation in *Catesbæi*, though it is not absolutely limited to them.

Though homogeneous in external bud and fruit characters, the group of swamp oaks is subdivisible into a series with broad-lobed leaves, the water oaks, in which the leaves are flatly imbricated in the bud as in the black and scarlet oaks, and a series with narrow entire leaves, the willow oaks, in which the leaves are revolute in the bud—strongly so in *Q. imbricaria*, *Q. Phellos*, *Q. laurifolia* and *Q. pumila;* less rolled in *Q. cinerea* and *Q. myrtifolia*, and thus approaching the western groups, though the fruits of the two are very different. Such Mexican bristle-leaved oaks as *Q. Grahami* are evidently of this general stock.

Grouped primarily according to the characters here selected rather than leaf form, these oaks fall into line as follows:

BLACK OAKS.

Quercus marilandica (black jack).

Quercus Catesbæi (turkey oak).

[11] Engelmann, *l. c.*, 376.

Quercus digitata (Spanish oak).
Quercus velutina (quercitron).

SCARLET OAKS.

Quercus coccinea (scarlet oak).
Quercus ellipsoidalis (Hill's oak).
Quercus rubra (red oak).
Quercus texana (Texas red oak).
Quercus nana (bear oak).

SWAMP OAKS.

Water oaks.

Quercus palustris (pin oak).
Quercus nigra (water oak).
Quercus georgiana (Stone Mountain oak).

Willow oaks.

Quercus imbricaria (shingle oak).
Quercus Phellos (willow oak).
Quercus laurifolia (laurel oak).
Quercus pumila (running oak).
Quercus brevifolia (cinnamon oak).
Quercus myrtifolia (myrtle oak).

OLIVE OAKS.

Quercus hypoleuca (white-leaf oak).
Quercus Emoryi (Emory's oak).

HOLLY OAKS.

Quercus agrifolia (evergreen oak).
Quercus Wislizeni (highland oak).
Quercus californica (Kellogg's oak).

EXPLANATION OF PLATES.

In all, the buds are enlarged three diameters, and the acorns and cupules are of natural size. No special care has been taken in the selection of material, except to get mature winter buds because the differences are less evident while they are developing, and to pick out average fruits from the varying assemblage presented by each species.

PLATE X. BLACK OAKS.—1, *Quercus marilandica;* 2, *Q. Catesbæi;* 3, *Q. digitata;* 4, *Q. velutina.*

PLATE XI. SCARLET OAKS.—1, *Quercus coccinea;* 2, *Q. ellipsoidalis;* 3, *Q. texana* (the northern form known also as *Q. Schneckii*); 4, *Q. texana* (from Texas); 5, *Q. rubra;* 6, *Q. nana.*

PLATE XII. SWAMP OAKS.—Water Oaks: 1, *Quercus palustris;* 2. *Q. nigra;* 3, *Q. georgiana.* Willow Oaks: 4, *Quercus imbricaria;* 5, *Q. Phellos;* 6. *Q. laurifolia;* 7, *Q. pumila;* 8, *Q. brevifolia;* 9, *Q. myrtifolia.*

PLATE XIII. WESTERN BLACK OAKS.—Olive Oaks: 1, *Quercus hypoleuca;* 2, *Q. Emoryi.* Holly Oaks: 3, *Quercus agrifolia;* 4, *Q. Wislizeni;* 5, *Q. californica.*

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HEREDITY OF FEEBLE-MINDEDNESS.

BY HENRY H. GODDARD, PH.D.

(*Read April 19, 1912.*)

In formulating the laws of human thought, the logicians recognized what they called the fallacy of too few heads of classification. This might be called the fallacy of ignorance or of immaturity. It is characteristic of immature minds, the child mind and the beginnings of any science. To the child who has just learned the meaning of "papa" and "mamma," it often happens that all men are "papas" and all women are "mammas," while the child born in certain localities believes that all men are either white or black. Similarly in the beginnings of science, we are limited through a lack of knowledge to a few heads of classification and our development comes by increasing our genera or species. Coming more closely to our particular problem, we find that for many years, mankind has been divided into those who are sane and those who are insane, the latter class including all those people whose behavior was so far from established norms that they could not get along comfortably in the world by themselves.

To-day the mental defectives or feeble-minded are alluded to in England as cases of congenital insanity. However, of late, we have begun to draw a rather sharp line between insanity and mental defect or feeble-mindedness, the distinction being that feeble-mindedness is an arrest of development whereas insanity is a degenerative process, the victim not simply stopping where he is but losing a part of the mentality that he once had. In the early years of childhood, it is practically impossible to differentiate between these two. The result is that we are apt to call everything feeble-mindedness which occurs in the early years. And we have assigned as a cause of the feeble-mindedness whatever physical condition seems to be uppermost. For example, if we have a case of imbecility which also has hemiplegia, we classify it as a case of hemiplegic feeble-mindedness and assume, as a rule, that the cause which has resulted in the brain lesion producing the hemiplegia, has also caused the mental defect.

The thesis to be maintained in this paper is that this is not necessarily the case but rather that our whole problem will be simplified if we recognize some more heads of classification in this particular. To put the matter in another form, we may say that as the result of our study into the heredity of feeble-mindedness, we have come to the conclusion that the human family is divisible not only into the sane and insane, the healthy and diseased; but further, the sane and healthy group is subdivided possibly into many groups or *strains;* and that the mental capacity or possibilities varies widely in the different strains, but is fairly constant in each strain and is transmitted regularly, that is to say, so long as any given strain is kept pure, we will have the same mental capacity and possibilities generation after generation; that variations occur here as they do in the plant and lower animal world; that inbreeding and crossbreeding produce new combinations just as they do in plants or animals. To illustrate, we have only to call to mind almost any line of animal breeding. There is the genus horse, with various species, and within the species there are so-called strains. Every breeder knows that those strains will be transmitted and that they must be reckoned with in all attempts to breed horses for particular purposes or with particular characteristics. The same thing is true of dogs. No trainer would attempt to train a bull dog to retrieve or to point. Furthermore coming closer to our special problem, every trainer knows that among the pointers, there are those that are easily and quickly trained to be high grade pointers; there are other strains that can never be trained to anything like the same efficiency.

The same thing seems to be true of the human race. There are strains that are capable of high mental development. These give us our geniuses or our brilliant leaders, or families with marked and valuable characteristics. Then there are strains with less capacity but still able to get along in the world and adapt themselves to their environment with fair success. These two groups are, of course, normal people. But when we go a step lower, we find a group of people whose capacity for development is so limited that they can never attain sufficient intelligence to get along in the world. Here we come to our group of feeble-minded and just as there are strains of varying degrees of intelligence which we call normal, so there are strains of varying degrees of defective intelligence, varying from those that are almost normal, almost able to take care of themselves, down to those who are so lacking in intelligence that they can do little more than procreate.

We are, for the time being, eliminating entirely all disease and abnormalities and fixing our attention upon what we call pure strains of feeble-mindedness. Furthermore, when this strain of pure feeble-mindedness is found uncomplicated as it often is, the mental condition is the chief peculiarity and the physical organism is oftentimes a remarkably perfect one, so that the strain is not recognized by any of its outward appearances, but only by those actions and movements which result from a less well-developed mentality. There can be found in institutions for the feeble-minded, persons of as fine physique and good health as can be found anywhere. This extends often even to details. For example: a dentist asserts that the finest set of teeth he has ever seen is in the mouth of an imbecile in an institution for feeble-minded.

Now it happens not unnaturally that these strains of defective mentality are liable to diseases of various kinds just as are so-called normal people. Whether the various diseases and accidents affect them in the same way as they affect people of normal intelligence, remains to be seen. It seems probable that in many cases the effect is more serious and this accounts for the fact that the physical condition has in so many cases masked the hereditary factor and so our understanding of feeble-mindedness is usually much complicated by the presence of these diseased conditions. An illustration will make this clear.

Feeble-mindedness and epilepsy are often combined, constituting a complex that is very troublesome.

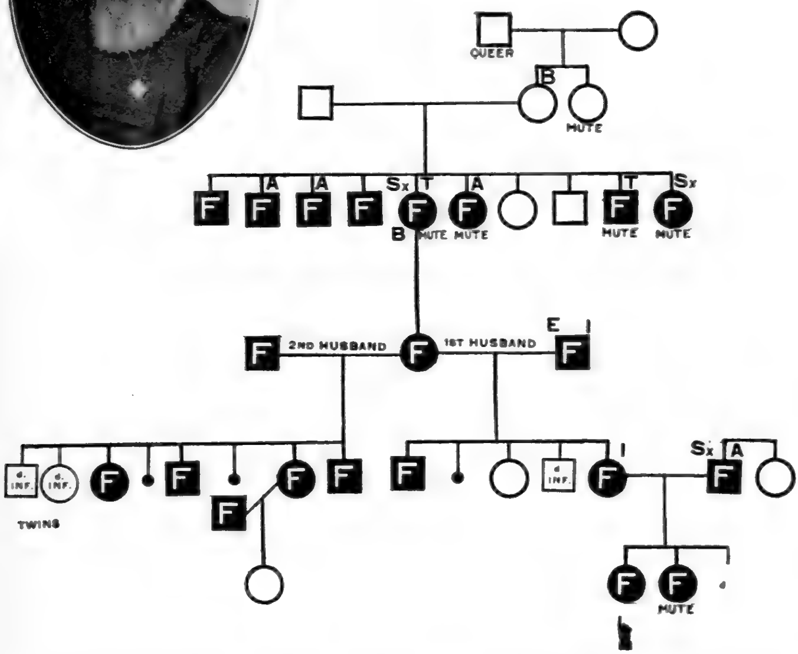
In the writer's opinion the problem would be much simplified by recognizing two groups: first those who belong to a strain of pure feeble-mindedness upon whom epilepsy has been grafted, and second a group of normal people suffering from epilepsy but in whom the epilepsy has produced an arrest of development and even set up a degenerative process. The clinical appearance of the two groups is much the same. The family history is needed to differentiate them.

Apparently also the Binet tests are useful on this line, those who are primarily feeble-minded testing in the same manner as other feeble-minded persons, that is to say, succeeding in the tests up to a certain definite point beyond which they cannot go, whereas those who are primarily normal but have deteriorated as a result of the epilepsy, show a scattering in their answers, that is to say, in some particulars, they show the intelligence of, for example, ten-year-old people while in others, they are only six, the degenerative processes set up by the epileptic attacks having destroyed certain mental processes and not others.

I shall not at this time go further into the question of the effects of the various diseases upon the different strains of mentality but shall content myself with showing you on the screen the portraits of cases of pure feeble-mindedness together with charts, showing that it is hereditary.

Note: The author showed a number of slides of perfectly normal-looking people but whose mentality ranged from that of two-year-old children up to that of ten-year-olds, although their physical age was in each case much greater. Each portrait was followed by a slide showing the hereditary character of the defect in several generations. One portrait with its accompanying family chart is here shown as an illustration.

Age 24 years.
Mental age, 10 years.



Squares are males: circles females. F = feeble-minded; A = alcoholic; Sx = sexually immoral; T = tuberculous; B = blind; *d inf* = died in infancy; I = insane; small black circle = miscarriage; E = epileptic. Hand points to child in the institution for the feeble-minded.

TRAINING SCHOOL FOR FEEBLE-MINDED CHILDREN,
VINELAND, N. J.

THE HEREDITY OF EPILEPSY ANALYZED BY THE MENDELIAN METHOD.

By DAVID FAIRCHILD WEEKS, M.D.

(*Read April 19, 1912.*)

Until recently it has been considered sufficient to determine the known number of epileptic ancestors or other relatives of a case of epilepsy, and then take this proportion as the index of heredity, with the natural result that the index increased as the study of the family was extended, resulting in a difference of from 20 to 75 per cent., as determined by different workers.

In our study of the inheritance of epilepsy at Skillman, we are endeavoring to analyze our data by the Mendelian method, which assumes that the inheritance of any character is not from the parents, grandparents, etc., but from the germ plasm out of which every fraternity and its parents and other relatives have arisen.

The relation of soma (body) and germ plasm is as follows:

1. If the body possesses a trait of the recessive to normality sort, it lacks the unit character upon which normal development depends, and it is *prima facie* evidence that the representative of that character is absent from its germ plasm, consequently such a person cannot transmit the character in question. The condition in the case when the determiner is absent may be called nulliplex.

2. If the body possesses a trait of the dominant to normality sort, it is evidence that the germ plasm has the corresponding determiner. But either one of two conditions is possible. (*a*) The determiner was derived from both parents, so that it is double in the germ plasm, and all the germ cells have the determiner; or else, (*b*) it came from one parent only, in which case it is single in the germ plasm, or simplex, and half of the germ cells have the determiner and half lack the determiner.

A moment's consideration will show that three kinds of somatic and six kinds of germ plasm matings, disregarding sex, are possible. These latter matings, together with the sort of offspring they may be expected to yield, are as follows:

I.	Nulliplex × Nulliplex	= 100 per cent. Nulliplex.
II.	Nulliplex × Simplex	= 50 per cent. Nulliplex; 50 per cent. Simplex.
III.	Simplex × Simplex	= 25 per cent. Nulliplex; 50 per cent. Simplex; 25 per cent. Duplex.
IV.	Nulliplex × Duplex	= 100 per cent. Simplex.
V.	Simplex × Duplex	= 50 per cent. Duplex; 50 per cent. Simplex.
VI.	Duplex × Duplex	= 100 per cent. Duplex.

Practically, it is not always easy to distinguish the simplex from

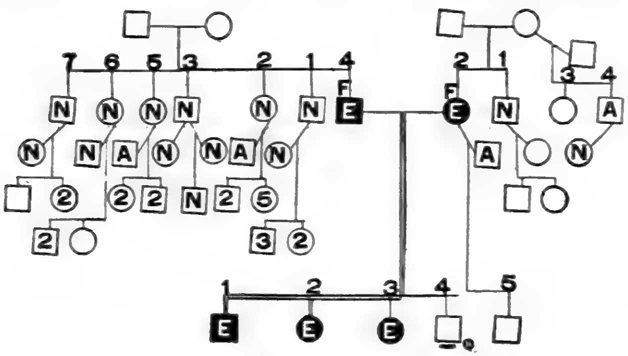


FIG. 1. In the above chart both of the parents are epileptic. There were four children from this mating, three of them were epileptic and the fourth, after the chart was made, was discovered to be feeble-minded. This case is of the type nulliplex × nulliplex. *E*, epileptic; *F*, feeble-minded; *A*, alcoholic; *N*, normal. Case 3,667.

the duplex condition, although frequently a simplex condition is indicated by an intermediate mental status.

The new method of obtaining the material is largely responsible for any advance which has been made in the study of the inheritance of epilepsy.

The field workers visit the parents and other relatives of the patient and interview them in their homes, where they are at ease, and free from restraining influences, as would not be possible elsewhere. The family physician, clergyman, school teacher and other interested persons are also interviewed, for the purpose of securing an accurate account of the mental status, environmental conditions, diseases, and causes of death, if dead, of as many relatives of the patient as possible.

The data thus obtained are recorded and tabulated on a heredity card, in such a manner that future additions and corrections can be easily made, without destroying or detracting from the work done to date.

The history and chart are filed with the case records. A cross index of place, name and trait help to locate the defective strain by

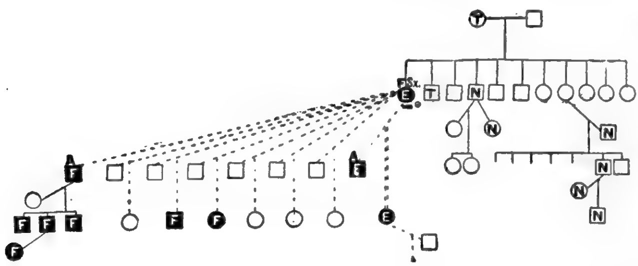


FIG. 2. This chart is a good illustration of the source of a large number of almshouse inmates. The central figure is an epileptic woman who has had seven illegitimate children all by different men; three of these died in infancy and the remainder are defective. This woman, who has spent the greater part of her life in the almshouse, was taken from there to keep house in a miserable hut for a feeble-minded man, one of whose feeble-minded sons married the feeble-minded sister of an epileptic man who is a patient at the New Jersey State Village. Her daughter, who is the patient, had one illegitimate child before she was cared for by the proper authorities. *E*, epileptic; *F*, feeble-minded; *A*, alcoholic; *N*, normal; *Sx*, sex offender; — — — —, illegal union. Case 586.

family name, defect and locality. An index of the names of individuals charted facilitates the tracing of families from one pedigree to another. A register is kept by counties, showing as far as possible the locality from which the individual comes; the age; the institution or other care received, no care, etc., of every epileptic known to us in the state. A reference index of relatives living in different counties, states or foreign countries, together with the name and location of any institutions in which they have been treated, is also kept.

It will be seen at a glance that data thus obtained have proved to be much more significant and trustworthy than the familiar family history obtained from the patient or his guardian at the time of his admission to the institution, and we are convinced, justifies careful study, which is more than can be said of the former history.

This study is based on 397 separate pedigrees of this number, however, seven came from the same fraternity; in another three are from the same fraternity and their mother is also a patient in the institution. In four other cases, two patients are from the same fraternity, and besides these, four others have been found to be

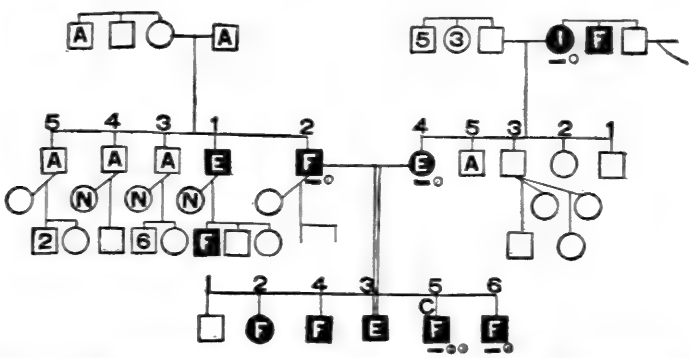


FIG. 3. The central mating in this case is that of a feeble-minded man and an epileptic woman. The man had an epileptic brother, who in turn had a feeble-minded son, while the woman came from an insane mother and had a feeble-minded uncle. There were six children; the first died in infancy, the second and fourth were feeble-minded, the third was epileptic, the fifth is a feeble-minded boy, who is at The State Home for Boys, while the last is also feeble-minded, and he is cared for at a Children's Industrial Home. The mother and father are dependent on the town for support, the mother's mother died in the State Hospital for the Insane. This mating is of the type nulliplex × nulliplex. *E*, epileptic; *F*, feeble-minded; *I*, insane; *A*, alcoholic; *N*, normal. Case 4,369.

related, thus connecting their pedigree with others already acquired, so that only 381 different families are involved in our study.

The frequency with which the same name occurs on many of the charts indicates that there is little doubt but that future study will determine their relationship and show some of these to be of the same blood.

The total number of epileptics recorded on the charts was 756, which was 3 per cent. of the total chart population of 21,558, or 9 per cent. of the 8,698 classified individuals.

In analyzing our data, we have classed it under the six kinds of matings, as follows:

NULLIPLEX $\times$ NULLIPLEX.

There are twenty-seven fraternities in which both parents are either epileptic or feeble-minded; 16 of these matings are principal matings and 11 secondary matings.

In three of the matings both of the parents were epileptic. Of the 28 conceptions, two were stillbirths, 3 miscarriages, 3 died before

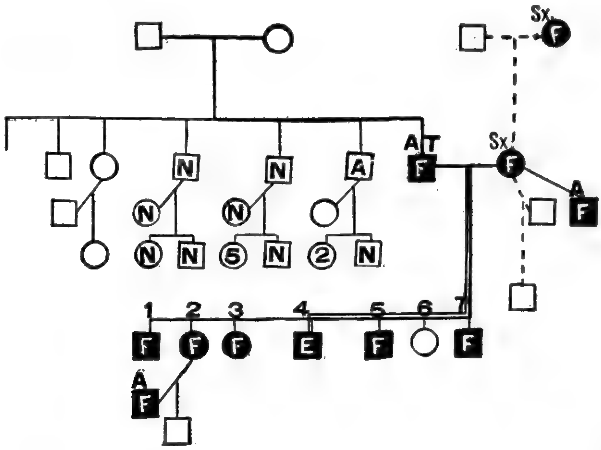


FIG. 4. This chart shows the offspring in a case where both the father and mother were feeble-minded; the father was alcoholic and died of tuberculosis, while the mother was sexually immoral and was the illegitimate child of a feeble-minded woman. There were seven children; one, the sixth, is thought to be by a different father; of the others five are feeble-minded and one is epileptic. After the father's death the mother married a feeble-minded man, who is the younger brother of her daughter's feeble-minded husband. *E,* epileptic; *F,* feeble-minded; *A,* alcoholic; *T,* tubercular; *Sx,* sexually immoral; *N,* normal; — — — — —, illegal union. Case 3,037.

two years of age, and one (an infant) is too young for classification, leaving 19 about whom something definite is known. Of these, 8 were epileptic, 3 feeble-minded, and 8, who came from parents who developed epilepsy late in life, were tainted. (Fig. 1.)

In fifteen fraternities in which one parent is epileptic and the other feeble-minded, there were 81 conceptions; 7 were too young to be classified, and 19 died before 14 years of age. Of the 55 classified, 29 were epileptic, 26 feeble-minded and 1 insane. (Figs. 2 and 3.)

In nine fraternities in which both parents were feeble-minded, there were 56 conceptions. Of these, 4 died before two years of age, 14 were too young for classification. Of the other 38 of whom something definite is known, 7 were epileptic, 28 feeble-minded and 2 drunkards, who may or may not have been feeble-minded. (Fig. 4.)

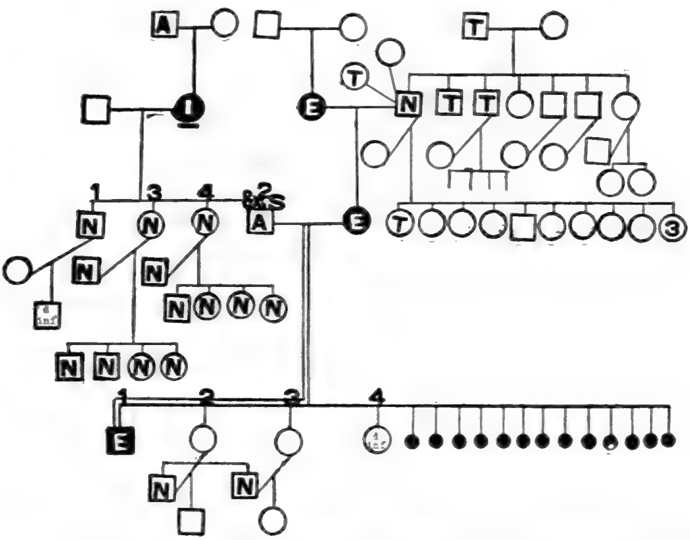


FIG. 5. In this history the mother is epileptic and descended from an epileptic mother; the father, who is alcoholic, is also syphilitic; his mother was insane. The first child is epileptic, the next two are neurotic, the last died before two years of age, and following this there were thirteen miscarriages. In contrast to the central mating this chart shows two normal matings; in these cases all of the children are normal. *E*, epileptic; *F*, feeble-minded; *S*, syphilitic; *I*, insane; *Sx*, sex offender; *N*, normal; *A*, alcoholic; ***d inf***, died in infancy. Case 1,772.

These matings are of the type nulliplex × nulliplex, and seem to justify the expectation that all children from these unions will lack the determiner for normality.

In five fraternities where one parent is insane and the other epileptic or feeble-minded, there were 29 conceptions; 5 died before 14 years of age, 2 unknown. Of the 22 available for study, 2 are epileptics, 4 feeble-minded, 1 insane, 8 tainted and 7 seemingly normal. These latter came from two fraternities, where in one case the father's insanity seemed to be traumatic and in the other alcoholic.

NULLIPLEX × SIMPLEX

Under this classification we have grouped separately those fraternities in which one parent was alcoholic.

In the consideration of the fraternities where one of the parents is epileptic or feeble-minded, and the other alcoholic, we have classed as alcoholic all of those parents who are habitually hard drinkers, or who go on frequent sprees.

In thirty-five fraternities there were 226 conceptions; 21 are yet too young to be classified, 79 died before 14 years of age (which is

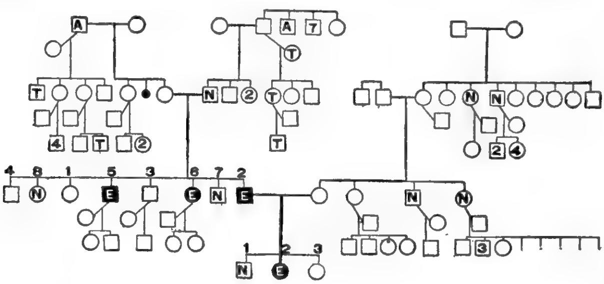


FIG. 6. In this case the father is epileptic and the mother is neurotic. The father had an epileptic brother and an epileptic sister. There were three children; the first was normal, the second epileptic and the third too young as yet for classification. This is an illustration of the nulliplex × simplex type of mating. *E*, epileptic; *F*, feeble-minded; *N*, normal; *T*, tubercular; *A*, alcoholic. Case, 3,402.

35 per cent., a high death rate). Of the 126 remaining, 39 are epileptic, 38 feeble-minded, and 28 showing some other taint (1 insane, 3 migrainous, 16 neurotic, 5 alcoholic and 3 sexually immoral), with only 21 apparently normal.

In these matings of the type nulliplex × simplex, we should expect 50 per cent. nulliplex, that is, epileptic or feeble-minded and 50 per cent. simplex, that is, apparently normal or showing only some slight defect. We have, however, 61 per cent. nulliplex, 39 per cent. simplex, the increase over the expectation being probably due to the fact that the alcoholic parent was also mentally defective, or that the alcoholism may, through poisoning the germ cells, be a contributing cause of epilepsy. (Fig. 5.)

In addition to the above, there were six matings where one parent was insane and the other alcoholic. Of the 29 conceptions, 9 died in infancy, 6 are unclassified, leaving 14 of whom something definite is known. Of these, 7 were epileptic, 3 feeble-minded, 2 neurotic and 2 apparently normal.

In considering the fraternities in which one of the parents is either epileptic or feeble-minded, and the other "tainted," we have classified as "tainted," the migrainous, neurotic and those who are mentally weak.

There were twenty-five fraternities with 161 conceptions; 60 died before 14 years of age, 24 are too young for classification, leaving 77 for study. Of these, 27 or 35 per cent. are epileptic, 9, or 11 per cent., feeble-minded, 24 showing some slight nervous or mental weakness, and 17 normal.

In these matings we should expect 50 per cent. nulliplex and 50 per cent. simplex. We obtained 47 per cent. mentally defective and 53 per cent. apparently normal, or showing some slight weakness, which is a very close fitting to the expectation. The discrepancy may be accounted for by the possible classification as simplex of individuals who are in reality nulliplex. (Fig. 6.)

In six matings of an insane parent with a "tainted" one, there were 45 conceptions; 10 died in infancy, 9 are unclassified. Of the 26 others, 9 were epileptic, none feeble-minded, 8 tainted, with 9 apparently normal.

Nulliplex × Duplex.

Under this classification we have tried to place the fraternities of which one parent was epileptic or feeble-minded, and the other reported normal.

In thirty-eight fraternities with 223 conceptions; 62 died in infancy, 36 are too young for classification. Of the 125 others, 39 or 32 per cent. are epileptics, 14 or 11 per cent. are feeble-minded, and 26 or 21 per cent. are neurotic, while 46 or 39 per cent. were apparently normal.

This fitting confirms very closely with what might be expected from the type simplex by nulliplex, indicating that the parents who have been classified as duplex (normal) are really simplex, in that half their germ-cells have and half lack the determiner for normality.

Twenty of the normal parents had ancestors who showed some mental or nervous weakness, this would justify their classification as simplex. In 26 cases little is known about the ancestors of the normal parent. The available information about three would

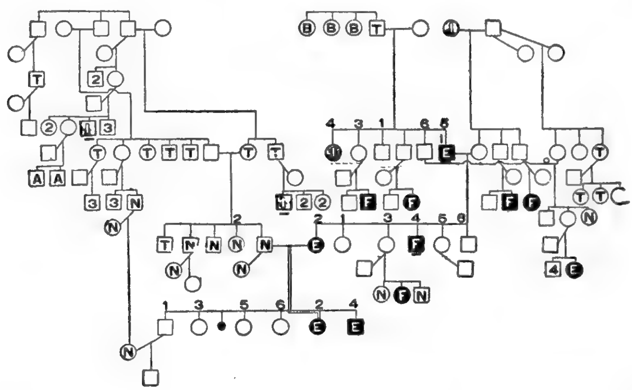


FIG. 7. The central mating in this pedigree is that of an epileptic woman, who descended from an epileptic father and has several defective relatives, and a normal man, who comes from normal ancestors. There were six children, two epileptic, and four neurotic. *E*, epileptic; *F*, feeble-minded; *I*, insane; *T*, tubercular; *B*, blind; *N*, normal. Case 2,207.

indicate that they are mentally normal. Judging from their offspring, we believe that subsequent data will show that these apparently mentally normal parents descended from tainted ancestors. (Fig. 7.)

Eleven matings of an insane and normal parent, resulted in 50 conceptions; 10 died before 14 years of age, 7 are too young for classification. Of the 33 remaining, 12 or 36 per cent. were epileptic, 2 or 6 per cent. feeble-minded, 18 or 55 per cent. seemingly normal, while 1 or 3 per cent. was neurotic.

SIMPLEX × SIMPLEX.

Under this type of matings we have grouped those fraternities coming from matings where neither parent can be classified as normal, or called mentally deficient, but showing some mental or nervous weakness.

There were eighty-four matings of this type, with a total of 540 conceptions. 152 died in infancy, with 52 unclassified. Of the 336 others, 97 were epileptic and 17 feeble-minded, in other words, 114, or 35 per cent., were nulliplex, an excess of 10 per cent. over the expected 25 per cent. (Fig. 8.)

In these matings there was an excess of epileptic and feeble-

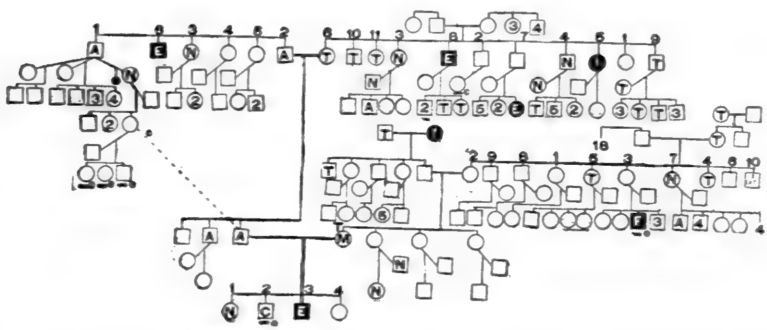


FIG. 8. In the central mating, the alcoholic, unchaste man who comes from a "tainted" strain, married a migrainous woman. There were four children: the first is normal, the second, criminalistic and has been an inmate in the State Reform School, the third is an epileptic, and the last is neurotic. This is an illustration of the simplex × simplex type of mating. *E*, epileptic; *F*, feeble-minded; *I*, insane; *A*, alcoholic; *T*, tubercular; *M*, migrainous; *N*, normal. Case 2,029.

minded beyond the expectations, which would seem to indicate that some of these tainted conditions are more closely allied with the cause of epilepsy and feeble-mindedness than has so far been recognized. The fact that there were more than five times as many epileptics as feeble-minded persons, tends to show that the neurotic and otherwise tainted conditions are more closely allied with epilepsy than with feeble-mindedness. It is a significant fact that out of the 84 matings, in four of them both parents were migrainous, while in 23 one parent was migrainous, and 14 of these were mated to alcoholics. Of the remaining 57 matings, in 7 both parents were alcoholic, and in 30 matings one parent was alcoholic, making a total of 44 (14 + 30) where one parent was alcoholic.

SIMPLEX × DUPLEX.

Under this classification we have attempted to analyze those fraternities in which one parent was "tainted," although not epileptic or feeble-minded, and the other one normal.

In one hundred and twenty-seven fraternities there were 790

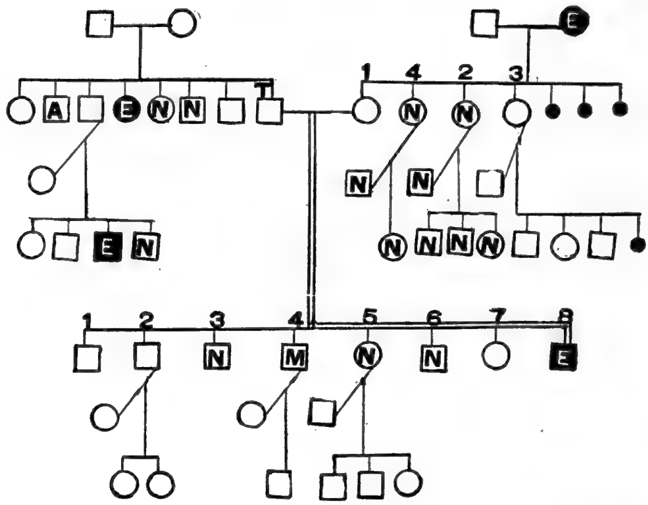


FIG. 9. In this case a neurotic woman, descended from an epileptic woman, married a man who was mentally normal, but who had an epileptic sister. The first child died at the age of seven, the second has defective speech, the third, fifth and sixth were normal, the fourth was migrainous, the seventh had St. Vitus dance and the last is an epileptic. *E*, epileptic; *F*, feeble-minded; *M*, migrainous; *A*, alcoholic; *N*, normal; *T*, tubercular. Case 2,673.

conceptions. Of the 477 classified as normal, mentally deficient or tainted; 130, or 27 per cent., are epileptic, 15, or 3 per cent., feeble-minded. (Fig. 9.)

At least 74 of these reported normal parents have been found by the field worker to have tainted heredity, so that these matings are of the type simplex × simplex, and the findings would seem to indicate that all the matings are of this type.

Duplex × Duplex.

Under this type of mating we have grouped all those fraternities in which both parents are recorded as normal.

In the study of seventy-six fraternities there were 441 conceptions; 62 are too young for classification or entirely unknown, 103

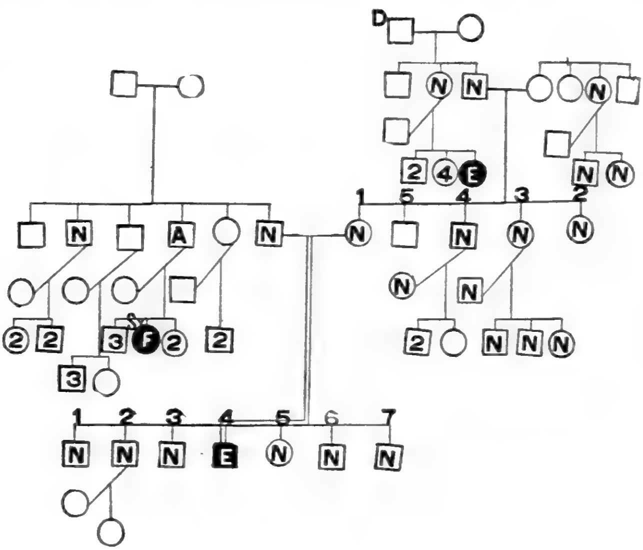


Fig. 10. This chart shows the mating of two normals. They each have defective relatives. Of the seven children the fourth is an epileptic and the others seem to be normal. *E*, epileptic; *F*, feeble-minded; *A*, alcoholic; *N*, normal. Case 2,983.

died before the age of 14 years. Of the 276 others, 172 are normal, 75, or 27 per cent., are epileptic and 3, or 1 per cent., feeble-minded, with 1 insane and 25 tainted, that is, 197 (172 + 25), or 71 per cent., are duplex or simplex in character. (Fig. 10.)

The results show that these normal parents are not duplex, but simplex, and a study of their ancestors justifies this conclusion, for in at least 45 of the matings, one or both of the parents descended from tainted ancestors.

All the available facts point toward the conclusion that the various common types of epileptics seen in institutions lack some element necessary for complete mental development, which is also true of the feeble-minded.

Two epileptic parents produce only defective offspring, when both parents are either epileptic or feeble-minded, their offspring are also defective, the defect taking the form of epilepsy, feeble-mindedness or some other neuropathic condition. This is also true of feeble-minded parents.

In the light of our present knowledge, the results obtained from the study of our data do not justify the classification of the reported normal parents of epileptics as duplex. We are forced to the belief that their germ plasm is simplex, and feel confident that more complete data would show the taint in their ancestors.

Our data seem to support the belief that alcohol is a cause of defect, in that more children of alcoholic parents are defective than where alcoholism is not a factor.

That there are more than five times as many epileptics as feeble-minded persons in those fraternities coming from matings where neither parent can be classed as normal, or called mentally defective, seems to indicate that neurotic and otherwise tainted conditions are more closely related to epilepsy than to feeble-mindedness.

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IS THE CONTROL OF EMBRYONIC DEVELOPMENT A PRACTICAL PROBLEM?

By CHARLES R. STOCKARD.

(*Read April 19, 1912.*)

Under favorable natural conditions two normal parents should, and usually do, produce a vigorous normal offspring. When, however, the conditions of development are modified or if in the second place the parents are not entirely normal the offspring is usually more or less defective. I shall attempt to show that the proper development of the offspring is dependent upon two main factors, first the physical qualities of the parental germ cells, and second the environment in which the embryo develops.

One is at first sight apt to think that deformities and defects are rare among men and other animals; but closer observation will show that the really structurally perfect individual is rather exceptional. Gross anatomical defects or monstrosities are frequently found among all animals, while lesser defects of minor importance are to be observed in a majority of individuals. These defects often cause no inconvenience, and indeed, we may be ignorant of their presence, since they are generally internal. Yet many apparently normal individuals sooner or later suffer or may actually die from some hidden developmental imperfection. The well-known congenital defects of the heart and other parts of the vascular system, digestive tract, etc., as well as the numerous developmental arrests in various parts of the body constantly remind the observer of the great loss in ability and energy that the race suffers as a result of faulty development.

These defects in construction must be considered a disease which causes the death of about 23 per cent. of the human race before or shortly after the time of birth (Sullivan's studies and French statistics), and handicaps a certain proportion of the survivors throughout their lives. We carefully study and use all known precautions to protect ourselves against post-natal infections and diseases, and much interest and time is given to combating the causes, yet little is said and scarcely anything done towards a control of development, or the hygienic protection of the developing individual.

This is really a morphological problem and is as truly a part of the fight against disease as is the treatment of abnormal physiological processes. It is not all of morphology to describe and study the detail of bodily structure, but its important task is to understand and analyze that structure, and if possible control and regulate its formation: and thus, if properly developed its goal is to relieve the race of its great structural disease—a disease which affects more individuals than any other one malady of man.

To most persons the above task seems at first thought a futile undertaking, and any one suggesting such control or preventive treatment might be interpreted as indulging in fanciful speculation. Yet the data available from the studies of defective persons in different countries of the world, and the experimental evidence furnished by work on lower animals makes the correction or prevention of developmental defects seem even today a problem to be practically handled to a slight degree at least.

To proceed as with any other disease, we must first ascertain the cause of these conditions, as the possibility of a cure depends upon the nature of the cause.

Are monstrosities and defective development due to some innate change within the germ cells of the parent, thus being incurable, as many former workers would have us believe? Or, are they due to changes produced in the germ cells by the action of some unusual condition in the body of either the male or female parent, or finally may they not be due to an unusual environment acting upon the developing embryo itself? In both of the latter cases the conditions are open to regulation or control. These questions may only be solved experimentally and the experiments have proven that the great majority of monsters are due to the action of unusual conditions upon either the parental germ cells or the developing embryo. There may be some changes of form or variations in animals which are due to innate changes in the germ-plasm but even these when fully understood may possibly be shown to result indirectly from some change in the chemical surroundings.

First to consider the modifications induced in the developing egg or embryo by a strange chemical environment. It has been found for the eggs of a number of animals that develop normally in sea-water that when certain chemicals are added to their environment they develop into various unusual forms.

I experimented for several years on fish's eggs and found that on adding any one of a large series of salts to the sea-water that the eggs developed abnormally and gave rise to a great number of monstrous individuals. The types of the monstrosities were variable, and the same kind of monster often resulted from different treatments. This was to be expected, but the important problem was to produce some definite type of monster in great numbers with any given treatment. This I finally succeeded in doing and in some experiments got as many as 90 per cent. typical cyclopean or monophthalmic monsters. These types of monsters first occurred in solutions of $MgCl_2$ in sea-water. In such solutions as many as 50 in 100 eggs formed one-eyed cyclopean embryos. Since Mg has the power to inhibit activity in animals and so acts as an anæsthetic I determined to try the action of a number of such substances on the developing eggs to ascertain whether they might also inhibit the lateral migration of eye parts. Alcohol, ether, chloroform, chloreton, etc., were employed and cyclopean monsters resulted from eggs developing in all of these substances. Alcohol gave the most decided effects and inhibited the normal production of eyes in almost all cases. All of these anæsthetics act more particularly upon the central nervous system of the adult and it is important to find that the development of the nervous system is also especially affected by them. In alcohol solutions the embryos showed almost every gross abnormality of the brain which is known to occur, and the spinal cord was often defective.

I have repeated the experiments of Féré with hen's eggs and find that when these eggs are exposed to fumes of alcohol many abnormal chicks result. When hen's eggs are placed in closed dishes over evaporating 95 per cent. alcohol enough of the fumes penetrate the shell and enter the contents of the egg to cause the developing chick to form abnormally.

McClendon has lately found that an excess of CO_2 and other substances also cause cyclopia and brain abnormalities. Many other workers have shown the effects of the environment on the developing egg.

It is, therefore, proven that the experimenter has the power to take an egg which would normally give rise to a perfect animal and by proper treatment he may cause it to form a typically abnormal individual. The monster may in many cases be able to survive and move about. No one can question that in these experiments the unfavorable environment modifies the form of the resulting individual.

Does this also occur in embryos developing in the mother's body? Children are born which exhibit the same types of deformities as those described above. Syphilitic mothers usually abort or give birth to abnormal children and there is much evidence to indicate that an alcoholic mother is more apt to produce an abnormal child than is a non-alcoholic mother.

Tubal pregnancies are common among women with venereal diseases and in such cases the embryo must necessarily develop under abnormal environment, having a poor surface for placental attachment in a region not adapted to the conditions of pregnancy. The conditions for embryonic nutrition are poor. Mall has found that while only 7 per cent. of uterine pregnancies in his records contained pathological embryos, that 96 per cent. of the embryos in tubal pregnancies were pathological, only 2 in 46 specimens being normal. This is strongly indicative of an abnormal environment as the cause of abnormalities. If these monsters were due to inherent tendencies in the germ cells one should not expect more abnormal tubal than uterine embryos.

Among lower mammals it has been shown that dogs fed on alcohol produce deformed and otherwise defective pups. I am now conducting a series of experiments with guinea pigs which show that a female treated with alcohol during her pregnancy will often abort or produce defective young, while the control animals are giving birth to normal young. Many more cases could be cited if time permitted.

Experiments on lower animals, therefore, show and human statistics seem to indicate that the cause of structural disease is often an abnormal developmental environment. To prevent such a disease the developmental conditions must be controlled and rendered as nearly normal as possible.

The second consideration is whether abnormal chemical environment may act on the parental germ cells in such a manner as to cause them to change and become incapable of giving rise to a normal individual. It is well known that certain disease toxins such as that of syphilis and substances such as alcohol and lead effect various body tissues so as to render them unfit for normal physiological activity. It is, therefore, only logical to suppose that the same or similar substances may effect the germ cells and so derange their chemical constitutions as to cause them to give rise to offspring of peculiar structure and qualities.

Bertholet has found that alcohol has a particular affinity for the reproductive glands just as it does for the nervous system. In examining the structure of the testicles from a large number of chronic alcoholics it was shown that spermatozoa were absent entirely or degenerate in form (azoospermy) in a majority of the cases. It is doubtless true that the ability of the spermatozoa to accomplish normal fertilization would be affected long before any definite structural change could be observed.

The crucial case is the treatment of the male in such a way as to render his spermatozoa unable to produce a normal development when combined with a healthy egg from a normal female. In this case the action must of necessity be on the germ cell only and not on both the egg and embryo as it might be in treating a female mammal.

It must be recognized that an individual owes its structure and character to the peculiar chemical constitution of the germ cells from which it arises. The germ cells of two species of animals are probably as different chemically as the animals are morphologically. Therefore, if the chemical nature of the germ cells is disturbed or injured by the action of poisons in the animal's blood they will probably show this injury in the type of individual to which they give rise.

Constantine Paul long ago found in studying 88 cases of pregnancy among women lead workers that 71 resulted in abortion, premature labour, or stillbirth while only 17 children were born alive and of these five died within the first year. Several of these women later produced healthy children after leaving this work. (This indicates that when the cause is known for defective development the cure may often be established by its removal.) Lead not only effects the developing fœtus but also acts directly upon the germ cells as is shown in the case of men working in lead while their wives were not exposed to the poison. Many of the offspring from such fathers are aborted and the children born are epileptic, feeble-minded or generally defective.

To return to the results furnished by the guninea pig experiments referred to above—I have chosen healthy individuals and treated them daily with the fumes of 95 per cent. alcohol to about the point of intoxication. Feeding alcohol and giving it by stomach tube was first tried, both of these methods were unsatisfactory as the guinea pigs did not take alcoholic food in sufficient quantity and the stomach tube disturbed the animals to such a degree that I feared the experimental result might be vitiated even though it could be partially controlled. The inhalation method is perfectly satisfactory; the animals are placed in a copper tank having a screen floor which holds them above the evaporating alcohol. The alcohol is breathed directly into the lungs and affects the animals readily, in much the same manner as weak treatments of ether or chloroform would. The animals are thus put into a condition of chronic alcoholism, being almost intoxicated six times per week. Many of these guinea pigs have been killed and their lungs, liver and other organs examined and found to be perfectly normal so far as their appearance goes. The conjunctiva over the eyes is very often affected by the fumes, during the beginning of the treatment the eyes often become white, this is transitory in most instances and the eyes finally clear again and remain in a normal condition from then on. Most of the specimens have fattened under the alcohol treatment.

The matings have been made in such a fashion as to test several questions. First, alcoholic males are mated with normal females, paternal influence, the crucial test for the effect upon the germ cells. Second, alcoholic females are paired with normal males, the maternal influence plus the direct action on the developing embryo. Lastly, alcoholic males and females are paired.

The results of 40 such matings are shown in Table I. The decided effects of the alcoholic treatment are seen when the records are compared with those of the normal guinea pigs.

TABLE I.

MATINGS OF ALCOHOLIZED GUINEA-PIGS.

Condition of Animal.	Number of Matings.	No Result or Early Abortion.	Still-born Litters.	Number of Still-Born.	Living Litters.	Early Deaths.	Surviving Young.
Alc. male × nor. female	24	14	5	8	5	5	5 1 + 4
Nor. male × alc. female	2	1	0	0	1	0	1 Preg. 2 in utero, 1 deformed.
Alc. male × alc. female	14	10	3	5	1	1 died 6th day	0
Summary	40	25	8	13	7	6	6 6 in 25
Nor. male × nor. female. *Control.*	8	0	0	0	8	0	15 15 in 15

In the 24 cases in which normal females were mated with alcoholic males, 14 gave negative results. Some of these probably aborted early as the parents were all fertile and the female is apt to eat the young before they have been observed when they are born prematurely. Five of the matings gave stillborn young, in some cases they were born a little before term. Litters were born alive but the young died soon after showing many nervous symptoms, such as epileptic-like seizures, and all died in convulsions. Only two litters consisted of normal offspring and these young, five in all, seem healthy though unusually small. It is thus seen that in 24 matings of *normal* females with alcoholic males only two gave normal results. Whereas in the control animals all matings have resulted in the production of normal offspring.

Only two matings were made between normal males and alcoholic females. One of these gave no result or was possibly aborted very early and lost, while the other mating produced one female offspring that lived to become pregnant by an alcoholic male. This last mentioned female was killed by accident, two embryos were found *in utero* one of which was deformed.

Fourteen matings were made between alcoholic males and females. Ten gave no result or aborted very early and were eaten, while four cases showed the following records. One young was born weak and died in convulsions on the sixth day after birth. Two cases of premature births of dead young. One female had young *in utero* when killed.

TABLE II.

Successive Matings of Ten Females.

Animal.	1st Mating.	2d Mating.	3d Mating.	4th Mating.
No. 10 alc.	Alc. male 4 = 1, young died 6th day.	Alc. male 4 = 0.	Alc. male 6 = 0.	Alc. male 4 = 1, embryo in utero 2nd week.
No. 12 alc.	Alc. male 5 = 0.	Alc. male 5 = 0.	Alc. male 4 = 0.	
No. 11 alc.	Alc. male 6 = 0.	Alc. male 6 = 0.	Alc. male 5 = 2, premature, still-born.	Alc. male 4 = 0.
No. 13 nor.	Alc. male 5 = 1, stillborn.	Alc. male 5 = 0.	Alc. male 4 = 0.	
No. 17 nor.	Eth. male 1 = 0.	Eth. male 1 = 0.		
No. 18 nor.	Alc. male 5 = 0.	Alc. male 5 = 0.	Alc. male 6 = 0.	
No. 7 nor.	Eth. male 2 = 2, premature, stillborn.	Eth. male 2 = 0.	Eth. male 2 = 0.	
No. 14 nor.	Eth. male 3 = 0.	Eth. male 3 = 0.		
No. 19 nor.	Alc. male 4 = 0.	Alc. male 6 = 1, stillborn.	Alc. male 6 = 0.	Alc. male 5 = 4, small but active.
No. 15 nor.	Alc. male 6 = 2, stillborn.	Alc. male 5 = 0.	Alc. male 5 = 2, died 4th week.	Nor. male = 1, normal young.

These results stand in marked contrast to the records of the control, which show all normal conceptions and normal offspring.

The second table shows the results of successive matings in ten of the females. The varying success of the conceptions in the same individual are striking.

Nice has quite recently recorded a similar series of experiments with alcohol on mice. Alcohol was given to the mice in their food. Nice finds that while there was a certain fatality among the offspring from alcoholic parents as compared with those from normal parents, where there was no fatality, yet nevertheless the offspring of alcoholic parents actually grew faster than those from the control. This may indicate that alcohol is not equally poisonous in its effects upon all animals, as might really be expected. The germ cells of mice may be more or less immune to the action of alcohol. It is well known that the action of alcohol is different in its effects on individuals from different human families. Some alcoholics show chiefly nervous disorders, hallucinations, delirium, etc., while others may have no nervous symptoms but exhibit various derangements of the digestive glands, kidneys, etc., or may have a fatty degeneration of almost all organs.

Finally it may be concluded that the experimental evidence goes to show that the development of an offspring may be modified by either treating the parents so as to affect their germ cells or by subjecting the developing embryo itself to unusual or injurious conditions.

The causes of many congenital defects are therefore known. It is possible to control embryonic development to such an extent as to produce abnormal structures. May not the proposition be reversed and unfavorable environments be treated in such a manner as to render them favorable to normal development? Diseased mothers may in some cases, at least, be made fit for the function of reproduction.

The regulation of structural disease becomes then a problem of morphology and hygiene. It is most important, and must precede, or go before, the selective mating of human beings or the eugenics movement. The most intellectual will rarely submit to direction in choosing a mate, yet every productive pair will welcome any possible means of improving the quality of their offspring.

While preventive measures are being used to protect the post-natal life of the individual, why not guard as far as possible its pre-natal development?

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AN AVIAN TUMOR IN ITS RELATION TO THE TUMOR PROBLEM.

By PEYTON ROUS, M.D.

(*Read April 19, 1912.*)

The behavior of malignant tumors has stimulated many hypotheses as regards their causation and yet in some of its phases has appeared to disprove all. The suggestions afforded by other normal or pathological growth processes lead in numerous and diverse directions. Today, despite an immense accumulation of data, the solution of the tumor problem waits upon fresh findings; and to foretell the line of research which will yield these findings has not seemed possible.

The successful transmission of neoplasms of the lower mammals, a few years ago, seemed at first to carry with it the immediate solution of the problem. But this did not prove to be the case. In order to obtain a tumor-strain for investigation, an animal with a "spontaneous" tumor was required; and the transmission of the growth was soon found to involve a transplantation process,—as genuine a transplantation as that of skin or other normal tissue. A new tumor in the strict sense was not thus engendered, but to a portion of the old another host was given. All efforts to separate out a cause for the neoplasm or to transmit it by other means than by graft of the living neoplastic cells were unsuccessful. The consistently negative results of such work, together with the general behavior of the transplanted neoplasms, have led many investigators to forego the idea of an extrinsic cause for malignant tumors in general and to attribute them to some inherent cell-perversion, or else to a cell-derangement precipitated by factors temporarily active. But it may be pointed out that the basis for such a conclusion so far as it rests upon experiment, rests upon work with the tumors of few species, Those of the rat and mouse have been employed almost exclusively.

The findings here to be presented were obtained in the study of a malignant tumor of the chicken, which closely resembles in its general characters the mammalian neoplasms, including those of man. That such growths exist has been generally recognized; and their status as true tumors has been established. But like the neoplasms of other birds, of reptiles, amphibians, and many mammals, they have remained almost unutilized for research. Our tumor of the fowl proved transplantable and has thus far been observed in several hundred chickens. It is a connective-tissue growth, a spindle-celled sarcoma. From its tissue there has been isolated a causal agent, ultramicroscopic in some, perhaps in all, of its forms, and undoubtedly a living organism. Though the agent gives rise to the sarcoma, and accompanies the growth, it does not take any obvious share in the disease phenomena. These are referable to the behavior of the neoplastic cells, a point now to be illustrated.

The original sarcoma arose in a young fowl of pedigreed, pure-blood stock, and its transplantation was successful only in this fowl's blood-relations. A similar peculiarity has been often observed on the transplantation of normal tissues, but it has not been noted in association with the transmission of diseases caused by a parasite. After propagation in several successive hosts, the sarcoma became less precise in its demands and could be transplanted to non-related fowls of the same variety. But like certain delicate tumors of mammals it was for a long time transmissible only within the limits of this variety, and at the latest test still grew most readily in such hosts. All attempts to transmit it to animals of other species have failed.

A transplantation of neoplastic tissue is involved in the growth's transmission under ordinary circumstances, and only by special means has it been shown to be unnecessary. Ordinarily when bits of the sarcoma are placed in a new and susceptible host they survive, are vascularized, and proliferating, form a new tumor. The multiplication of the implanted cells obviously suffices to produce the neoplasm. In the histological pictures there is no indication that the elements of the host ever become incorporated as true neoplastic tissue. No tumor arises in hosts so unfavorable to the engrafted tissue that it dies.

The growth consists of spindle-shaped cells supported by a scanty, vascular framework; and the sole differentiation which these cells undergo is to an attenuated form with the production of a few intercellular fibrils. In the disposition of the cell-strands and bundles there is no suggestion of focal arrangement such as frequently indicates, in the case of the granulomata, the presence and position of an exciting cause; while at the growth's borders a cellular reaction is practically absent. The tumor elements multiply rapidly by mitosis and amitosis, and the neoplasm grows, not only by expansive enlargement but also through an active invasion and replacement of the normal structures by tumor cells. In the course of the invasion tumor cells frequently penetrate the walls of blood or lymph-vessels, and are freed in the circulation. By their transportation, lodgment and growth secondary sarcomata are caused at points distant from the primary mass. This important characteristic of tumors in general has been placed beyond doubt as regards the avian growth by means of direct experimentation. The host, which at first seems unaffected by the tumor, emaciates as the growth increases in size, and, if it escapes intercurrent processes eventually dies in coma.

The conditions which determine the success or failure of the sarcoma when transplanted to a new individual are in general referable, as are those of its behavior and dissemination, to the sarcoma cells as such. The influence of variety of the host and of blood-relationship has already been referred to. Young hosts prove most favorable, as for all transplantable tissues, normal or neoplastic. Hosts which are ill of causes that involve emaciation are relatively unfavorable, a circumstance noted in its relation to mammalian growths by other workers, and especially interesting because these hosts are more susceptible, as a rule, to the frankly infectious processes. A certain proportion of hosts, although of the proper variety for the tumor's growth, manifest a resistance such that it does not develop when implanted in them; while others in which the growth has developed and retrogressed are completely resistant, for a time at least. Similar types of resistance have already been demonstrated for the tumors of rats and mice. Furthermore they have been elicited against a normal tissue capable of growth on transplantation (embryonic tissue).

Taken together the foregoing traits identify the chicken sarcoma as a typical malignant tumor. In them there is nothing to suggest the presence of a parasitic cause for the disease, but much that has been held to favor the view of an intrinsic cell-derangement.

For the first attempts to separate out the sarcoma's cause filtration was employed. The tissue of a rapidly growing tumor was ground with sand, taken up in Ringer's solution, shaken for some time, centrifugalized, and the supernatant fluid was passed through a Berkefeld filter which held back small bacteria. The injection of a few cubic centimeters of the limpid fluid thus obtained gave rise to the characteristic spindle-celled growth in fowls previously normal; and this growth was capable of further transplantation through an indefinite series of hosts. More recently the causative agent has been differentiated from the living tumor cells by drying, by glycerinization and by repeated freezing and thawing,—processes which the tumor cells fail to survive. It remains active for many months in dried sarcomatous tissue, and for at least one month in tissue placed in 50 per cent. glycerin. It is quickly rendered innocuous by temperatures above 53° C., by 50 per cent. alcohol, by 2 per cent. phenol, by saponin in high dilutions, by chloroform and toluol in the proportions which prevent bacterial growth during autolysis, and by autolysis itself. It will not pass through a dialyzing membrane, nor, in our experience, through a porcelain filter. These various features seem sufficient to identify it as a living organism in distinction from a ferment. The organism has never been directly observed in fresh or stained preparations; and the morphology of the individual tumor cells does not suggest its presence. Attempts to cultivate it *in vitro* have not as yet proven successful.

The neoplastic change brought about by the agent takes place slowly compared with the proliferation of the cells, once they have become sarcomatous. Growth of the tumor, dissemination, injury to the host, immune processes, all are referable to these cells suddenly endowed with new properties. The introduction into a susceptible fowl of a large amount of the filterable agent is not in itself sufficient to cause a tumor. The development of a growth under these circumstances is conditional upon the presence of a cell-derangement, such, for example, as is produced by the injection of infusorial earth. Yet even when the element of cell-derangement has been supplied, and the agent injected in quantity, a considerable percentage of the fowls fail to develop a sarcoma. The nature of the factors responsible for this failure has not been determined. The importance of cell-derangement as a contributory cause of human sarcomata has long been recognized.

The chicken sarcoma is strikingly non-infective under ordinary conditions. During the last three years more than a thousand fowls, with or without the tumor, have been kept together in close quarters, yet no instance of natural transmission has been observed. An examination of numerous spontaneous chicken tumors from various sources has shown that the sarcoma is not epidemic. These facts find an explanation in the various factors by which the agent's action is conditioned.

In conclusion it should be stated that the experiments with the chicken sarcoma have not yielded a method whereby a causative agent can be separated from the tumors of rats and mice. But they clearly prove that the characteristics of malignant tumors in general are compatible with the presence of a living causative agent. Such a cause for them seems, indeed, far from improbable.

Note: Dr. James B. Murphy has shared, as joint author, in the work on the chicken sarcoma since the recognition of the latter's filterable cause; and more recently Dr. W. H. Tytler has aided in the study of some of the growth's problems.

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THE PROTEIN POISON.

By VICTOR C. VAUGHAN, M.D.

(*Read April 19, 1912.*)

For many years I have been studying the chemistry of the bacterial cell. In 1900 I devised the large tanks for growing massive cultures. These have proved quite satisfactory, and I have been able to get bacterial cellular substances quite free from all impurities, in large amount. After many years of unsuccessful effort Wheeler and I, in 1903, succeeded in partially isolating the poisonous group from the cellular substance of certain pathogenic bacteria. This we did by heating the cellular substance with a two per cent. solution of sodium hydroxid in absolute alcohol. When this is done at the temperature of boiling alcohol the cell substance is split up into a poisonous and a non-poisonous part. The former is soluble in alcohol, while the latter is insoluble. This gives us not only a method of preparation, but also one of partial separation. I may say that the evidence that a distinct cleavage of the bacterial cell is secured is shown by the fact that all the carbohydrate and all the phosphorus in this cellular substance remains in the insoulble or non-poisonous part. The poisonous portion contains no phosphorus and no carbohydrate, but it does give the biuret and the Millon reaction, and must therefore be classed as a protein. This protein has never been obtained as yet in a state of chemical purity. The best preparation that we have been able to secure up to this time kills guinea pigs when injected intravenously, in doses of .5 of a mg. There are certain reasons for believing that its effect upon man is still more pronounced.

Having found this poison in pathogenic bacteria we next looked for it in non-pathogenic organisms, and we found it in these quite as abundantly as in the pathogenic forms. It therefore follows that the pathogenicity of the bacterial cell does not depend upon its capability of producing a poison, because all bacterial cells contain a poison. Whether a germ is pathogenic to a given species of animal or not depends upon its capability of growing and multiplying in that animal's body.

Next we looked for this poison in certain animal proteins, such as the white of egg, the proteins of blood serum, the casein of milk, etc. In all of these the same or a like poison was found by the same method. Later we tested vegetable proteins, such as the gluten of flour, the zein of corn meal, the edestin of hemp seed, etc. Up to the present time we have examined more than thirty proteins of bacterial, animal and vegetable origin, and in all of these the same poisonous group has been detected.

It has long been suspected, and indeed I may say, known, that the protein molecule contains a poisonous group. At first it was supposed that the diverse proteins which man takes in his food are but slightly altered in the alimentary canal, and before absorption. It is now known that this is not true, and that in the healthy man all proteins are broken down into amino acids by the ferments of the alimentary canal, and that these amino acids are, either during absorption or directly thereafter, resynthesized so as to form the proteins which are characteristic of man's body. The precipitin test has demonstrated that every species of animal has its own specific protein bodies. Every albuminous molecule contains a poisonous group. Peptones injected into the blood act as poisons; therefore the peptone group contains a poisonous molecule, and it is this poisonous molecule in the peptone group which we have succeeded in partially isolating. The symptoms induced by this protein poison are marked and characteristic. They divide themselves into three distinct groups. Soon after the injection of a minimum fatal dose in one of the lower animals there is evidence of peripheral irritation. This is shown by the fact that the animal becomes restless and attempts to scratch itself, not only the part adjacent to the point of injection, but every portion of its body which it can reach. This is known as the stage of peripheral irritation. In man it is characterized by itching and by an erythematous eruption which begins about the place of injection, and rapidly spreads over the body. In the second stage the animal lies in a lethargic condition, with rapid, difficult respiration. It prefers not to move, and when urged to do so it shows that it has partially lost the power of coördinating its movements. It drags its posterior extremities, or it sways from side to side. This is known as the paralytic stage. The third stage manifests itself by clonic covulsions, which repeat themselves after intervals of rest, becoming more and more violent, until death results. After reaching the convulsive stage recovery is rare, although it does occasionally occur. The symptoms are produced by the injection of protein poison, whether obtained from bacterial, animal or vegetable proteins. It should be stated that in order to study these symptoms properly the dose should approach the minimum quantity. When the dose is excessive the first and even the second stage may not be observed. The animal is speedily thrown into a convulsion, and death results within a few minutes. When a non-fatal dose is given the first and second stages appear, and may last in guinea pigs for an hour, possibly two, but recovery is rapid and apparently complete. It is of importance to note this fact, that when recovery does take place it follows rapidly, and apparently the animal is as well as ever within two or three hours, and possibly earlier.

We had studied this protein poison and its effects upon animals when the phenomenon of protein sensitization, improperly called anaphylaxis, was discovered. All will understand that protein sensitization is demonstrated by injecting a protein, any protein, into an animal and waiting for a certain length of time, or until the animal becomes sensitized, when a second injection into the same animal causes the symptoms which I have described, in the same order as observed when the protein poison is administered, and that the final effects are the same. Comparing the phenomena of protein sensitization with those of protein poisoning Wheeler and I in 1907 offered the following explanation of protein sensitization: When a foreign protein is injected into an animal it must be disposed of in some way. Unless introduced in large amount it is not eliminated by the kidney. It soon disappears from the circulating blood and is deposited in various tissues, the exact place of deposition depending upon the kind of protein injected and the species of animal. In order to deal with this foreign material certain body cells develop a specific proteolytic ferment, which splits up the protein injected, and no other. The first dose is gradually split up, and consequently produces no recognizable effect upon the animal. When a proper interval of time is allowed to elapse before the second injection, this new ferment, in the form of a zymogen is stored up in certain cells of the body, and when the second injection of the same protein is made this zymogen is activated, and converted into a ferment which splits up the injected protein with great rapidity, setting free the same poison which we obtained by splitting up proteins with sodium hydroxid in absolute alcohol. This explanation of the phenomena of protein sensitization was published by Wheeler and myself in 1907. Recently it has been confirmed in France by Nicolle and Abt, and in Germany by Friedberger. It is true that Friedberger does not fully give us credit for this work. He says that we suggested this explanation, and he has demonstrated it. It is unfortunately true that much of the scientific work done in America must go to Germany and be approved before it is accepted by other Americans. This is due to our lack of confidence in ourselves and in one another. The German has so long been accustomed to stamp his products as "made in Germany," that much of our scientific work comes back with this stamp upon it. However, it is not my purpose to complain about this matter. My European confreres have given me, on the whole, fair credit for work done along this line.

More recently we have attempted to use the knowledge which we have gained in the study of the protein poison in the explanation of many of the phenomena of immunity and of disease. The essential difference between egg-white and the typhoid bacillus is that the former is a non-labile, dead protein, while the bacillus is a labile, living protein. If egg-white could grow and multiply after being introduced under the skin, or into the blood of an animal, it would be just as dangerous to prick a finger with a needle moistened with this relatively harmless, bland protein as it would to inoculate oneself with the anthrax bacillus. As early as 1907 Wheeler and I held that protein sensitization and bacterial immunity are one and the same thing. In sensitization the animal dies on the second dose. In immunity the animal survives the second dose. Sensitization and immunity are therefore apparently antipodal, but are in fact the same thing. A man drinks water containing the typhoid bacillus, and he does not develop typhoid fever that day, nor the next. He passes through a period of incubation, which in typhoid fever is somewhere about eight or ten days. During this time the typhoid bacillus is multiplying in his body in great numbers, and in doing so it is converting his proteins into typhoid proteins. Suddenly the period of incubation stops and the disease begins to manifest itself. The period of incubation stops when the body cells have become sensitized to the typhoid protein, and begin to break it up. From that time on the fight is between the living cells of the body with the ferment which they pour out, and the bacilli.

It occurred to us that if this theory be true we might demonstrate it by repeated injections of small quantities of some protein body, and determine what effect such injections might have upon body temperature. In these experiments we have used egg-white principally because we wanted to get away from cellular structure and from the supposed influence of life. We wanted to take a dead substance. Of course in doing so we recognized the fact that egg-white does not grow and multiply in the body, and consequently we must keep up the supply by repeated injections. I have published several papers upon this, notably in the *Zeitschrift für Immunitätsforschung,* and therefore I am relieved from the necessity of going into detail in this article. Suffice it to say that by varying the size of the dose and the interval between the doses one can induce in the lower animals any kind of fever that one wishes. One can place an animal in a typhoid condition, and by repeated injections keep the animal in this condition with a temperature identical with that of typhoid fever for days and weeks. On the other hand, by more frequent injections one can induce in a rabbit an acute, fatal fever, terminating in a few hours; or, by again varying the size of the dose and the interval, one can secure at will the picture of remittent or intermittent fever. Fever, therefore, results from the introduction of a foreign protein into the body, the sensitization of the body cells to that protein, and finally the cleavage of that protein by the ferment elaborated by the sensitized body cells. Now in nature practically all the proteins that find their way into the body undigested are living proteins, in the form of bacteria or protozoa. They grow and multiply in the body, without materially disturbing for the time being, the life of the individual. This continues during the period of incubation but when the body cells have become sensitized and begin to split up the foreign protein the period of incubation ceases and that of disease begins.

We have shown that repeated injections of foreign protein not only cause fevers of various kinds, but lead to emaciation of the animal body, to increased elimination of nitrogen, and to decreased urinary secretion, and, in short, to all the phenomena that are characteristic of the febrile diseases. Death from any of the infectious diseases is due to one and the same poison, and that poison is a constituent of the protein molecule. Symptoms vary in different diseases for two reasons: In the first place, the foreign proteins have different predilection places in the body in which they are deposited. In the second place the ferment which splits up these foreign proteins is specific for different diseases. The most successful diagnostician cannot determine the nature of the bacterial organism which causes the symptoms of meningitis. The symptoms are the same so long as the organ involved is the same. The meningitis may be due to the meningococcus, to the streptococcus, to the typhoid bacillus, or to the tubercle bacillus. Still, the symptoms are the same because the cleavage of the foreign molecule occurs in the same part of the body. Again, every medical man knows how difficult it is to distinguish between typhoid fever and acute general miliary tuberculosis, because in both instances the foreign protein is largely in the blood current. As I have stated, most bacterial proteins have predilection places in which they are deposited. The typhoid bacillus prefers the mesenteric and other glands; the pneumococcus is deposited generally in the lungs, though it may be found in the intestinal walls. The meningococcus finds its favorite place for growth and development in the coverings of the brain. The tubercle bacillus grows most frequently in the lungs, though it has fed upon man for so long a time that it is now able to sustain itself in almost any part of his body.

From what has been said it must follow that fever on the whole is a beneficent process. It is one of the phenomena of the parenteral digestion of proteins. The foreign protein has gotten into the body, is growing and multiplying, and in doing so is utilizing the proteins of man's body. It must be destroyed, and the body cells pour out a ferment which digests the foreign protein. This is nature's way of disposing of the foreign material, and it is apparently about the only way that nature has of doing it. I repeat therefore that fever on the whole is a beneficent process. It is an attempt on the part of nature to get rid of the invading protein. Like many other of nature's processes it may be overdone, and death may result from fever, per se.

That fever does result from a fermentative cleavage is shown not only by the facts which I have already enumerated, but those which we have learned in combating fever. Nearly all, if not all, of the anti-febrile reagents which have been employed in medicine are anti-ferments, and they lower the temperature by retarding the process of protein cleavage. Both natural and acquired immunity, apart from toxic immunity, may be explained by the facts as stated above. In natural immunity the foreign protein is either unable to grow and multiply, and this means that its ferments are unable to split up the proteins of the body, or the ferments of the body split up the invading protein before it has time to grow and multiply. This explains natural immunity, whether it be racial or individual.

Acquired immunity is explained by the fact that the first attack of the disease, or inoculation with a modified virus, develops in the body cells a ferment which is stored up, and which on a second injection of the same protein, acts rapidly, and effectively, and splits up the invading virus. In vaccination for smallpox we use a virus modified by its passage through the cow. This modified smallpox virus develops in the body cells a ferment which is capable of splitting up the smallpox virus, and the next time this individual comes in contact with a smallpox patient, or receives the smallpox virus, it is split up and destroyed before it has time to grow and multiply.

This also explains the beneficial effects that undoubtedly have been obtained by the various vaccines now so widely and often so unintelligently used.

I wish to suggest that the exanthematous diseases may be explained by the fact that the foreign proteins of certain diseases are deposited in the skin, and that this tissue is the site of the destruction of the foreign body. I may say in support of this that we have repeatedly injected egg-white into the ear vein of rabbits. After varying periods of time we have shown by sensitizing animals with blood taken from the heart that the egg-white has wholly disappeared from the circulating blood of the rabbit. Later it can be shown that this egg-white has been deposited in the skin, in the kidney, in the brain, and in various other organs of the rabbit. It seems to me that our work upon the protein poison furnishes us with facts, by means of which we are able to explain many of the phenomena of immunity and of disease.

SOME GEOCHEMICAL STATISTICS.[1]

By FRANK WIGGLESWORTH CLARKE.

(*Read April 20, 1912.*)

More than twenty years ago, in a paper on the relative abundance of the chemical elements,[2] the present writer compared a number of averages of analyses of igneous rocks, representing different regions, and showed that they were essentially identical. From these averages, combined into a general average, the mean composition of the igneous part of the lithosphere was computed, and the result obtained has since been confirmed by the study of much larger masses of data than were originally attainable.[3] Other estimates, made by other computers upon similar lines, have since served to check my own, thereby giving to my conclusions a high degree of probability. The figures obtained have received a fairly general acceptance, and have served as a basis for other computations of a fundamental character.

This acceptance, however, has not been universal. The process of averaging analyses is criticized by several writers,[4] who urge that it is unphilosophical. An analysis of a dike rock is given the same weight as that of a widespread and important formation, whereas each rock should be weighted in accordance with its volume. But we do not and probably cannot know these volumes, partly because detailed surveys are lacking, and partly because a surface outcrop fails to tell us what bulk of rock may lie below. If we try to estimate the volumes of the many rocks represented in the average, or

[1] Published by permission of the Director of the U. S. Geological Survey.

[2] *Bull. Phil. Soc. Washington,* 1889, Vol. 11, p. 131. Also in Bull. 78, U. S. Geological Survey, 1891, p. 34.

[3] See Bull. 491, U. S. Geological Survey, "The Data of Geochemistry," pp. 22–27.

[4] See, for example, Daly, *Proc. Amer. Acad.,* 1910, Vol. 45, p. 211; Loewinson-Lessing, *Geol. Mag.,* 1911, p. 248; and Mennell, *Geol. Mag.,* 1904, p. 263, and 1909, p. 212.

even the areas exposed, we shall find ourselves relying in great part upon arbitrary assumptions, a procedure fully as unphilosophical as that which it would supplant. Estimates of that and similar kinds have been made, most recently by Loewinson-Lessing, whose figures give essentially the same result as that obtained by the method he has criticized. The method by volumes is doubtless ideal, but impracticable; and the true, philosophical procedure is to do the best we can with the available data. It is highly probable that the rocks of minor importance will balance one another, the persilicic and subsilicic varieties occurring in something like equal proportions. This supposition is sustained by the groups of average analyses which will presently be given. If we trust to individual judgments, different observers will reach widely different conclusions. Loewinson-Lessing supposes that the average rock may be about the mean of an average granite and an average basalt; Daly[5] argues in favor of a fundamental basaltic magma; Mennell, whose experience has been gained in a granitic region, regards granite as the dominant rock with all else of minor importance. Mennell makes a strong argument in favor of his contention; but there is weighty evidence against it. If we study recent lavas, that is, the rocks which issue from unknown depths far below the surface, we shall see that rhyolite, the effusive equivalent of granite, is much rarer than andesite or basalt. The Deccan trap, the Columbia River basalt, the andesites of South America, the lavas of Iceland and the Hawaiian Islands are good illustrations of this statement. Moreover, the river waters which originate in areas of crystalline rocks contain almost invariably an excess of lime over soda, which would hardly be the case were granite predominant. Much so-called granite is really either quartz diorite or quartz monzonite, rocks which are probably far more abundant than has been commonly supposed.

In order to test the method of averaging analyses we may now compare the averages so far obtained by different computers, and then pass on to averages of rocks from distinct and widely separated areas. In these averages only the more important constitu-

[5] Bull. U. S. Geol. Survey, No. 209, 1903, p. 110.

ents of the rocks are considered, for the reason that the less conspicuous components have not been generally determined. They will be separately discussed later. All the means have been recalculated to 100 per cent., and water, for obvious reasons, is excluded. The methods for the determination of water are far from being uniform, and the variations are so great as to obscure the essential agreements between the other figures. The first table contains the following averages.

(*A*) The average of 248 "superior" analyses of igneous rocks selected by Washington from Roth's tables. See U. S. Geol. Survey, Prof. Paper No. 28. Average computed by the present writer.

(*B*) The average of 536 British rocks, computed by Harker. "Tertiary Igneous Rocks of the Isle of Skye," Mem. Geol. Survey United Kingdom, 1904, p. 416.

(*C*) Washington's average of 1,811 rocks from all parts of the world. U. S. Geol. Survey, Prof. Paper No. 14, p. 106.

(*D*) Loewinson-Lessing's estimate of a mean between an average granite and an average basalt. Inserted here for comparison with the other columns.

(*E*) The average of all the data relating to the composition of igneous rocks contained in the laboratory records of the U. S. Geological Survey. Computation by F. W. C.

	A	*B*	*C*	*D*	*E*
SiO_2	61.13	60.49	58.83	60.17	61.68
Al_2O_3	15.03	15.81	15.97	15.43	15.41
Fe_2O_3	3.50	4.90	3.36	3.55	2.67
FeO	4.38	2.77	3.91	4.07	3.55
MgO	2.86	3.81	3.88	3.62	3.97
CaO	4.81	4.95	5.27	5.63	5.02
Na_2O	3.75	3.26	3.95	3.24	3.49
K_2O	3.32	2.84	3.19	2.82	3.07
TiO_2	.78	.53	1.05	.89	.77
P_2O_5	.25	.22	.37	.35	.27
MnO	.19	.42	.22	.23	.10
	100.00	100.00	100.00	100.00	100.00

The general agreement is striking, and Loewinson-Lessing's estimate fits well in with the others. The next table is devoted to the igneous rocks of North America, and the analyses are nearly all taken from the Survey records.

(*F*) Average of 250 analyses of rocks from the Atlantic slope, Maine to Georgia. 78 of these are taken from Washington's tables, the others were made in the Geological Survey.

(*G*) Average of 113 analyses of rocks from the Yellowstone Park.

(*H*) Average of 137 analyses of rocks from Colorado.

(*I*) Average of 195 analyses of rocks from California.

(*J*) Average for all North America. The figures of column *E* combined with those of 398 analyses given in Washington's tables.

	F	*G*	*H*	*I*	*J*
SiO_2	59.16	61.22	62.87	62.20	61.47
Al_2O_3	15.17	16.35	16.66	15.87	15.63
Fe_2O_3	2.16	3.30	2.67	2.12	2.67
FeO	5.36	2.58	2.40	3.46	3.22
MgO	4.92	3.47	2.06	3.93	4.02
CaO	5.69	4.95	4.01	6.06	5.12
Na_2O	3.46	3.83	4.11	3.49	3.62
K_2O	2.76	3.22	4.10	1.92	3.06
TiO_2	.98	.69	.74	.58	.81
P_2O_5	.23	.31	.27	.27	.27
MnO	.11	.08	.11	.10	.11
	100.00	100.00	100.00	100.00	100.00

For Europe the following data are sufficient, all the figures, except Harker's, having been taken from Washington's tables.

(*K*) Harker's average for British rocks, as previously cited.

(*L*) Average of 231 analyses of rocks from Norway, Sweden and Finland.

(*M*) Average of 420 analyses of rocks from the German and Austro-Hungarian Empires.

(*N*) Average of 250 analyses of Italian rocks.

(*O*) General mean of the foregoing 1,427 analyses, plus 122 of rocks from parts of Europe not otherwise covered.

Good analyses of rocks from Asia, Africa and Australia, at least as given by Washington, are too few for satisfactory combination. In the next table I give a general average for North

	K	*L*	*M*	*N*	*O*
SiO_2	60.49	60.84	58.83	60.18	59.89
Al_2O_3	15.81	16.70	15.76	15.88	16.07
Fe_2O_3	4.90	3.75	3.96	3.90	4.18
FeO	2.77	2.68	3.75	3.44	3.18
MgO	3.81	2.10	4.09	2.82	3.59
CaO	4.95	4.39	5.73	5.83	5.30
Na_2O	3.26	4.98	3.74	3.36	3.70
K_2O	2.84	3.68	3.18	4.17	3.25
TiO_2	.53	.63	.67	.10	.51
P_2O_5	.22	.14	.22	.21	.20
MnO	.42	.11	.07	.11	.13
	100.00	100.00	100.00	100.00	100.00

America, South America and Europe, South America being represented by the average of 82 analyses cited by Washington. The weights assigned are stated under each column.

	J, N. America.	*P*, S. America.	*O*, Europe.	*Q*, General Mean.
SiO_2	61.47	61.13	59.89	60.76
Al_2O_3	15.63	16.29	16.07	15.87
Fe_2O_3	2.67	3.76	4.18	3.40
FeO	3.22	2.93	3.18	3.19
MgO	4.02	3.18	3.59	3.78
CaO	5.12	5.54	5.30	5.23
Na_2O	3.62	4.01	3.70	3.67
K_2O	3.06	2.16	3.25	3.08
TiO_2	.81	.66	.51	.67
P_2O_5	.27	.14	.20	.23
MnO	.11	.20	.13	.12
	100.00	100.00	100.00	100.00
Weight	8	1	7	

The last column may be taken as probably representing, with certain obvious limitations, the average igneous rock of the entire visible position of the lithosphere. The agreement between the preceding columns is so close as to suggest that similar averages from other parts of the world are likely to be of the same general order. It is hardly conceivable that analysts, dealing with rocks from such diverse regions as Colorado, South America, Germany, Great Britain, etc., should *select* subsilicic and persilicic rocks or salic and ferric rocks, in nearly identical proportions. The selection has been made by nature itself, and although there are differences indicating the existence of petrographic provinces, they are so slight as to leave the essential identities unobscured. Some human selections are indicated in certain regions; for example, in Norway, the high soda is due to the disproportionate attention paid to the nepheline syenites; while in Italy the leucite rocks of Vesuvius lead to an apparent excess of potash. In the mean for all Europe these differences balance each other.

The general agreement between the several averages is well brought out by means of the method developed in the quantitative classification of igneous rocks. For this comparison, Professor Iddings has kindly made the necessary computations, with the subjoined results: Duplications of averages are of course avoided.

Average.	Column.	Magmatic Symbol.	Name.
Roth	*A*	II. 4. 2. 3.	Adamellose.
Harker	*B, K*	II. 4. 3. 3.	Harzose.
Washington	*C*	II. 5. 2. 3.	Monzonose.
Loewinson-Lessing	*D*	II. 4. 3. 3.	Harzose.
Survey	*E*	II. 4. 3. 4.	Tonalose.
Atlantic Coast	*F*	II. 5. 3. 4.	Andose.
Yellowstone Park	*G*	II. 4. 3. 4.	Tonalose.
Colorado	*H*	II. 4. 2. 3.	Adamellose.
California	*I*	II. 4. 3. 4.	Tonalose.
North Europe	*L*	II. 5. 2. 4.	Akerose.
Central Europe	*M*	II. 5. 3. 4.	Andose.
Italy	*N*	II. 5. 2. 3.	Monzonose.
N. America	*J*	II. 4. 3. 4.	Tonalose.
S. America	*P*	II. 5. 3. 4.	Andose.
All Europe	*O*	II. 4. 3. 4.	Tonalose
General mean	*Q*	II. 4. 3. 4.	Tonalose.

In brief, all the averages fall in class II., dosalane, and in orders 4 and 5, but near the boundary between the two. The principal variations are in the rangs and sub-rangs, and are mainly due to the varying proportions of the alkalies. The average rock may be classed as tonalose, or, to use a more familiar term, as andesite. It is evident that in order to have any statistical validity, such averages as are given here must represent fairly large areas, and a considerable number of analyses. Small areas, especially those of volcanic islands, may vary widely from the mean; for example, analyses of 32 Hawaiian rocks gave in the average, only 48.55 per cent. of silica. Such local variations, however, could hardly exert any noteworthy influence upon the continental averages which represent more truly the general magma. They would be balanced, or more than balanced, by other areas of granitoid or dioritic character.

The tables so far given serve only to show the probable uniformity of the accessible magmas. In order to complete them, a number of minor constitutents of igneous rocks must be considered; which, however, have only been determined with adequate frequency in the laboratory of the United States Geological Survey. For example, in round numbers, 1,100 nominally complete analyses have here been made, and in 736 of them barium oxide was determined or proved to be absent. The mean of these determinations, counting absences as zero, is 0.100 per cent., which may be a maximum. If the remaining 364 rocks were all free from barium, and so regarded, the mean percentage of BaO would be 0.067, a minimum. Between these two figures the most probable value would lie, but nearer the maximum than the minimum, the mean being 0.084. Upon this basis of computation the following table of percentages has been constructed.

	No. of Determ.	Maximum.	Minimum.	Mean.
BaO	736	0.100	0.067	0.084
SrO	616	0.040	0.022	0.031
Li_2O	577	0.011	0.005	0.008
NiO	287	0.027	0.007	0.017
Cr_2O_3	270	0.050	0.012	0.031
V_2O_3	87	0.024	0.002	0.013
S	748	0.112	0.076	0.094
F	98	0.100	0.010	0.055
Cl	260	0.062	0.015	0.038
ZrO_2	305	0.025	0.007	0.016
CO_2	662	0.490	0.330	0.410

It is evident that these figures are not of equal significance. Some of them rest upon too few determinations, especially those for fluorine and vanadium. The experience of the Survey laboratory, however, leads me to believe that vanadium is very widely diffused in the igneous rocks, and that the mean assigned to it may possibly be exceeded. Chromium, nickel and zirconium are also more abundant than they were formerly thought to be. As for carbon dioxide, the figure given is probably much too high, for its presence in igneous rocks is mainly but not entirely ascribable to alteration. The maximum for CO_2, 0.49 per cent., may nevertheless be admitted in computing the composition of the entire lithosphere, as an allowance for carbonaceous matter which would otherwise escape attention. Copper does not appear in the table, but it is sometimes determined, and the order of its abundance is perhaps about the same as that of lithium, say 0.01 per cent. Boron, possibly, ought also to be taken into account, but it is seldom estimated, and no figure can be assigned to it. As for water, which up to this point has been neglected, the average shown by the Survey analyses is 1.95 per cent. This figure, which is excessive so far as the unaltered igneous rocks are concerned, may, however, be taken as including the water enclosed in the lithosphere and not otherwise estimated. The allowance is ample.

Including the minor constitutents, the Survey analyses alone give the subjoined mean composition for that portion of the lithosphere which is represented by rocks of igneous origin. The total is recalculated to 100 per cent.

SiO_2	59.85
Al_2O_3	14.95
Fe_2O_3	2.59
FeO	3.45
MgO	3.85
CaO	4.87
Na_2O	3.39
K_2O	2.99
H_2O	1.92
TiO_2	.75
CO_2	.48
P_2O_5	.27
MnO	.10
Minor constituents	.54
	100.00

This differs from the general mean already given under column *Q* in that it includes only the Survey data, and takes account also of water, carbon dioxide, and the minor constituents of igneous rocks. The important values, however, are all of the same order of magnitude in both estimates. The undetermined elements cannot aggregate over 0.5 per cent., and represent minor corrections which may be considered at some future time when suitable data are at hand. For present purposes they are negligible.

The mean composition of the sedimentary rocks has been determined in a different way. Composites of many samples were prepared and analyzed as if they were single samples, a method which saved much labor and was as satisfactory as if numerous individual analyses had been made. The data thus obtained have been repeatedly published, except in the case of the shales, for which a new estimate is here given. The analyses, recalculated to 100 per cent., are as follows:

(*A*) Composite of 78 shales plus 45 individual analyses taken from the laboratory records of the U. S. Geological Survey. 123 shales in all.

(*B*) Composite analysis of 253 sandstones.

(*C*) Composite analysis of 345 limestones.

	A	*B*	*C*
SiO_2	59.23	78.33	5.18
Al_2O_3	15.68	4.76	.81
Fe_2O_3	3.59	1.07	.54
FeO	2.85	.30	
MgO	2.71	1.16	7.90
CaO	2.58	5.49	42.57
Na_2O	1.27	.45	.05
K_2O	3.14	1.31	.33
H_2O	4.97	1.66	.77
TiO_2	.65	.25	.06
CO_2	2.40	5.02	41.54
P_2O_5	.15	.08	.04
MnO	.05	——	.05
Minor constituents	.73	.12	.16
	100.00	100.00	100.00

These three columns represent the three dominant types of sedimentary rocks, and differ from the figures given the igneous rocks in certain losses by leaching, mainly of lime, magnesia and alkalies, and in a gain of water and carbon dioxide received from percolating waters and the atmosphere. There is a small increase in volume consequent upon the gains; the materials lost are principally to be sought for in that universal reservoir, the ocean.

For the relative proportions of the sedimentary rocks several estimates have been made, which, however, can only be regarded as rough approximations to the truth. By studying the way in which an average igneous rock can break down, I have computed that the shales form 80 per cent., the sandstones 15 per cent., and the limestones 5 per cent. of the total.[6] Van Hise[7] distributes them as 65, 30 and 5 per cent. respectively, and Mead,[8] by a graphic process, has found 80, 11 and 9 per cent. Combining the composite analyses just given in accordance with these ratios the following mean values are obtained for the total composition of the sedimentaries. The fourth column contains the average of the three separate estimates.

	Clarke.	Van Hise.	Mead.	Average.
SiO_2	59.39	62.29	56.47	59.38
Al_2O_3	13.30	11.67	13.14	12.70
Fe_2O_3	3.06	2.69	3.04	2.93
FeO	2.33	1.94	2.31	2.19
MgO	2.74	2.50	3.00	2.75
CaO	5.01	5.46	6.50	5.65
Na_2O	1.09	.96	1.07	1.04
K_2O	2.73	2.45	2.69	2.63
H_2O	4.27	3.77	4.23	4.09
TiO_2	.56	.42	.55	.51
CO_2	4.75	5.15	6.21	5.37
P_2O_5	.13	.12	.13	.13
MnO	.05	.05	.05	.05
Minor constituents	.59	.53	.61	.58
	100.00	100.00	100.00	100.00

The first of these averages is the most probable, since it harmonizes best with the mean composition of the igneous rocks. If we reduce it to the form adopted for the latter, by rejecting its accessions, carbon dioxide and water, and also neglecting the minor constituents, it may be compared with the average marked *E* as follows:

	Igneous *E*.	Sedimentaries.
SiO_2	61.68	65.70
Al_2O_3	15.41	14.72
Fe_2O_3	2.67	3.38
FeO	3.55	2.58
MgO	3.97	3.03
CaO	5.02	5.54

[6] U. S. Geol. Surv., Bull. 491, p. 31.
[7] U. S. Geol. Surv., Monograph 47, p. 940.
[8] *Journn. Geol.*, 15, 238.

	Igneous *E*.	Sedimentaries.
Na_2O	3.49	1.21
K_2O	3.07	3.03
TiO_2	.77	.62
P_2O_5	.27	.14
MnO	.10	.05
	100.00	100.00

This comparison shows an increase in silica, due to concentration Alumina is lowered, iron is nearly constant although the proportions of the two oxides are reversed, and potassium is constant also. Soda and magnesia show losses due to leaching. Lime is increased, which suggests that the 5 per cent. of the sedimentaries assigned to limestone is probably too high. Mead's estimate of 9 per cent. is certainly excessive. The largest uncertainty is due to the facts that the composite shale used for analysis did not include certain magnesian rocks, and the limestones did not embrace the dolomites. The deficiency of magnesia, however, is mainly to be found, with the soda, in the ocean. On the whole the comparison is satisfactory, although the lowering of the alumina is unexplained. The least satisfactory feature of the combination is the average composition of the shales; but even here the percentage of soda is probably good. In the important igneous rocks the proportion of soda varies within narrow limits, and any combination of them would yield sedimentary residues in which that oxide should show much the same relative loss. The Survey average for soda (column *E*) gives 3.49 per cent. The mean of 100 rhyolites given in Washington's tables yields 3.48 per cent., while for 220 basalts the percentage is 3.24. From the preceding table the ratio between igneous and sedimentary soda is 1.21 to 3.49, an order of magnitude which is not likely to be very much changed. The influence of certain variations in it will be considered later.

From the quantity of sodium in the ocean the mass and volume of igneous rock needed to furnish it are easily computed, and also the similar data for the sedimentaries. The oceanographic data are fortunately quite good, even though they may not be rigorously exact. The mean density of sea water, according to Murray, is 1.026, and its average proportion of saline matter is 3.5 per cent. by weight. For the volume of the ocean there are several estimates. In my former calculations it was taken as 302,000,000 of cubic miles, while Murray found a larger figure, 323,722,150 cubic miles. These values, however, are now supplanted by later and more definite estimates, as follows: According to Karstens,[9] the volume of the ocean is 1,285,935,211 cubic kilometers, or 308,509,000 cubic miles. Krümmel,[10] still later, estimates the volume as 1,329,945,870 cubic kilometers, or 319,087,500 cubic miles. From these figures, with density 1.026, the mass of the ocean is as follows:

Karstens, 1,319,369,526,436,000,000 metric tons.

Krümmel, 1,364,524,469,802,000,000 metric tons.

The saline matter, 3.5 per cent., is therefore:

Karstens, $46,178 \times 10^{12}$ metric tons.

Krümmel, $47,758 \times 10^{12}$ metric tons.

Puting the specific gravity of the oceanic salts at 2.25, their volume is easily found by the subjoined equation:

$$\frac{3.5\,V \times 1.026}{100 \times 2.25} = x,$$

in which V represents the volume of the ocean. The value of x then is,

With Karstens' volume 4,923,800 cubic miles.

With Krümmel's volume 5,092,600 cubic miles.

The second of these values, derived from Krümmel's estimate of the volume of the ocean, represents a quantity of saline matter which would cover the entire surface of the earth, 197,000,000 square miles, with a layer 136.5 feet deep, or 468 feet over the land area alone. Figures like these show that the salts enclosed in the rocky crust of the earth are, in amount, relatively insignificant.

From Dittmar's analyses of sea water, made for the reports of the Challenger Expedition, the mass of each radicle contained in the oceanic salts can be calculated. In the following table I give Dittmar's percentage composition of the salts, and in a second column the weights corresponding to the total mass of $47,758 \times 10^{12}$ metric tons as found from Krümmel's figure the volume of the ocean.

[9] Inaugural Dissertation, Kiel, 1894.

[10] Encyclopedia Britannica, 11th ed., Vol. 19, p. 974.

	Per Cent.	Metric Tons $\times 10^{12}$.
Cl	55.292	26,406
Br	.188	89.8
SO_4	7.692	3,673.5
CO_3	.207	98.8
Na	30.593	14,611
K	1.106	528.2
Ca	1.197	571.7
Mg	3.725	1,779
	100.00	47,758

The average specific gravity of 958 igneous rocks, collected in Washington's Tables, is 2.737; and one cubic kilometer of rock should therefore weigh 2,737,000,000 metric tons. From the average of the Survey analyses given on p. 221 *ante,* the mean percentage of sodium in igneous rocks is 2.51, and from Washington's average 2.90. Hence the sodium contained in the ocean, $14,611 \times 10^{12}$ metric tons, would be furnished by the complete decomposition of the following volumes of igneous rock:

From the Survey average, 212,680,000 cubic kilometers.

From Washington's average, 184,080,000 cubic kilometers.

Some sodium, however, remains in the sedimentary rocks, namely, 0.90 per cent. as computed from the *reduced* average analysis. On comparing this figure with those for the total sodium of the igneous rocks, the volumes of the latter actually decomposed become, approximately,

Survey, 318,950,000 cubic kilometers.

Washington, 260,160,000 cubic kilometers.

In order to determine the volume of the sedimentaries these figures require two small corrections. First, a deduction must be made for the soda, potash, lime and magnesia lost during erosion, and now represented by the corresponding radicles in the ocean. Secondly, for the difference in density between the original rocks and the sedimentaries, indicated by the ratios 2.737 : 2.6. The first correction is approximately $24,095 \times 10^{12}$ metric tons, or 8,803,000 cubic kilometers. Making the corrections, we have, for the actual volume of the sedimentaries,

Survey, 326,590,000 cubic kilometers, or 78,338,000 cubic miles.

Washington, 264,600,000 cubic kilometers, or 63,481,000 cubic miles.

The higher of these figures is equivalent to a shell of rock completely enveloping the earth, 2,100 feet thick, or covering the land area to the depth of 7,198 feet. This estimate is probably a maximum, but it gives fairly well the order of magnitude of the volume to be determined. An exact estimate is of course unattainable, but the total volume of the sedimentary rocks cannot much exceed 80,000,000 of cubic miles, or roughly, one fourth the volume of the ocean. If we apportion the volume actually found between the different classes of the sedimentaries their volumes in cubic miles become:

Shales	62,662,400
Sandstones	11,749,200
Limestones	3,916,400
	78,328,000

This leads to the surprising conclusion that the volume of the limestones is less than that of the oceanic salts, or at least is a quantity of the same order of magnitude. If the fundamental igneous rock was more largely basaltic than the average analyses show, the proportion of limestone would be increased, but probably not to any very great extent. Some allowance should be made for sodium salts enclosed within the rocks; but it is easy to show that such a correction must be small. If all the sandstones had an average porosity of 20 per cent., and if its pore space, once saturated with sea water, retained all of its sodium, the total amount retained would be 110×10^{12} metric tons. This amount, which is evidently excessive, is only 0.75 per cent. of the sodium in the ocean. Its inclusion in the foregoing computations would raise the volume of rock decomposed to 78,100,000 cubic miles, an increase smaller than the unavoidable uncertainties of the computation.

The foregoing estimate of the volume of the sediments obviously includes those which cover a great part of the ocean floor, as well as those which are now on land. Some of the latter, indeed, were once oceanic deposits, and are now, by erosion, being partially returned to the sea, either mechanically as salt and sand, or dissolved in the water of rivers. An exact knowledge of the chemical work of river water is therefore of great statistical importance from several points of view. In a former memoir[11] I have given a careful estimate of the composition of river waters, and of their entire dissolved load. This estimate is reproduced in the following table: Column I. gives the average composition of the inorganic matter carried in solution by rivers. In column II. the annual contribution of each radicle to the ocean is stated in metric tons.

	I. Per Cent.	II. Metric Tons per Annum.
CO_3	35.15	961,350,000
SO_4	12.14	332,030,000
Cl	5.68	155,350,000
NO_3	.90	24,614,000
Ca	20.39	557,670,000
Mg	3.41	93,264,000
Na	6.40	175,040,000
K	1.51	41,299,000
$(Al, Fe)_2O_3$	2.75	75,213,000
SiO_2	11.67	319,170,000
	100.00	2,735,000,000

The figures in the second column represent the quantity of inorganic matter annually removed from 40,000,000 square miles of the earth's surface, the remaining area being, so far as additions to the ocean are concerned, practically negligible. Interior deserts, closed basins, and the circumpolar lands are left out of account. From 40,000,000 square miles of land, 2,735,000,000 tons of dissolved matter are carried each year to the sea. This quantity, however, is not a true measure of chemical denudation. The NO_3 is of atmospheric origin or else derived from organic sources, and 8 per cent. of the CO_3 represents recent accessions from the atmosphere. Much of the latter radicle is accounted for by the solution of limestones, and was once, of course, atmospheric, but it is now a part of the present erosion. Making the indicated deductions the total quantity of matter transported in solution is reduced to 2,495,585,000 tons annually; or 25×10^8 in round numbers. This, with a probable specific gravity of 2.6 has a volume of 0.96154 cubic kilometer, equivalent to a layer 0.000009281 meter deep, or 0.0003655 inch over the 40,000,000 square miles of land. At this rate the mean

[11] A preliminary study of chemical denudation. Smithsonian Misc. Coll., Vol. 56, No. 5, 1910.

surface of the continents would be lowered by solvent erosion alone, to the extent of one foot in 32,833 years. In some areas the rate is much more rapid, in others it is slower; but the average is as close as can be computed with the data now in hand. Its uncertainty may be as great as ten per cent., or perhaps even greater. The chief uncertainty is due to our lack of precise knowledge concerning the greater African and Asiatic rivers.

From the ratio between fluviatile and marine sodium the age of the ocean can be calculated. The ocean contains $14,611 \times 10^{12}$ metric tons of sodium, and the rivers contribute 175,040,000 tons annually. Hence, if the ocean were originally fresh, its entire content of sodium would be supplied by the rivers in 83,472,000 years. This form of calculation was first applied by Joly,[12] whose work is well known; and has since been discussed by Sollas[13] and also by myself in the memoir already cited. The quotient thus obtained, however, is subject to various corrections, which have been considered by the authors named above, and which operate in opposite directions. Whether they compensate or not it is impossible to say. The calculation, so far, assumes a uniform rate of supply since the surface of the earth took on its present form, and that assumption has been well criticized by Becker.[14] He shows that in all probability the rate is diminishing, for the reason that the exposure of fresh rocks, of unleached material, is constantly growing less and less, and the true age of the earth since stability was established, lies between 55 and 70 millions of years. The higher of these values appears to be the more probable. If, however, the ocean were primitively saline, the quotient representing its age would be still smaller.

Sodium tends to accumulate in the ocean, while the other saline radicles added to it are more or less precipitated as solid deposits on its floor. Calcium and magnesium are removed as carbonates, silica goes to build the skeletons of radiolarians, diatoms, and so forth; potassium is taken to produce glauconite, etc. These deposits or sediments cover vast areas to an unknown thickness, but their

[12] *Trans. Roy. Soc. Dublin* (2), Vol. 7, p. 23; Rep. British Assoc. Adv. Sci., 1900, p. 369.

[13] *Quar. Journ. Geol. Soc.*, Vol. 65, p. xli.

[14] Smithsonian Misc. Coll., Vol. 56, No. 6.

annual increment can be approximately determined. If, from the yearly contributions of rivers the amount of each radicle remaining in solution is subtracted, the rate of chemical sedimentation becomes known. In order to make this calculation, the age of the ocean must be assumed; but variations in the latter estimate affect the results but little. For example, the ocean contains 571.7×10^{12} tons of dissolved calcium, which, divided by the age, gives the annual addition. If the age of the ocean is 100,000,000 years the annual increment of calcium in solution is 5,717,000 tons; if only 50,000,000 years it is 11,434,000 tons. Subtracting these quantities from the total calcium of the river waters the remainders become 551,953,000 and 546,236,000 tons respectively, the difference being much less than the uncertainties in the data employed. If, for the sake of uniformity, we take the uncorrected age of the ocean, 83,472,000 years, the chemical or biotic sediments are represented by the following annual quantities.

SO_4	288,021,000 metric tons.
Ca	550,821,000 metric tons.
Mg	71,951,000 metric tons.
K	34,971,000 metric tons.
$(Al, Fe)_2O_3$	75,213,000 metric tons.
SiO_2	319,170,000 metric tons.

These are the quantities of the several substances annually removed from solution in the ocean, which, in combination assume the following form.

$CaCO_3$	1,347,440,000 metric tons.
$CaSO_4.2H_2O$	50,936,000 metric tons.
$MgCO_3$	251,830,000 metric tons.
K_2SiO_3	69,045,000 metric tons.
Limonite	87,905,000 metric tons.
Silica	295,096,000 metric tons.
Total	2,104,252,000 metric tons.

The last group of figures needs some explanation. From the analyses of oceanic sediments published in the reports of the Challenger Expedition I find that the ratio between sulphate calcium and carbonate calcium is 1 : 45.5. Calcium, therefore, is apportioned between the two salts in that ratio, but much of the SO_4 radicle is left unaccounted for. Part of it goes to form pyrite, and part is decomposed by organic agencies and lost, but the proportion of loss is unknown. It is, doubtless, large. The potassium which is taken up by clays or else in glauconite is in either instance represented as silicate, and hence a part of the silica is regarded as in combination. The sesquioxides are calculated as limonite, although a part of them is certainly alumina; but no refinement of a calculation here would change the order of magnitude as given. The several orders of magnitude are probably close to the truth, and we may say with much confidence that the precipitates, including such substances as coral, shell, diatomaceous ooze and what not are formed at a rate of something like 21×10^8 metric tons a year, plus a small but undefined allowance for that part of the sulphur which has been fixed as pyrite.

At the figure given, chemical sediments are now forming in the ocean sufficient to cover 88,000,000 square miles of the sea floor to the depth of 0.0001337 inch annually. The whole area of the ocean is 139,440,000 square miles, but the portion covered by the red clay, where the precipitation is relatively insignificant, must be deducted. If the rate had been uniform throughout geological time, 83,472,000 years these sediments would form a layer about 930 feet deep, but such a calculation is unsound. Large areas of what were once marine sediments are now land, and, moreover, neither the rate nor the distribution of the deposits can have been uniform. The limestones that are forming now are largely derived from the solution of older deposits, Cambrian, Silurian, Devonian, Cretaceous, etc., and their carbonates have been deposited in the ocean, not once only, but possibly several times. In the earliest geologic eras, when sediments began to form, the proportion of carbonates to other salts thrown down must have been much smaller than today. An average thickness of 930 feet over the assumed area is therefore a great exaggeration; and needs to be reduced.

It is probably impossible to determine, with any approach to precision, the actual quantity of marine sediments that have been formed. We can, however, make a plausible estimate, which shall, at least, give us some conception of their order of magnitude. It has already been shown that the limestones, which are mostly of marine origin, have a volume of 3,916,400 cubic miles. With a specific gravity of 2.7 their mass becomes $42{,}092 \times 10^{12}$ metric tons. From the figures given on p. 230 *ante,* the calcareous and magnesian sediments are now forming at a rate bearing a certain ratio to that of the other deposits, the limonitic and siliceous residues. This ratio, which is roundly 1,650:452, if constant throughout geologic time, would give for the latter class of sediments, proportional to the limestones, a mass of $11{,}664 \times 10^{12}$ tons; the sum of both classes of precipitates being $53{,}756 \times 10^{12}$ tons. The corresponding average thickness over the sedimentary oceanic area would then be 287 feet, or less than one third of the figure previously given. The actual thickness, however, must be much less; for a large part of the once marine sediments are now elevated into land. According to the best estimates,[15] the land area of the globe is now covered by 23 per cent. of archæan and eruptive rocks, and 77 per cent. of sedimentaries. Adding this sedimentary area to that of the ocean, the total becomes 132,180,000 square miles, and the average thickness of the chemical sediments reduces to 191 feet. At the crude value assigned to geologic time this represents a rate of deposition of only 0.000027 inch annually. If the age of the earth is less than 83,472,000 years, the mean annual rate of deposition will be proportionately increased, but not to anything like the present magnitude.

Whether the ratio assumed between the calcareous and siliceous sediments is justifiable or not, is a question admitting of argument. It seems, however, probable, that in the earliest geologic ages, when the land area was occupied principally by igneous rocks, the salinity of the rivers was relatively low, but the proportion of silica to lime in the waters was higher. This suspicion is justified by a study of the river waters of today, especially those issuing from granitoid areas. In such waters silica is often in excess of lime, while in waters from sedimentary areas the reverse is commonly true. The ratio here assumed represents a balancing between waters of both classes, and is therefore as legitimate as any other which might be chosen. Here it must be borne in mind that we are dealing with probabilities only, nothing more.

[15] Von Tillo as modified by Becker. See Becker's memoir already cited.

So far, the mechanical sediments, such as silt and sand, have not been considered. From the surface of the United States, according to Dole and Stabler,[16] the rivers annually carry to the sea 270,000,000 tons of dissolved substances, and 513,000,000 tons in suspension. If this ratio, which is only approximate, should hold for the whole world, the quantity deposited in the ocean during geologic time would be $102,370 \times 10^{12}$ tons, and the total sedimentation, chemical and mechanical, becomes $156,126 \times 10^{12}$ tons. This quantity, distributed over the entire sedimentary area, continental and oceanic, gives an average thickness of about 550 feet, or 0.000079 inch a year.

The total volume of the marine sediments thus computed, is 13,873,000 cubic miles. The volume remaining in the ocean is very nearly two thirds of this figure, 9,239,000 cubic miles. The volume of all the secondary rocks derived from the decomposition of igneous rocks was previously found to be 78,338,000 cubic miles. Hence the portion now on the land area of the globe amounts to 69,099,000 cubic miles of rock, consisting in great part of materials which were never transported very far from their original place of formation.

To the foregoing estimates of the oceanic sediments at least one large but undetermined correction needs to be applied. The ocean receives great quantities of dust, representative of aerial erosion, and also quantities of volcanic ejectamenta. For these nonfluviatile additions no valid estimates can yet be made. The major portion of them, however, must come from disintegrated sedimentary rocks, sands, and soils, and so do not affect to any serious extent our estimates of rock decomposition. The oceanic share of the sediments should be increased, but less than appears at a first glance. The marine sediments now on land must include a part of the contributions made to the ocean by atmospheric transportation. The actual distribution of the sediments is naturally very uneven. They are probably thin near the margin of the red clay, and thick along the continental shelves. Coral rock, for example, has been bored to a depth of 1,100 feet without reaching its limit. The mechanical sediments are of course mainly deposited relatively near to shore.

[16] U. S. Geol. Surv. Water Supply Paper, No. 234, p. 83.

In order to prevent misapprehension it may be well to reiterate the statement that these estimates of the marine sediments are necessarily crude, and represent orders of magnitude only. With better evidence, better estimates may at some future time be made, but accuracy in them is unattainable. The other figures given, for the composition of the igneous rocks and of the ocean are probably near the truth but are still subject to revision and improvement.

THERMAL RELATIONS OF SOLUTIONS.

By WILLIAM FRANCIS MAGIE.

(Read April 20, 1912.)

The thermal relations of solutions afford evidence of a peculiar and valuable kind about the nature of solutions. The electrical conductivity of solutions has been explained by the hypothesis that the molecules of the solute are partly dissociated into ions in the solution. When this hypothesis is further tested on the assumption that the osmotic pressure is proportional to the number of free molecules and ions in the solution, the experimental results of Dieterici, of Kahlenberg, of Jones and others show disaccord with the predictions of the hypothesis. I venture to believe that a study of the heat capacities and the heats of dilution of solutions will confirm the view that the reason for this disaccord lies in the assumed relation of the osmotic pressure to the dissociation, so that while the dissociation hypothesis is confirmed, the relation of the osmotic pressure to the dissociation is shown to be different from that which was originally assumed.

Five years ago I presented to this Society a paper in which I discussed the heat capacities of solutions. I will summarize here the principal results described in that paper, in order to render the present discussion more complete.

The heat capacity of a gram-molecular solution of an electrolyte diminishes with increasing dilution. The change in the heat capacity is directly proportional to the change in the dissociation, determined from the electrical conductivity. In most cases, at ordinary concentrations, the heat capacity of the water is diminished, and we are led to infer an interaction between the water and the molecules and ions of the solute of such a sort as to diminish the freedom of the water. A study of the constants of the formula by which the heat capacity is expressed leads to the conclusion that the heat capacity of the water associated with the molecules of the solute is increased, while that of the water associated with the ions is diminished. A similar relation holds for the volumes of solutions of electrolytes. Since the heat capacity and the volume of a body are both quantities in their nature additive of the similar properties of the parts of the body, it is to be expected that there will be a similarity in their behavior in any complex and changing body like a solution. The relations described confirm in a striking way the correctness of the dissociation hypothesis and the general accuracy of the dissociation factors obtained from observations on electrical conductivity, while they also indicate as a necessary conclusion from the facts, that there is interaction between the solute and solvent. This general theory which was formerly based on the facts which have been described, receives, I believe, strong confirmation from the study of the heats of dilution.

When a solution containing one gram-molecule of solute is diluted by the addition of a unit volume of water, heat is either evolved or absorbed. This amount of heat is the heat of dilution. It is of course a function of the concentration. It also shows a remarkable dependence on the temperature. For example, if a solution of barium chloride containing one half gram-molecule in 50 gram-molecules of water is diluted to double its volume at 7° C. 49 gram-calories of heat are absorbed. The same dilution at 24.5° C. is accompanied by an evolution of 18.5 gram-calories. At some intermediate temperature, about 17° C., there is no heat either evolved or absorbed. In all cases the absorption of heat is greatest at the lowest temperature of observation, and diminishes as the temperature is raised, to become positive in some cases, as in the example just given, at temperatures common in an ordinary room. The greater the dilution, the lower the temperature at which the heat of dilution changes its sign.

A very simple thermodynamic argument proves that the rate of change of the heat of dilution with the temperature, for a fixed concentration, or what we may call the temperature coefficient of the heat of dilution, is equal to the negative value of the rate at which the heat capacity of the solution changes with an increase of volume of the solution. Using l to represent the heat of dilution, taken positive if heat is evolved, θ, the absolute temperature, H, the heat capacity of the solution and of an arbitrary amount of additional solvent, from which the solvent is taken with which the solution is diluted, and v, the volume of the solution, we find

$$\frac{dl}{d\theta} = -\frac{dH}{dv} = -a.$$

We may set $dH/dv = a$, a quantity independent of the temperature, because, first, Teudt has proven it to be so independent, within reasonable ranges of temperature, by direct observations, and, secondly, because the formula

$$l_1 - l_2 = -a(\theta_1 - \theta_2)$$

obtained from the differential equation on that supposition agrees with observations within the temperature ranges in which it has been tested. Treating a therefore as independent of the temperature we get

$$l = -a\theta + e,$$

in which the heat of dilution is expressed as the sum of two terms, one of which is proportional to the absolute temperature, the other independent of temperature. Such a relation could not be expected to hold for all temperatures, but within the narrow ranges open to experiment it seems to be valid. Of the two terms the first one is positive in all actual cases, for it is a general rule that the heat capacity of an electrolyte diminishes as the dilution increases. It corresponds to an evolution of heat. The second term is nearly of the same magnitude as the first, and is negative, corresponding to an absorption of heat.

From the experimental relation already described, connecting the heat capacity of the solution with the dissociation, it follows that the quantity a is equal to a negative constant multiplied by the rate at which the dissociation increases as the volume of solution is increased. The evolution of heat therefore which is expressed by the term $-a\theta$ is proportional to the increase in the dissociation and to the absolute temperature. This can be explained by the theory of the constitution of a solution which has already been described. As dissociation proceeds molecules of water which have been in union with the molecules of the solute are released and their heat capacity is diminished. At the same time molecules of water are associated with the new ions, and their heat capacity is also diminished. The act of dissociation thus diminishes the heat capacity, and therefore the number of degrees of freedom of the solution in proportion to the change of the dissociation factor, and the energy associated with those degrees of freedom, which is proportional at these temperatures to the absolute temperature, is liberated in the solution as heat. The negative term e being nearly equal at each concentration to the corresponding positive term, also varies to a first approximation with the dissociation. When calculated for the dissociation of a complete gram-molecule it is of the same order of magnitude as the heat of combination of the elements constituting the solute. It presumably contains the heat of dissociation along with the internal work done during the dilution.

The condition that $dH/dv = a$ is independent of the temperature enables us to find a formula for the relation between the osmotic pressure and the temperature expressed in terms of the thermal constants. A thermodynamic argument shows that the osmotic pressure p satisfies the differential equation

$$\frac{d^2p}{d\theta^2} = -\frac{a}{\theta};$$

and if a is assumed independent of θ we integrate this equation and obtain

$$p = -a\theta(\log\theta - 1) + b\theta + e.$$

The quantities b and e are functions of the volume but are independent of the temperature.

Now by another thermodynamic argument we can deduce the heat of dilution from this value of the osmotic pressure. We obtain

$$l = -a\theta + e$$

as before, in which the function e is that which appears in the expression for the osmotic pressure. This formula can be tested by comparison with the results of experiment. From observations of the depression of the freezing point we can calculate the osmotic pressure for a fixed concentration at 0° C. and using this in connection with the heat of dilution for the same concentration we can determine the constants of the formula. With these we can then calculate the osmotic pressure at 100° C. and compare it with the value found for this quantity from observations of the elevation of the boiling point. I was able to do this with the observations of Kahlenberg on the freezing and boiling points of sodium chloride solutions combined with those of Thomsen on the heat capacities and of myself on the heats of dilution. The agreement of the observed boiling points with those predicted from the formula was excellent. Incidentally this agreement confirms the validity of the assumption from which the formula was derived, that a is independent of the temperature.

Another test of a less searching character can be made by using the osmotic pressures given by the formula at different temperatures to calculate the ratio of the vapor pressure of the solution to that of the pure solvent. According to von Babo's law this ratio should be independent of the temperature. Calculations for sodium chloride solutions show that while it is not strictly the same at all temperatures between 0° and 100° C. yet the differences between ratios at different temperatures are excessively small, and lie within the errors of the observations by which von Babo's law has been tested.

The terms a and e of the formula for the heat of dilution are manifestly not quantities which are fundamentally kinetic in their nature. They express rates of change of energy with change of volume. Their appearance in the formula for the osmotic pressure indicates that the osmotic pressure is not to be explained as a kinetic phenomenon, as the pressure of a gas is, but as the result of forces acting between the solute—its molecules and ions—and the solvent. These thermal relations, therefore, afford strong evidence, and evidence with as little admixture of hypothesis as is possible in the nature of the case, first of the validity of the dissociation hypothesis by which the laws of electrolytic conduction are explained, and secondly, of the dependence of the osmotic pressure on the forces which are exerted between the parts of the solution and the pure solvent.

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NEW MAGNETIC CHARTS OF THE INDIAN OCEAN.

By L. A. BAUER.

(Read April 20, 1912.)

The charts exhibited embody the results of magnetic observations made during the summer and fall of 1911 on board the non-magnetic yacht *Carnegie* operating under my direction as Director of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington.

The necessity of the new charts arose from the exceptionally large errors found in the most recent magnetic charts at present in use by mariners. Thus, for example, the errors in the compass directions for two of the most recent charts approximate respectively four degrees and six degrees, though one of them was issued as recently as 1910. With the exception of a few values found by the vessel, the *Galilee*, used in the Pacific Ocean work, these are the largest errors thus far revealed. In the portions of the Atlantic Ocean thus far covered by the *Carnegie* the compass chart errors have generally been below two degrees, though running at times up to two and a half degrees.

The chart errors in the compass directions are usually found to be systematic, that is, in the same direction for large stretches, and are to be ascribed largely to erroneous secular changes allowed for in attempting to bring previously observed values up to date.

Thus, for example, by comparing the *Carnegie* values of 1911 with those obtained on board the German Antarctic vessel, the *Gauss*, in 1903, it is found that the north end of the compass moved to the eastward (hence diminished west declination) at the average rate of about 11′ per year off the southeast end of Africa, whereas in the vicinity of the islands of St. Paul and New Amsterdam in the Indian Ocean (lat. 35° 16′ S., long. 74° 46′ E.) it moved to the westward (increased west declination) at the average rate of about

13′ per year. The charts give secular changes of only about one fourth of these amounts, so that the error of reduction in but ten years amounts to almost 2°. It is doubtless due to these large secular changes disclosed in the Indian Ocean, and especially their rapid variation with geographic position, that the large errors mentioned have crept into the charts.

The errors in the other magnetic elements, while of less importance to the mariner, are of consequence to theoretical investigations regarding the earth's magnetism. In the magnetic dip, the errors on the present cruise have amounted at times to 4°, and in the horizontal intensity to about one-twentieth part. While some of the results derived from previous analyses of the earth's magnetic field have pointed to the possibility of large and more or less systematic chart errors, it was not suspected that they would reach the magnitude disclosed by the work of the *Galilee* and of the *Carnegie*.

The *Carnegie* is at present making a circumnavigation cruise and is expected back in New York towards the end of 1913, having left the same port in June, 1910. Up to February 1, 1912, this vessel had already covered about fifty thousand miles. She left Manila on March 23, in command of Mr. W. J. Peters, bound for the Fiji Islands.

Owing to the non-magnetic structure of the *Carnegie* and the absence in consequence of any deviation corrections, it is possible to obtain and communicate results expeditiously. The data are promptly transmitted to the chief hydrographic establishments issuing magnetic charts in order to enable them to make the necessary corrections from time to time.

THE DIARY OF A VOYAGE TO THE UNITED STATES, BY MOREAU DE SAINT-MERY.

By STEWART L. MIMS.

(*Read April 18, 1912.*)

In his *Souvenirs intimes sur Talleyrand,* published at Paris in 1870, M. Amédée Pichot remarked in his preface:

"If we were to write a complete biography of Talleyrand, we would be able to give some details, very little known, concerning his exile in America, where M. de Beaumetz and he found themselves with other notable *émigrés* among whom was Moreau de Saint-Méry. . . . This information has been obtained from an unpublished diary, kept by Moreau de Saint-Méry, which M. Margry has examined and from which he has communicated to us certain extracts concerning the sojourn of Talleyrand at New York, Boston and Philadelphia."

Pichot made two quotations from this "unpublished diary," one at pp. 209–212, describing the intimate relations existing between Talleyrand and Moreau, the other at pp. 212–213 giving the text of a letter written by Talleyrand to the French Minister of Foreign Affairs to acknowledge a letter inclosing the decree of September 3, 1795, which reopened the doors of France to the famous exile. Pichot contented himself with these two citations, either because his friend Margry[1] did not choose to give him more material, or because the limitations of his own study did not permit him to quote more extensively from the notes which were actually communicated to him.

Although many studies have appeared on the life of Talleyrand since 1870 and some have made use of Pichot's citations, apparently none, not even such recent biographers as MacCabe, Lacombe and

[1] Pierre Margry, author of "Mémoires et Documents pour servir à l'histoire des origines françaises des pays d'outre-mer" and of some studies relating to the history of French colonization in America, was at this time archivist at the Ministry of the Marine.

Loliée,[2] have attempted to find the source from which the citations were taken to see whether it contained other interesting material upon the sojourn of the great diplomat in America.

It was my good fortune, a little over a year ago, to find in the manuscript catalogue of the *Archives Coloniales* at Paris, the title, "Le Voyage aux Etats-Unis de l'Amérique par Moreau de Saint-Méry pendant les années de 1793 à 1798."

Although it called me far afield from the work in which I was engaged, I could not resist the temptation to cast a furtive glance at the manuscript to see what its interesting title meant. That furtive glance grew into the absorbing task of reading from page to page until I had finished the story which the volume contained—a story all but forgotten and lost for three generations among the dusty archives of the Colonial Office.[3] It is to this story that I wish to direct your attention for a few moments.

With the author of the diary many of you are already acquainted from the paper which one of your members presented before this society at its last annual meeting.[4] Permit me to recall, however, the salient facts in his life.

Born at Fort Royal, Martinique, on January 13, 1750, Médéric-Louis-Elie Moreau de Saint-Méry[5] was of a family which had emigrated from Poitou to settle at Martinique in the seventeenth century and had won a place of prominence by furnishing in succeeding

[2] MacCabe, "Talleyrand, a Biographical Study," London, 1906; Bernard de Lacombe, "La vie intime de Talleyrand," Paris, 1910; Frédéric Loliée. "Talleyrand et la société française," Paris, 1910.

[3] Victor Tantet, late archivist of the *Archives Coloniales,* made use of the diary to write a very interesting article which appeared in *La Revue* (1905), Vol. 52, pp. 378–396, and entitled "Les Réfugiés politiques français en Amérique sous la Convention—Moreau de Saint-Méry libraire à Philadelphie." I knew nothing of the existence of this article until after I had found and studied the diary.

[4] Joseph G. Rosengarten, "Moreau de Saint-Méry and his French Friends in the American Philosophical Society," *Proceedings* of this Society, Vol. 50, pp. 168–182.

[5] This short sketch of Moreau is based on Silvestre, "Notice Biographique sur M. Moreau de Saint-Méry," Paris, 1819 (a short pamphlet of 24 pp.), and Fournier-Pescay's article in *Biographie Universelle* on Moreau de Saint-Méry.

generations many judges to the principal courts of the island. After spending his boyhood days at Martinique, the young Moreau, at the age of nineteen, took ship for France to acquire that training in the principles of the law which would fit him to follow in the footsteps of his fathers.

After his arrival at Paris, he began to study with such rare enthusiasm and success that at the end of fourteen months he sustained his thesis in Latin and received the degree of bachelor of law. At the end of three years he won the honor of attaining the rank of *avocat au parlement* and was prepared to turn his face towards his native island in order to follow his chosen profession.

At his return to Martinique he found himself an orphan, the fortune of the family in ruins and nothing to rely upon, in making a place for himself in the world, except the training which he had just received. The French colony of St. Domingo, the richest of all the West India islands, seemed to offer a more promising future and accordingly he left Martinique and settled at Cap Français (today Cape Haiti) in 1772 to begin the practice of law. After eight years of successful practice, he was elected a member of the *conseil supérieur* of St. Domingo. It was in the discharge of the duties of this office that Moreau began the difficult task of codifying the laws of the island in order that his decision as a judge might be more intelligent and scientific.

The previous attempts which had been made to codify these laws in 1716, 1738 and 1757 had not been successful. The King had commissioned de la Rivière in 1771 to undertake the task, but his work had been slow and discouraging. Hearing that Moreau was engaged in the same work, de la Rivière gracefully gave way to the younger and more competent man. In preparation for his work Moreau visited all parts of St. Domingo, Martinique, Guadeloupe and St. Lucia, thus laying the basis for that larger and later work of preparing his monumental collection of documents, relating to the history of the French West Indies and to be found today in the *Archives Coloniales* at Paris—a collection which has made his name immortal among all students of West India history. He received a commission from Louis XVI. to return to Paris in order to complete and publish the results of his work. From 1784 to 1790 appeared successively the six volumes of his well-known collection of laws, entitled "Loix et Constitutions des Colonies françaises de l'Amérique sous le Vent."

At his return to Paris, Moreau quickly won admission into the intellectual and political life of the capital. He became one of the founders of the Musée de Paris and contributed much to its efficiency. At the outbreak of the revolution in 1789, he became one of its ardent champions. He was chosen as one of the electors of Paris, who at one time virtually ruled over all France. He boasted afterwards during his exile that in serving as their president he was "king of Paris for three days." He was deputy of Martinique in the *Constituante,* and played an important part, especially in matters which related to the administration of the colonies.

But with Robespierre's accession to power and the inauguration of the Reign of Terror in 1793, Moreau was forced to flee from Paris and seek refuge in Normandy. It was only a temporary refuge that he found, however, for Robespierre placed his name upon the fatal list of those for whose blood he thirsted. Gathering up all that he held most precious, among them the manuscripts of some unpublished works, Moreau escaped with his family to Havre, where by good fortune a ship was ready to sail for the new world.

It was therefore in quality of an *émigré* that Moreau de Saint-Méry set out upon a voyage to the United States. He sailed from Havre on November 9, 1793, aboard the *Sophie* (Lowther, Captain) bound for New York. After a long struggle against head winds and frequent storms, lasting for one hundred and nineteen days the vessel was forced to put in at Norfolk, where it cast anchor on March 8, 1794.[6] After a stay of two months at Norfolk, Moreau proceeded by water to Baltimore, passing thence to New York by way of Wilmington, Philadelphia and Princeton. He remained at New York from May 25 to August 21, being forced to earn his living by hard work as shipping clerk for the house of Daniel Merian, which was only a *"prête-nom"* to conceal the shipment of provisions to the French government. During his residence in New York, Moreau

[6] The diary contains a most interesting account of this voyage.

made the acquaintance of a German nobleman, de la Roche by name, with whom he formed a partnership for the establishment at Philadelphia of a stationery and book-store and printing shop. He accordingly removed to Philadelphia, where he remained from October 14, 1794, to August 23, 1798, when he set sail for France.

It is the story of these five years in America that Moreau de Saint-Méry records in his diary. Step by step one may follow him to hear his appreciation of the hospitality of old Virginia or his enthusiasm over the beauty and charm of the Virginia belle, whose musical voice seems to have fired his heart; or to hear him marvel at the number of religious sects at Baltimore, all living in the perfect harmony of an attractive society, or one may turn to the descriptions of the life of New York and Philadelphia. In these descriptions and throughout the diary are to be found many interesting data on the prices, the cost of living, the expenses of travel, the manners and customs of the people. In other passages one may follow the author into the presence of such public men as Washington, John Adams or Alexander Hamilton. Thus under date of August 26, 1794, is recorded a visit to the last named:

> "I went to see the Minister, Hamilton, having a letter of introduction from Talleyrand. On arriving at the building in which his office was located, I found a porter, clad in a long gray vest, who informed me that the minister was not in. On leaving the house and before I had gone very far, I met a gentleman whom I believed, tho' I know not why, to be Hamilton and I turned and followed him. We entered the corridor almost together. On seeing Mr. Hamilton, for it was he, the porter took a key down from a peg and opened the door of the Minister's office and I was asked to enter. I was much pleased that I had been warned not to have the air of being inquisitive or of plying the minister with questions. But he showed great confidence in me by talking frankly of both France and America. . . . I did not fail to be struck by his bureau. Its furniture and furnishings together were not worth more than fifty francs [ten dollars]. A large pine table, covered with a green cloth, served as his desk. His books and papers were upon simple wooden shelves. On the end of one shelf was a slate-colored vase and a plate with some drinking glasses. The porter who waited on him wore, besides the vest of which I have spoken, trousers of the same cloth which did not reach low enough to hide his bare leg. In a word I saw around me what must have been in accord with the customs of the Spartans."

Moreau's later impressions led him to speak of Hamilton as "devoured with the ambition of making people believe that he was the soul of everything" [in the government] and that "the security of the United States depended entirely upon his ability." Again he wrote:

"Hamilton, who knew only America and was unacquainted with Europe except through books, was a lover of a strong centralized government which knew how to command obedience without compromise. Civil war did not frighten him, because he was a man of courage and had natural military ability and believed and in fact was accustomed to say that the United States would never have a real and stable government until internal dissensions had proved its necessity and caused it to be established. . . . He was of small stature, had an admirable composure, very small eyes and had something of the mysterious in his countenance. He spoke French, but very imperfectly. He was a man of much intelligence and kept a close watch upon himself. He was very brave, disregarded personal interests in his public service, was an admirer of the laws and of the government and financial system of England. He was very dictatorial and was very jealous of the prerogatives of the executive power."

Besides these interesting features, the diary has another of perhaps greater value, namely, some remarkable passages which describe the group of French *émigrés* at Philadelphia and the intimate relations existing between some of the chief among them.

It has already been noted that Moreau de Saint-Méry established a book-store and printing press at Philadelphia. His house was located at the corner of Front and Walnut streets. From the catalogue which he published at the beginning of his career as bookseller,[7] it can be seen that his store offered for sale many books printed in English, Dutch, Italian, Spanish and French—a fact which must have attracted not only cultured Philadelphians, but also the French *émigrés* in the city. His store became in fact the rendezvous of many notable exiles from France. Talleyrand, de Noailles, Talon, de Beaumetz, Demeunier, La Colombe, La Rochefoucauld, duc de Liancourt, and the duc d'Orléans (the future Louis Philippe) were all visitors at the shop of Moreau. Some of them, including Talleyrand, Blacon and de Beaumetz, frequently remained for supper and like boys scuffled and played pranks upon one another about the store.

In regard to Talleyrand the most notable of the many *émigrés*

[7] A copy of this catalogue is still to be found in the library of the American Philosophical Society.

who found a temporary refuge in "the ark of Noah," as Philadelphia was happily called by one of them, the diary contains some important data. Moreau's first meeting with Talleyrand in America is recorded under the date of May 22:

"After the end of the session of Congress, I was on my way with my two companions [Goynard and his son] to see the executive mansion which was in the course of construction, . . . when I noticed that in a stage which approached rapidly there were two men waving their hands at us. . . . One of them jumped to the ground and ran to throw himself in my arms. It was Beaumetz. The other, less agile, climbed down from the stage. It proved to be Talleyrand. Both of them had just arrived from England. What joy! What happiness! How many repeated embraces! . . . They invited me to dine with them. I went at once to break the good news to my home and then rejoined them. What a glorious dinner it was! How many things we had to tell one another after two years of separation! After dinner we all went to see Blacon, the comte de Noailles and Talon. New surprises and new rejoicings! During our reunion a hail and thunder storm raged outside as though heaven wished to recall to our minds the misfortunes from which we had escaped in our own country."

From this date forward it is easy to trace in the diary the intimate relations which were established between Moreau and Talleyrand. Here is an entry to tell us that they have dined together, there, another to describe an evening together, or yet another to describe a little group with Talleyrand in their midst to listen to Moreau read from the yet unpublished manuscript of "La Danse" or of his description of St. Domingo. When the two were separated, the diary indicates a constant exchange of notes and of letters. In regard to this, it may be interesting to note in passing, the diary contains no less than seventeen notes and letters from the hand of Talleyrand to his "*cher maître*," as he came to call Moreau in affectionate terms. When Talleyrand was at Philadelphia their relations became most intimate. Moreau's own words must tell the story:

"No words could express adequately the nature of my liaison with Talleyrand. Every day, after his return to Philadelphia in the month of October, 1795 to June 11, 1796 [the date of Talleyrand's departure for Europe], he came to my office at eight in the evening. There alone (except when Beaumetz, Talon, Blacon, de Noailles, Volney or some others came also) we opened our hearts to one another and shared one another's deepest feelings. We told our most intimate secrets. Thus we passed our time together in delightful communion until supper was announced. Talleyrand ordinarily did not sup, while I ate some rice cooked with milk on the stove in my store. . . . I had some excellent Madeira which Talleyrand liked very much. . . . How many times, after the late hour had dispersed the rest of the company, did Talleyrand go with them across the little court-yard and then steal back to prolong the evening with me. He yielded finally when my wife came and said to him: 'Tomorrow you will stay lazily in your bed until noon, whereas your friend must be up and open his shop at seven.' . . . Thus we passed every evening together without missing a single one, in talking of the past, of the present and of the future of our country. In connection with the future we talked of Louisiana and of plans to colonize it for ourselves. Sometimes we talked seriously of the matter and Talleyrand concluded that we must become the governors.

"In this plan, as well as in others which we made to remain together, Talleyrand and I closed our talks together, our hands clasped in a pledge that for the rest of our lives we would share with one another our failures and our successes even in money matters. . . . In a word never did the common expression, 'united as two fingers of the same hand,' describe so accurately the liaison between two persons as that between Talleyrand and myself."

At his departure for Europe on June 11, 1796, Talleyrand took with him some two hundred copies of Moreau's "La description de la partie espagnole de St. Domingue" to find sale for them at Hamburg and in France. He offered to take Moreau's son with him back to Paris and to provide for his education. After his return to Europe Talleyrand did not forget the friend of his days of exile, for the diary contains letters written in affectionate terms from Hamburg and Paris. It was in fact through Talleyrand that Moreau was permitted to return to France and by Talleyrand's pecuniary aid that he was able to take his family from Bordeaux to the capital. It was due to Talleyrand's influence that Moreau obtained shortly afterwards the position of historiographer at the Ministry of the Marine.

The diary closes at a date shortly after Moreau's return to Paris and we are left to conjecture as to what were the relations of the two friends in later life. It seems, however, perfectly plausible to suppose that the appointment of Moreau as ambassodar at Parma in 1801 (later to become and remain its regent until his disgrace by Napoleon in 1806) was the result of Talleyrand's influence exerted in his behalf.

It is pleasant to dwell upon these pages of the diary, because they throw a pleasing light upon Talleyrand's character. He is generally thought of as the prince of diplomats, employing human speech to conceal his own thoughts, but here we have him unveiling his very soul to a kind and sympathetic friend.

The diary shows, however, that Moreau de Saint-Méry's shop became something more than the rendezvous for such notable *émigrés.* From his printing press went forth many notable works published in French, such as de Liancourt's study on the prisons of Philadelphia, and three of his own notable works, "La Danse," "La déscription de la partie espagnole de St. Domingue" and "La déscription de la parte française de St. Domingue."[8] At his press also was published from October 15, 1795, to March 14, 1796, a daily newspaper in French entitled *Courrier de la France et des Colonies,*[9] edited by Gaterau, an *émigré* from St. Domingo. In its pages were printed the latest news of the great revolution in France and of the most recent developments in the French West Indies. How eagerly the numerous *émigrés* then at Philadelphia and in other cities must have read it! It must have come as a messenger to them in their exile. It served also as a social organ for them, for it contained notices of balls and concerts and meetings of French societies. Moreau's press, therefore, in publishing such a paper must have occupied an important place in the lives of the wider circle of French exiles in Philadelphia. The diary contains passages which throw light upon the life of this wider circle and reveal something of its numbers and of its importance.

There is to be found in the diary, therefore, a wide range of material, varying from passing comments upon public men and upon the customs of the people to serious studies upon the history and life of some of the chief American cities, and including some new and most interesting material upon the life of many exiles who fled from persecutions in France and revolts in the West Indies to find refuge in our fair land of liberty and freedom.

[8] These three works appeared at Philadelphia during the years 1795–1798.

[9] A complete file of this unique publication is to be found in the library of the Athenæum at Boston. It appeared in a single sheet, 4 pages, each page measuring 24½ c.c. by 20 c.c.

In closing, I should like to express my thanks for this opportunity of calling the attention of the American Philosophical Society to this unpublished diary of one of its former members,[10] who must have spent, as indeed its proceedings show, many delightful evenings in its halls and who with pride placed after his name upon the title pages of his well-known works "Member of the American Philosophical Society."

When he sailed upon the voyage which was to take him back to the country and to the people he loved, Moreau de Saint-Méry must have left in this society many friends who thoroughly appreciated his great talents and who had been attracted by his interesting personality. It is fortunate that such a man left for us a record of his sojourn in America and that it is possible to rescue it from the dust of archives.[11]

[10] Moreau was elected to the society on January 16, 1789, before he left France. The records show that he attended its meetings regularly after his arrival in Philadelphia in the fall of 1794.

[11] The diary will be published in the near future at the Yale University Press.

THE CLASSIFICATION OF CARBON COMPOUNDS.

By MARSTON TAYLOR BOGERT.

(Read April 20, 1912.)

The system of classification adopted for a science at any given period registers quite accurately the state of the science at that period, and the changes in the classification therefore record its progress. It is, hence, practically impossible to give any intelligible description of the various methods of classification which have been employed for carbon compounds without at the same time sketching briefly the changing conceptions and theories of which they were to so large an extent the natural reflection, for without such a setting the picture would have no proper background or perspective.

The classifications which are considered are particularly those which have been used for textbook instruction in organic chemistry, and no place is given to those which have been devised solely for the patent offices, for reference, or for other special purposes.

Man being naturally of an inquiring mind, he has probably speculated upon the composition of this world of ours ever since he first appeared upon it, for in the oldest records we find theories concerning the elements of which it is composed.

The doctrine of the four so-called "elements"—earth, air, fire and water—was first enunciated in Greece by Empedocles, about 440 B. C., but generally bears the name of Aristotle. Neither Empedocles nor Aristotle regarded these elements as different forms of matter, but rather as different properties or manifestations of one original matter. Aristotle also added a fifth element, **οὐσία,** to which he ascribed an ethereal or immaterial character and which he assumed permeated the universe. As the oldest writings of India contain a similar theory of four elementary principles and an ethereal substance, it is possible that both Aristotle and Empedocles were familiar with this fact and were only introducing into Greece this ancient Indian theory.

The oldest nations were familiar with the metals and refer to them frequently in their writings, but it should not be forgotten that some of the earliest chemical facts on record have to do with carbon compounds. The only acid known to the ancients was acetic (as vinegar), so that the name of this substance and the idea of acidity were expressed by closely related words; in the Greek, ὄξος for vinegar, and ὀξύς for acid; in the Latin, acetus and acidus. The first reagent of any kind mentioned was the extract of gall nuts, which Pliny says the ancients used to detect the presence of green vitriol in verdigris. The first salts artificially prepared were those obtained by the action of vinegar upon alkalies. The first crude attempts at distillation were with turpentine. The ancients were familiar also with fats, resins, organic coloring matters (like indigo and Tyrian purple), sugar, gums, the preparation of wine from grape juice, of beer from malted grain, of mead from honey, of soap from fats, and many other facts in these and related fields. Organic chemistry, therefore, does not give place in point of age to inorganic. Largely due to the influence of Alchemy, however, the object of which was the transmutation of baser metals into silver and gold, the mineral side of the subject was the first to be extensively developed.

According to the pseudo-Geber, all metals consisted of sulfur and mercury, in varying amounts and in different degrees of purity. The old Aristotelian "elements" he appears to have regarded as subsidiary constituents, or perhaps as the ultimate components of the sulfur and mercury. To the pseudo-Geber's two elements, Basil Valentine added a third, "salt," not meaning any particular compound but the properties characteristic of common sodium chloride, and he assumed these three to be the elementary constituents not only of metallic substances but of organic as well; sulfur endowing the substance with combustibility, or the property of changing in the fire, and also explaining color changes, mercury giving metallic properties and volatility, and salt representing the principle of solidification and of resistance to fire.

In spite of the great amount of experimental work carried out by the alchemists, and the large number of new facts discovered by them, their writings were so obscured by mysticism, exaggeration and deceit, that little real progress was made toward a more accurate understanding of the nature of chemical compounds which might be utilized in constructing a more satisfactory method of classification. No attempts were made to determine the actual constituents of compounds, for it was assumed that in the formation of a compound the original substances were annihilated and an entirely new substance created. Hence the only classification in vogue was a rough grouping of substances according to their physical properties, or apparent outward resemblance, and many of our common names are reminders of this bygone empirical method. Thus, olive oil and other vegetable and animal oils were grouped with oil of vitriol and oleum tartari (deliquesced potassium carbonate); spirit of wine (alcohol) with fuming spirit of Libavius (stannic chloride), spirit of hartshorn (ammonium hydroxide solution) and spirit of nitre (nitric acid); butter with butter of antimony (antimony trichloride) and other semi-solid metallic chlorides. Colorless solids, soluble in water and of characteristic well marked taste, were all classed as "salts," and this group thus included sugar.

The goal toward which the alchemists strove was the philosopher's stone, the grand elixir or the magisterium, as it was variously called, whose virtues were such that it could not only transmute baser metals into silver and gold, but could also prolong life indefinitely. As the claims concerning the transmutation of metals were increasingly discredited and the trickery and deception of the alchemists exposed, more investigators directed their attention toward the second great function of the philosopher's stone, the prolongation of life, and many compounds were discovered of considerable therapeutic value. Great interest was aroused by these investigations, and Paracelsus finally announced that "the object of chemistry is not to make gold but to prepare medicines." Thus, in the first half of the sixteenth century, chemistry began to develop in a new direction, at first not far removed from alchemy, but gradually diverging from it more and more widely, and approaching closer and closer to medicine, until the coalescence of the two sciences appeared practically complete. And thus arose the period of iatro chemistry, when chemistry, which had long been looked upon as a valuable helpmeet to medicine, came to be regarded as the basis of the entire medical art.

Although in this period the chief development was again along the mineral side, probably because of the relatively greater simplicity and stability of these preparations, still no little organic investigation was conducted and a number of new compounds were added to the science. Little progress was made in gaining a truer insight into the character of chemical compounds, and hence no important changes in classification appear. Paracelsus himself, the founder of the iatro-chemical school, adopted Basil Valentine's three elements (sulfur, mercury and salt) as the basis of his doctrines.

By the middle of the seventeenth century, chemistry awakened to the fact that it had a destiny of its own to realize, struggled to its feet and, refusing longer to be supported by other sciences, started forward, to be sure rather unsteadily and uncertainly at first, but with the firm determination to do something for itself.

The history of chemistry proper begins with Robert Boyle about 1660, who taught that its main object was the determination of the composition of matter. Through his labors, and those of Rouelle and others, the terms "element" and "chemical compound" were more fully explained and appreciated; nevertheless many of their colleagues still adhered to the old alchemical or even the Aristotelian elements. Kopp, in his "Geschichte der Chemie," gives an excellent picture of the epoch-marking effect of Boyle's ideas:

"What a contrast is exhibited between the ancient idea of the cause of difference in various forms of matter and that which obtained at the time of Boyle! If we consider these two opposite conceptions historically, and the transition from the one to the other, they appear like two totally dissimilar pictures; but, like dissolving views, changing the one into the other by slow degrees. In the first place we have the Aristotelian idea, according to which, matter itself devoid of properties, becomes endowed with characteristic qualities by the addition of properties, and forms, when invested with these properties, the various substances known in nature; then this idea passes gradually into that of the alchemists, but becomes confused in the transition, inasmuch as the differences of physical condition and properties are no longer regarded as the only causes of varieties in substances; the difference in chemical properties receives more attention, the existence of elements, the producers of such properties is assumed; and thus the path is prepared which leads to the idea of chemical composition. Then we see the Aristotelian theory gradually becoming indistinct, whilst the idea of the importance of the chemical deportment and composition of bodies assumes prominence, and at last we see clearly that the differences between the substances which nature presents to us in such overpowering numbers, or which we have ourselves formed artificially, depend upon differences in their chemical composition. The idea of chemical composition, which makes its first appearance indistinctly in the history of the chemistry of the Middle Ages, now forms the foundation of the science."

The most important and interesting problem at this time, and the one upon which most attention was focused, was the chemistry of combustion. Attempts to explain the phenomena of combustion finally led to the phlogiston theory of Stahl, which dominated the science from the end of the seventeenth through the eighteenth century.

In 1675, Nicolas Léméry published his "Cours de Chimie," which soon became one of the most popular textbooks of the time and passed through thirteen editions during its author's lifetime. In it he divided all natural substances into mineral, vegetable, and animal; including in the second group plants, resins, gums, fungi, fruits, acids, juices, flowers, mosses, manna and honey; and under the third heading describing the various parts of animal bodies. This classification was quite generally adopted, and thus arose a distinct separation of mineral chemistry from the chemistry of substances occurring in plants and animals. The phlogistonists had previously opposed any such subdivision, contending that the differences observed depended upon a variation in the composition of the bodies classed under the three heads. So Becher, in 1669, argued that the same elements occur in the three natural kingdoms, but that they are combined in a simpler manner in mineral substances than in vegetable or animal. Stahl, in 1702, asserted that in vegetable as well as in animal substances the watery and combustible principles predominated, and that these ultimate constituents made their appearance when the organic compound was heated out of contact with air, water and combustible charcoal being formed. These ideas were successfully combated by Boyle, who had shown, as early as 1661, in his "Sceptical Chymist," that the application of heat leads to quite different results depending upon whether air is present or not, and that the various residues thus obtained are unlike.

Many organic substances were discovered during this phlogiston period, but their real composition (even qualitative) remained unrecognized. For example, it was assumed that the ultimate constituents of alcohol were oil and water, or a combustible and a mercurial principle. By far the greater number of the investigations recorded were still in the inorganic field, probably for reasons already given, and also because it had not as yet been possible to prepare organic compounds synthetically. While, as has been said, many authors adopted Léméry's method of separating mineral, vegetable and animal substances, others still adhered to the old system of grouping together all acids (sulfuric with lactic, tartaric, etc.), all salts, etc.

Boyle's influence was soon effective in directing a closer scrutiny of the composition of compounds, and gradually the true elements were isolated and studied.

The discovery of the composition of carbonic acid gas by Lavoisier in 1775, and that of water by Cavendish, showed the presence of carbon and hydrogen in alcohol (1784). Lavoisier, having established the true principle upon which combustion depends, analyzed various organic substances and came to the conclusion that vegetable substances were composed generally of carbon, hydrogen and oxygen, while animal substances contained also nitrogen and occasionally phosphorus. He did not distinguish organic chemistry as a special branch of the science, or define it as "the chemistry of the compound radicals." He discussed all acids together, subdividing them into mineral, vegetable and animal.

Macquer, who was professor of medicine in the University of Paris, and a contemporary of Lavoisier, in his "Elements of the Theory and Practise of Chymistry" (English translation of 1775) discusses mineral, vegetable and animal oils together, and in the separate sections of his work devoted to vegetable and animal chemistry divides the subject according to the method of treatment employed to obtain the substance rather than according to the character of the substance itself. Thus we have as the main headings, "Operations on unfermented vegetables," "Operations on fermented vegetable substances," and "Operations on animal substances."

Fourcroy (about 1790), however, in his well-known text-book, makes a clean-cut division, placing the vegetable acids in the section dealing with the vegetable kingdom, and the animal products all under the animal kingdom.

It should be noted that at this time carbon was supposed to exist as such in plants and animals. So Chaptal, in 1791, says:

> "Carbone exists ready formed in vegetables. It may be cleared of all the volatile and oily principles by distillation, and, by subsequent washing in pure water, it may be deprived of all the salts which are mixed and confounded with it."

In Thomson's "System of Chemistry'" (third edition, 1807), marsh gas and olefiant gas are discussed with the element carbon, but the other carbon compounds are scattered under various headings where they are mixed in with inorganic substances.

In the text-books and treatises on chemistry at this period it was customary to combine mineralogy and geology with the mineral part, botany with the vegetable section, and physiology with the portion dealing with animal chemistry, while occasionally physics received as much space as chemistry in the introductory chapters.

The ætherin theory of Dumas and Boullay, propounded by them in 1815, and later adopted by Berzelius, was an adaptation of the early theories concerning the composition of organic compounds (by which they were supposed to consist of an aqueous and a combustible principle) to new conditions. In their theory, many derivatives of alcohol were regarded as compounds of C_2H_4 (to which Berzelius had given the name "ætherin"), in the same way that ammonium salts are derived from NH_3:

$$C_2H_4 \cdot HCl = NH_3 \cdot HCl,$$

$$C_2H_4 \cdot H_2O(\text{alcohol}) = NH_3 \cdot H_2O,$$

$$C_2H_4 \cdot H_2SO_4 = NH_3 \cdot H_2SO_4,$$

$$(C_2H_4)_2H_2O(\text{ether}) = (NH_3)_2H_2O(?).$$

The attempt was made to apply this system of classification to other derivatives of alcohol and even to extend it to all organic compounds; but it never won any widespread recognition.

Berzelius, in 1817, explained the difference between inorganic and organic compounds by stating that every oxidized inorganic compound contained a simple radical, while organic compounds consisted of oxides of compound radicals; and that in vegetable substances the radical usually consisted of carbon and hydrogen, while in animal substances it consisted of carbon, hydrogen and nitrogen. He therefore defined organic chemistry as "the chemistry of the compound radicals" (1843). His conception of the structure of organic compounds was a dualistic electro-chemical one, in which the organic radicals played the same rôle as the elements in inorganic compounds; thus, both electro-positive and electro-negative radicals were assumed.

Gmelin, in the first edition of his great "Handbook" (1817), says that a clear distinction should be made between inorganic and organic chemistry, but that this is a distinction which can be more readily felt than strictly defined. He describes inorganic compounds as binary compounds, the simplest consisting of compounds of two elements, a basic oxide or an acid oxide, which can again unite to form a binary compound of a higher order, *i. e.,* a salt. Organic substances, on the other hand, are at least ternary compounds, or are composed of three simple substances, generally united in less simple ratio than in inorganic. Hence, he includes in the inorganic portion of his book methane, ethylene, cyanogen, and the like. He adds, further, that organic compounds cannot, like the inorganic, be artificially built up from their elements.

Berzelius also supported the last statement, claiming that in living structures the elements obeyed totally different laws from those which regulate their behavior in the inanimate world. Organic bodies were thus regarded as the special products of a mysterious vital force and, although he admitted that bodies occurring in nature might be converted into other organic compounds by chemical reactions, he maintained that none could ever be built up from their elements. Consequently, Wöhler's production of urea from ammonium cyanate in 1827, being an incomplete synthesis, did not immediately overthrow the vitalistic doctrine. Then too, this synthesis remained for some time the only case of the kind, and urea itself was regarded as standing halfway between inorganic and organic compounds, because of the ease with which it decomposed into carbon dioxide and ammonia.

As the result of the classic researches of Liebig and Wöhler, in 1832, upon the radical of benzoic acid, the radical theory was enlarged by both Berzelius and Liebig.

Dumas, in 1837, explained the origin of so large a number of organic compounds from so small a number of elements, by stating that the latter unite to various radicals, which occasionally act as chlorine or oxygen, and occasionally as a metal. Cyanogen, ethyl, benzoyl, etc., were therefore said to constitute the elementary bodies of organic chemistry, their elementary components only being recognized when the organic nature of the compound was entirely destroyed. It is easy to see therefore why the search for these organic radicals was vested with such interest. In fact, the discovery and isolation of these radicals became the most interesting problem of the day and led to many valuable results.

In the text-books of this date, we find practically all organic compounds grouped under the two headings of Vegetable and Animal Chemistry; very few organic substances remained in the Inorganic part. An ever increasing number of these compounds found place in the separate chapters on Carbon and its Derivatives. Thus, in the manual compiled by Webster in 1826, when lecturer in chemistry at Harvard University, we find, in addition to CO, CO_2, and other simple compounds previously discussed with carbon, also the chlorides of carbon, cyanogen, cyanogen halides, HCN, thiocyanic acid, CS_2 and thiocarbonates; in Dumas' great "Traité de Chimie" (1828) also rose oil, naphthalene, sweet oil of wine, naphtha, petroleum, turpentine, cyanic and fulminic acids. In most cases, the acids, being most important, were the first to be considered under the heading Vegetable Chemistry, then followed the other groups—oils (fatty and volatile), carbohydrates, camphors, alkaloids, etc., the rapid increase in the knowledge of organic compounds being exhibited in the closer and more logical classification within the groups. The term "organic chemistry," to include both vegetable and animal chemistry, used by Berzelius in his "Handbook," was quite generally adopted.

In 1836, Laurent advanced his nucleus theory which, although never generally accepted, was used by Gmelin in his "Handbook," with certain alterations, as a foundation for a classification of organic compounds. According to this theory, every organic compound contains a group of atoms termed a "nucleus" or "germ." Primary nuclei consist of carbon and hydrogen, and in these the hydrogen may be replaced by other elements or groups of elements, thus giving rise to derived or secondary nuclei, analogous in composition and chemical properties to the primary nuclei. Other atoms may be attached to this nucleus, or they may quite surround it, and when these are removed the primary nucleus reappears.

In 1839, Dumas developed his substitution theory to a theory of chemical types. An advance was made in the replacement of the dualistic formulas by unitary ones.

Gerhardt's residue theory appeared at about this time. It may well be explained in comparison with the older radical theory. According to the latter, ethyl nitrate, for example, was regarded as the nitrate of ethyl oxide, $(C_2H_5)_2O \cdot N_2O_5$; while, according to Gerhardt, the combination of the nitric acid and alcohol occurs in such a manner that one compound gives up a hydrogen and the other a hydroxyl, forming water, the two "residues" then uniting to ethyl nitrate.

The discovery of the compound ammonias by Wurtz (1849) and Hofmann led to the arrangement of organic compounds on types of various simple inorganic bodies. For example, it was assumed that the hydrogen in ammonia not only could be replaced atom for atom by other elements, but also by compound radicals.

Gerhardt's type theory was really a combination of his residue theory with the older radical theory. His four fundamental types were hydrogen, hydrochloric acid, water and ammonia; H—H, H—Cl, H—O—H, $N \begin{cases} H \\ H \\ H \end{cases}$, to which Kekulé subsequently added methane, CH_4. These proving insufficient, multiple and mixed types were invented.

So early as 1838, Gerhardt had called attention to the fact that by the action of sulfuric acid upon various substances compounds were produced in which the characteristic properties of the constituents were not present. To distinguish such, he coined the term "copulated compounds." His original views were considerably enlarged and modified by Berzelius. According to this point of view, many radicals were assumed to be composed of several simpler ones. Thus, the fact that many monobasic acids (written on the water type) could frequently be decomposed with liberation of the CO group as CO_2, together with the alcohol radical, caused the acid radicals to be looked upon as made up of CO and an alcohol radical, $CH_3 \cdot CO—O—H$, instead of $C_2H_3O—O—H$, and paved the way for the modern structural formulas.

It was Williamson who showed that the existence of compound radicals could be assumed just as well for inorganic as for organic compounds, and that organic chemistry could no longer be correctly designated as "the chemistry of the compound radicals."

With the discovery of substances common to both plants and animals, the subdivision of organic chemistry into vegetable and animal chemistry was quite generally abandoned.

Gmelin says in his "Handbook" (Vol. VII., pp. 4 and 5):

> "Carbon is the only element which is essential to organic compounds; every one of the other elements may be absent from particular compounds, but no compound which in all its relations deserves the name "organic" is destitute of carbon. . . . If we were to regard as organic those carbon compounds which have been classed hitherto among inorganic substances, namely carbonic oxide, carbonic acid, sulfide of carbon, phosgene, cast iron, etc., we might define organic compounds simply as 'the compounds of carbon'; but organic compounds are still further distinguished by containing more than one atom of carbon. . . . Hence the term 'organic compounds' includes all primary compounds containing more than one atom of carbon."

This last qualification was unfortunate, for it was soon shown that the atomic weight of carbon was 12, instead of 6, and that, therefore, methyl alcohol and formic acid contained only one atom of carbon and would be excluded from organic compounds by the above definition.

Kane, several years before (about 1840), had exposed himself to no such difficulty. In his "Elements of Chemistry" he discussed all organic compounds as carbon derivatives and prefaced this chapter with the following remarks:

"The element which is peculiarly organic and which, with the one exception of ammonia, exists in all bodies derived from an animal or vegetable source, is carbon. It is hence that I have deferred the description of carbon and its compounds until I could pass directly from it to the great variety of organic bodies of which it is the basis. With the constituents of inorganic bodies it has but an accidental connection; for, as I shall hereafter show, there is no form of carbon which has not at some time made part of an organized being."

In the great "Handwörterbuch" of Liebig, Poggendorff and Wöhler (1851), we find the following:

"Since, however, a natural boundary between organic and inorganic compounds in general does not exist, and can no longer be assumed, since we know that both are subject to the same combining laws, and since, therefore, if a separation is desired, an artificial and arbitrary boundary line must be drawn, it appears simplest to designate organic chemistry directly as 'the chemistry of the carbon compounds,' and only a few, namely the simplest carbon compounds—CO_2, CO, $COCl_2$, CS_2 and carbamic acid—are more conveniently referred to inorganic chemistry."

Kekulé later (1866) expressed himself in similar vein. He says:

"We must come to the conclusion that the chemical compounds of the vegetable and animal kingdoms contain the same elements as those of inanimate nature. We know that in both cases the same laws of combination hold good, and hence that no differences exist between organic and inorganic compounds either in their component materials, in the forces which hold these materials together, or in the number or mode of grouping of their atoms. . . . If, however, for the sake of perspicuity, a line of demarcation is to be drawn, we must remember that this boundary is an empirical rather than a natural one and may be traced at any point which seems most desirable. If we wish to express by 'organic chemistry' that which is usually considered under the name, we shall do best to include all carbon compounds. We, therefore, define organic chemistry as 'the chemistry of the carbon compounds,' and we do not set up any opposition between inorganic and organic bodies. That to which the old name of organic chemistry has been given, and which we express by the more distinctive term of the chemistry of the carbon compounds, is merely a special portion of pure chemistry, considered apart from the other portion only because the large number and the peculiar importance of the carbon compounds renders their special consideration necessary."

This change in the significance of the term "organic" chemistry marks the passing of the old Vitalistic doctrine, and before we lose sight of it altogether, it may not be amiss to quote some interesting passages from Meldola's recent work on the "Chemical Synthesis of Vital Products." He says, among other things, that while it is quite true that we can produce in the laboratory substances identical with those formed in the living organism, in the majority of cases we cannot maintain that the syntheses are identical in their mechanism, and those who would "explain" the biochemical processes by a simple chemical equation should bear in mind the fact that "the sign connecting the two sides of the equation stands for the whole unexplored region of biochemical transmutations." We lack exact knowledge of the nature of the synthetic processes going on in the living organism, and there is little reason for believing that they have much analogy with our laboratory methods. In fact, we cannot duplicate in the laboratory the most fundamental of all these syntheses—the photosynthesis accomplished by plants, in which carbon dioxide is absorbed by an organic compound and the product decomposed with liberation of oxygen. While the author does not at all array himself on the side of the vitalists, he concludes, from the summary of experimental results recorded in his book,

"that the testimony of pure chemistry cannot, as it stands at present (*i. e.*, about 1904), be legitimately interpreted into a direct negation of Vitalism in any form. This negation may, and probably will be made possible in the future, when our chemical methods have been made to approximate more closely to the vital methods."

Until about the year 1830, it was supposed that the same element could present itself in only one form, endowed with one invariable set of properties, and that from the combination of the same elements in the same proportions, only one and the same substance could possibly result. The discovery of isomeric compounds, consequently, led to a more careful search for the cause of the difference in the properties of substances with the same percentage composition. With the establishment of the correct relations of atom, molecule and equivalent, the way was opened for the valence hypothesis, and in 1858 Kekulé said:

"I do not regard it as the chief aim of our time to detect atomic groups which, owing to certain properties, may be considered radicals, and thus to include the compounds under certain types, which in this way have scarcely any other significance than that of type or example formulas. I am rather of the opinion that the generalization should be extended to the constitution of the radicals themselves, to the determination of the relation of the elements among themselves, and thus to deduce from the nature of the elements both the nature of the radicals and that of their compounds."

The recognition of the quadrivalence of carbon atoms and their power of uniting with each other, accounted for the existence and combining value of radicals, as well as for their constitution. The type theory therefore found a broader generalization and amplification in the extension of the valence hypothesis of Kekulé and Couper to the derivatives of carbon.

While in years gone by, as has been said, the classification of carbon compounds was mainly or exclusively according to the source from which they were obtained, in modern times the classification has been based solely upon their structural relations and entirely independent of their origin.

One of the first to adopt this method of classification was Löwig, in 1840. Gmelin, in 1848, arranged carbon compounds in his "Handbook" according to the number of carbon atoms they contained, and subdivided them on lines similar to those suggested in Laurent's nucleus theory, as already mentioned.

Schiel, in 1842, remarked upon the fact that alcohol radicals form a simple and regularly graded series of bodies, of which the properties as well as the composition exhibit corresponding regular gradations, and he predicted the existence of other similar series. Shortly afterward, Dumas pointed out that the fatty acids constitute such a series. Gerhardt, in his "Précis de Chimie Organique" (1844), collected a large number of such groups, gave to them the name "homologous series," and distributed them under the general divisions suggested by his type theory. This recognition of homologous series as the units in classifying organic compounds was a great step in advance, simplified the classification enormously, and was very fruitful in stimulating investigation to discover other similar series.

The terms "fatty" and "aromatic" chemistry appeared about 1858. At first used in more restricted sense, they were gradually extended until the former covered all acyclic compounds and the latter nearly all cyclic. This subdivision of organic chemistry has been generally adopted (with few exceptions) ever since. More recently, it has been found advisable, particularly in the larger text-books, to split up aromatic chemistry into carbocyclic and heterocyclic. So that we now have the three classes, fatty (or aliphatic), carbocyclic (or isocarbocyclic), and heterocyclic. And yet this classification is no longer satisfactory, for there is no sharp dividing line between straight-chain and cyclic compounds, the one merging gradually into the other. Certain cyclic structures (as the ethylene oxides, lactones, lactames, imides, etc.) are invariably discussed under fatty chemistry, and certain straight-chain compounds (like the olefin terpenes and their derivatives) are generally taken up under aromatic chemistry, while the alicyclic compounds, as their name indicates, form the natural transition from aliphatic to cyclic structures.

With the filling in of the gaps heretofore existing between aliphatic and aromatic chemistry, the time seems appropriate for a change in our classification of carbon compounds which shall recognize the essential unity of the subject, and no longer give the impression that organic chemistry is composed of three varieties of chemistry—fatty, carbocyclic and heterocyclic.

The method which appeals particularly to the writer, and which he has followed with his classes at Columbia University for the past ten years, is to begin with the hydrocarbons, as the simplest carbon compounds, and discuss in succession the various series of hydrocarbons, saturated and unsaturated, acyclic and cyclic, before passing on to the next group. After a careful consideration of these fundamentally important compounds, other classes of carbon compounds are taken up in similar manner; all of the simple halogen derivatives being considered together, all the nitro bodies, all the alcohols, and so on. All other classes are very conveniently regarded as derivatives of the hydrocarbons. With a knowledge of the properties of the various series of hydrocarbons, the study of their derivatives then resolves itself chiefly into the following questions: (1) What are the characteristic properties of the group under consideration (be it halogen, amino, carboxyl, or any other group)? (2) In what manner are its properties influenced by the hydrocarbon nucleus to which it is attached, and by the other groups present? (3) How are the properties of the entire molecule likely to be affected by the introduction of such an element or group? To take a single case, by way of illustration, the simple hydroxyl derivatives of the hydrocarbons are numerous and important, and certain well defined characteristics cling to the hydroxyl group irrespective of the particular hydrocarbon nucleus to which it is attached. Thus, its hydrogen may be replaced by metals (giving alcoholates or phenolates), by hydrocarbon radicles (giving ethers), by acid radicals (giving esters), or the entire hydroxyl may be replaced by a halogen by acting upon it with a phosphorus halide. That the behavior of this hydroxyl group is influenced, however, by the hydrocarbon nucleus to which it is attached, can be seen at once by comparing a phenol with an alcohol. Further, the presence of the hydroxyl group alters the properties of the entire molecule, as appears immediately when we compare the behavior of benzene and of phenol towards bromine, nitric acid, oxidizing agents, and so forth.

In this way, the characteristic properties of the different substituents may be firmly fixed in the mind, as well as the general nature of the various classes of organic compounds, and the student learns to associate certain chemical reactions with certain chemical structures, and to reason intelligently from a given structural formula as to the chemical behavior of the substance, whether he ever heard of the compound before or not, thus learning not only to deduce correct constitutional formulas, but also to grasp at a glance the chemical properties summarized by such formulas.

This method of classification saves an immense amount of repetition and brings home very clearly the fundamental properties and relationships of organic compounds, as well as the application of these properties in analytical and industrial chemistry. Another advantage which follows from this arrangement, is the manner in which it lends itself to laboratory illustration. As all compounds containing the same substituting element or group are discussed together, examples for laboratory practice may be drawn from either the acyclic or the cyclic field.

The author claims no originality for this suggested classification, except so far as certain details are concerned, for it was recommended and adopted so long ago as 1864 by that distinguished Russian chemist, Butlerow, in his "Lehrbuch der organischen Chemie," and has won adherents in this country in Professors W. A. Noyes, Kremers, and possibly others. My reasons for presenting it at the present time are the evident need for some change in our present system, brought into the foreground by the approaching publication of the new edition of Beilstein's monumental "Handbuch der organischen Chemie" and the creation of national commissions on the nomenclature of organic compounds, and my firm belief, as the result of experience, that the adoption of such a system will aid in inspiring and stimulating greater interest in the study of organic chemistry.

Columbia University, New York, N. Y.,
Organic Laboratory,
April 15, 1912.

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PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA

FOR PROMOTING USEFUL KNOWLEDGE

VOL. LI AUGUST–SEPTEMBER, 1912 NO. 206

THE HENRY M. PHILLIPS PRIZE ESSAY.

REPORT OF THE JUDGES.

PHILADELPHIA, March 30, 1912.

TO THE PRESIDENT AND COUNCIL
OF THE AMERICAN PHILOSOPHICAL SOCIETY,

Gentlemen:

The undersigned, a committee of Judges elected by the American Philosophical Society on December 1, 1911, to examine the Essays submitted to the Society in competition for the Henry M. Phillips Prize, respectfully report that they have examined with care the nine essays submitted for the prize, and, after personal consultation and discussion, have awarded the prize to the essay entitled "Sovereignty can only be an unit and must remain an unit.—Bismarck," which proves to be the work of Charles H. Burr, Esq., of Philadelphia. The Committee found very great difficulty in deciding between this essay and one written by "Historicus" [Edward S. Corwine, Esq., of Princeton, New Jersey].

JOSEPH H. CHOATE,
J. M. DICKINSON,
JOHN C. GRAY,
HENRY WADE ROGERS,
JAMES BROWN SCOTT.
Committee.

THE TREATY-MAKING POWER OF THE UNITED STATES AND THE METHODS OF ITS ENFORCEMENT AS AFFECTING THE POLICE POWERS OF THE STATES.

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THE TREATY-MAKING POWER OF THE UNITED STATES AND THE METHODS OF ITS ENFORCEMENT AS AFFECTING THE POLICE POWERS OF THE STATES.

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"Sovereignty can only be an unit, and must remain an unit."—*Bismarck.*

To the treaty-making power, the United States owes the possession of three-fourths of its territory. Yet, the very President who negotiated the first acquisition, denied the constitutional right he assumed to exercise when Louisiana was purchased, and justified by considerations of national expediency, the provisions of a treaty which he had declared to be an unwarranted usurpation of power.[1] In more recent history, when, following the Mafia riots, Italy withdrew her minister, the Secretary of State declared to that country and to the world, the powerlessness of the Federal government to afford redress for a violated treaty.[2] Again, but a few years since, when Japanese treaty rights seemed about to be ignored by California authorities, the then Secretary of State enunciated the supremacy of treaty provision over State law in uncompromising terms.[3]

Only with these and similar instances in mind, can one appreciate at once the far-reaching magnitude of the treaty-making power, and the confusion of ideas by the people and by publicists alike, con-

[1] See note 1.
[2] *Infra*, pp. 204–208.
[3] *Infra*, pp. 207–209.

cerning its extent and its effectiveness. Toward the clarification of those ideas, this essay is an attempt.

It is an unescapable essential in English law that the actual facts, the surrounding circumstances, the causes and the results, which make up a practical controversy brought up for practical decision, must be within the knowledge of those who judge, and guide their minds to the principles which both underlie and spring out of their decisions. The common law is an effort—so far as that effort may be available under the conditions—to apply the methods of induction in arriving at truth respecting the problems which life offers to a court for solution. Always there is present in the processes of the law a secondary and subordinate deductive application of principles theretofore evolved to the concrete facts of the particular cases newly arising; but in the larger sweep of time, the main effort of the common law is toward the determination of truth by the methods of induction.

The recognition of this inherent nature of English law must be ever present to the inquirer and student. Thus only will the law be conceived, as it is, an organic body, a thing living. The decided cases are the manifestations of its life, and these must be analyzed with all possible consideration of the facts out of which they came, the manner of thought of the times when they were decided, the stage of development which the principle of law sought to be examined had then reached. Language of a member of the Supreme Court of the United States used in delivering its opinions, carried with it quite different connotations, has for us today varying authoritative force, according to the period of our history when it was written. The same words have different implications and meanings and values, when uttered in the earliest days of the Supreme Court, in the years preceding the outbreak of the Civil War, in the Reconstruction period, in this twentieth century. It is for the student of law, with what historical knowledge he may possess, to endeavor to envisage the political conditions existing when the decisions examined were delivered; with what literary discrimination is his, to separate the salient and authoritative utterances of a judge from the illustrative and ephemeral; with what power of inductive logic he has acquired, to trace through the recorded decisions the development and validity of the judicial conclusions reached. And however weak and inadequate may be the natural faculties and acquired knowledge of the student, let him and those who do him the honor of examining his work, remember that true method, laboriously and sincerely used, can alone reach valid results. The most brilliant *a priori* discussion of what the law will be found to be, must give place to the humblest study of what the law really is. The crowning advantage of true method is that the method, and not the student's genius, attains the goal. Grant only to the student capacity for sincerity and for labor, and, as he works by the historical method, the circumstances and political conditions of the time spread themselves out before us; the judges speak to us in language, the authority and prophecy underlying which we at this distance of time far better understand than did they; the slowly developing principles of law lie self-revealed before us in their beginnings, their growth, their maturity. The student is rightly forgotten, the method is all.

To collect together the cases relevant to our subject decided by the Supreme Court of the United States, and then to spread them before us in historical sequence for examination and analysis in the light of surrounding circumstances and preëxisting decisions, is the object of this essay. The assumption is general that such cases are few in number. A recent essay thus begins:

> "Something has been written on the extent of the treaty-making power of the President and the Senate. Little has been decided. . . . A very few cases have involved a determination of the extent of the treaty-making power, and in these few the point decided is so narrow, was so inadequately, or not at all argued, or has been rendered so doubtful by dicta of later judges of the Supreme Court as to leave the whole question open."[4]

This is a conclusion which has little foundation in fact. Rather must one prepare oneself for a great number of cases which require consideration, and the student must be careful not to obscure the

[4] "The Extent of the Treaty-making Power of the President and Senate of the United States," Professor William E. Mikell, *American Law Register,* Vol. 57, p. 435.

subject by losing himself in the immaterial. There are great enlightening constitutional cases, and a multitude of only illustrative and cumulative value. A sense of proportion must accompany one always. Therefore in this essay, with inconsiderable exceptions, the decisions of courts other than the Supreme Court of the United States have been, although examined, passed over without mention. And detailed analysis to show the irrelevancy of certain cases in the Supreme Court, has often been omitted. There remains a great wealth of significant and conclusive material.

Mingled, however, with problems of essentially legal nature are problems fundamentally *political.* These are, moreover, political problems of the greatest magnitude in a nation's life, arising as they do out of relations with the other powers of the world. By processes quite other than the calm slow advance of the English race toward the establishment of principles of law, will be determined the political scope of the treaty-making power of the United States. Sudden is the emergency, momentous the issues, on the *executive* rests primarily the decision; economic *desiderata,* party politics, the shrieks of journalism, the make-weight of individual temperament —one or all may influence the result; and the treaty is signed. One influence alone is not felt: the opinion of the Supreme Court of the United States. Years later that Court may be heard in explanation of the event, in support of it, in apology for it—never yet in the nation's history has the Court been heard in its undoing. It was thus when Louisiana was purchased, and Texas annexed; likewise in similar instances will it be again. So, at the beginning of this essay, and in no uncertain words, it has seemed best to endeavor to bring out in bold relief the thought that in their larger significance many of the problems involved in the exercise of the treaty-making power are political, and only subordinately and secondarily legal. Conclusions may therefore be found to lack sanction in legal reasoning while they find it in political considerations. And in attempting at times to forecast the future and suggest the line of development along which the attitude of the people of the United States toward the treaty-making power may proceed, such political considerations must necessarily have their place.

Before examining, however, into the primarily political questions affecting the treaty-making power which may present themselves for solution, it will be well to excerpt the clauses of the Constitution relative to that power. They are as follows:

"No State shall enter into any treaty, alliance, or confederation." *Article I, Section 10, Clause 1.*

"No State shall, without the consent of Congress . . . enter into any agreement or compact with any State, or with a foreign power." *Article I, Section 10, Clause 2.*

"He [the President] shall have power, by and with the advice and consent of the Senate, to make treaties, provided two thirds of the Senators present concur." *Article II, Section 2, Clause 2.*

"The judicial power shall extend to all cases, in law and equity, arising under this Constitution, the laws of the United States, and treaties made, or which shall be made, under their authority." *Article III, Section 2, Clause 1.*

"This Constitution, and the laws of the United States which shall be made in pursuance thereof; and all treaties made, or which shall be made, under the authority of the United States, shall be the supreme law of the land; and the judges in every state shall be bound thereby, anything in the constitution or laws of any state to the contrary notwithstanding." *Article VI, Clause 2.*

The history of the adoption of these clauses by the framers of the Constitution in Federal Convention is interesting and has a certain significance.

It will be recalled that the Convention met in accordance with a resolution of the Congress of the Confederation adopted February 21st, 1787. The date named was May 14th, 1787, but it was not until May 25th that the Convention organized. On May 29th Governor Randolph of Virginia presented a series of resolutions to serve as leading principles in the formation of the new government. These, known as the Virginia plan, were discussed by the Convention sitting as a committee of the whole, and were severally amended, approved, or rejected. On June 15th, a series of resolutions, which became known as the New Jersey plan, was introduced. On July 26th, the Convention adjourned to August 6th, having appointed a committee of detail to prepare a constitution along the lines of the resolutions theretofore adopted. On August 6th the committee reported, and the Convention passed *seriatim* upon the provisions reported. On September 8th the committee of style was appointed, which, on September 12th, reported the Constitution substantially as it was afterwards adopted. On September 15th the Convention adjourned.

The two clauses of Article I., Section 10, of the constitution existed in substance in the Articles of Confederation, where in the first and second paragraphs, respectively, of Article VI, it is said:

> "No State, without the consent of the United States in Congress assembled, shall send any embassy to, or receive any embassy from, or enter into any conference, agreement, alliance, or treaty with any king, prince, or state. . . .
>
> "No two or more states shall enter into any treaty, confederation, or alliance whatever between them, without the consent of the United States in Congress assembled, specifying accurately the purpose for which the same is to be entered into, and how long it shall continue."

On August 6th the committee of detail reported the Articles XII. and XIII. as follows:

> "No State shall coin money; nor grant letters of marque and reprisals; nor enter into any treaty, alliance, or confederation; nor grant any title of nobility."
>
> "No State, without the consent of the Legislature of the United States, shall emit bills of credit, or make anything but specie a tender in payment of debts; nor lay imposts or duties on imports; nor keep troops or ships of war in time of peace; nor enter into any agreement or compact with another State, or with any foreign power; nor engage in any war, unless it shall be actually invaded by enemies, or the danger of invasion be so imminent, as not to admit of delay, until the Legislature of the United States can be consulted."[5]

The committee on style varied the expression of these provisions,[6] and just as the Convention was about to adjourn, the wording was still further but immaterially changed.[7]

The provision for making of treaties by the President and Senate, afterwards contained in the Second Section of the Second Article of the Constitution, was the subject of some controversy. In Governor Randolph's speech presenting what became known as the Virginia plan, he referred to dangers existing on account of State violations of treaties made under the Confederation, as con-

[5] Records of the Federal Convention, Max Farrand, Vol. II., p. 187.

[6] Ibid., p. 597.

[7] Ibid., p. 621.

stituting one of the paramount considerations which should move the Convention to form an effective Federal government; but his fifteen resolutions do not in any way cover the subject of treaties.[8] The inference would seem to be that he assumed that Congress, as the treaty-making power under the Confederation, would likewise exercise the power under the Constitution. However that may be, the first mention of the treaty-making power occurs in the New Jersey plan on June 15th, where the reference is to the extension of the judicial power to questions arising under treaties, and to the enforcement of treaties.[9] When the committee of detail reported a draft of the Constitution on August 6th, the First Section of the Tenth Article according to the then arrangement, was as follows:

> "The Senate of the United States shall have power to make treaties, and to appoint Ambassadors, and Judges of the Supreme Court."[10]

On August 15th Colonel Mason, of Virginia, seconded a motion to take the power of originating revenue bills from the Senate, and Madison's notes say:

> "He was extremely earnest to take this power from the Senate, who he said could already sell the whole country by means of treaties."[11]

The notes next record the speech of Mr. Mercer of Maryland:

> "He contended (alluding to Mr. Mason's observations), that the Senate ought not to have the power of treaties. This power belonged to the Executive department; adding that treaties would not be final so as to alter the laws of the land, till ratified by legislative authority. This was the case of treaties in great Britain; particularly the late Treaty of Commerce with France.
>
> "Col. Mason did not say that a treaty would repeal a law; but that the Senate by means of treaty might alienate territory &c., without legislative sanction. The cessions of the British Islands in W— Indies by treaty alone were an example—If Spain should possess herself of Georgia therefore the Senate might by treaty dismember the Union."[12]

On August 23rd the provision in the form that it came from the committee of detail, giving the power of making treaties to the Senate, came before the Convention. The report of the proceedings by

[8] Farrand, Vol. I., pp. 20–2.
[9] Ibid., p. 245.
[10] Farrand, Vol. II., p. 183.
[11] Ibid., p. 297.
[12] Ibid., p. 297.

Madison is instructive. He urges that the president should be an agent in making treaties. Gouverneur Morris moved an amendment: "but no treaty shall be binding on the United States which is not ratified by a law." This was opposed by several on the ground of the practical difficulty it would cause in negotiations, and the amendment was defeated by a vote of 8 to 1, one State being divided. The report, given in full in the appended notes,[13] concludes thus:

"Mr. Madison hinted for consideration, whether a distinction might not be made between different sorts of treaties—allowing the President and Senate to make treaties eventual and of alliance for limited terms—and requiring the concurrence of the whole Legislature in other treaties."[14]

On August 31st, a committee of one member from each State was appointed, to whom were referred the parts of the Constitution, consideration of which had been postponed.[15] This committee reported on September 4th. In this report, the clause stood:

"The President by and with the advice and consent of the Senate, shall have power to make treaties. . . . But no treaty shall be made without the consent of two thirds of the members present."[16]

On September 7th this section came up for adoption. Madison's record says:

"Mr. Wilson moved to add, after the word 'Senate' the words, 'and House of Representatives.' As treaties he said are to have the operation of laws, they ought to have the sanction of laws also. The circumstance of secrecy in the business of treaties formed the only objection; but this he thought, so far as it was inconsistent with obtaining the Legislative sanction, was outweighed by the necessity of the latter.

"Mr. Sherman thought the only question that could be made was whether the power could be safely trusted to the Senate. He thought it could; and that the necessity of secrecy in the case of treaties forbade a reference of them to the whole Legislature.

"Mr. Fitzsimmons 2ded. the motion of Mr. Wilson, and on the question

"N. H. no. Mas. no. Ct. no. N. J. no. Pa. ay. Del. no. Md. no. Va. no. N. C. no. S. C. no. Geo. no.

"The first sentence as to making treaties was then agreed to; nem: con:"[17]

[13] See note 2.

[14] Farrand, Vol. II., pp. 392–4.

[15] Ibid., p. 481.

[16] Ibid., p. 495.

[17] Ibid., p. 538.

Later this same day the final sentence of the clause was before the Convention. Madison's report continues:

"Mr. Wilson thought it objectionable to require the concurrence of two thirds which puts it in the power of a minority to control the will of a majority.

"Mr. King concurred in the objection; remarking that as the Executive was here joined in the business, there was a check which did not exist in Congress where the concurrence of two-thirds was required.

"Mr. Madison moved to insert after the word 'treaty' the words 'except treaties of peace' allowing these to be made with less difficulty than other treaties—It was agreed to nem: con:"[18]

The report then relates that Madison further moved to amend by permitting treaties of peace to be negotiated by two thirds of the Senate without the concurrence of the President.[19] This was defeated.[20]

On September 8th a reconsideration of the whole clause was agreed to, and the following motions were made with the indicated results:

That the words "except treaties of peace" be stricken out: ayes 8; noes 3.

That two thirds of the Senate must concur be stricken out: ayes 1; noes 9; divided 1.

That no treaty be made with the consent of two thirds of all the members of the Senate: ayes 3; noes 8.

That a majority of all the Senators suffice: ayes 5; noes 6.[21]

In the report of the committee of style the existing form was adopted.[22]

The sixth resolution offered by Governor Randolph had enumerated among the powers given to Congress the right "to negative all laws passed by the several States, contravening in the opinion of the national legislature, the articles of union."[23] The twelfth resolution had included among the subjects of Federal judicial jurisdiction, "questions which may involve the national peace and harmony."[24] On May 31st this resolution passed with the amendment

[18] Ibid., p. 540.

[19] Ibid., p. 541.

[20] See note 3.

[21] Farrand, Vol. II., p. 544.

[22] Ibid., p. 599.

[23] Farrand, Vol. I., p. 21.

[24] Ibid., p. 22.

added on motion of Benjamin Franklin of the words: "or any treaties subsisting under the authority of the Union."[25] On June 8th the reconsideration of this resolution was moved and a long discussion ensued between those who felt the power was necessary to insure Federal effectiveness, and those who, like Mr. Williamson, of North Carolina, feared it "might restrain the States from regulating their internal police."[26] The resolution was eventually disapproved by a majority.[27] On June 13th the twelfth resolution was adopted.[28] On June 15th the New Jersey plan was submitted, which specially included within the jurisdiction of the Federal judiciary, cases "in the construction of any treaty or treaties."[29] When the committee of detail reported, the power given to Congress by the sixth resolution of the Virginia plan had disappeared, and the jurisdiction of the United States Supreme Court was declared to extend "to all cases arising under laws passed by the Legislature of the United States."[30] No reference to cases arising under treaties was included. A series of amendments then ensued. The judicial power was declared to extend to cases in equity as well as at law.[31] In addition "to all cases arising under laws" were included those arising under the Constitution[32] and under treaties.[33]

The committee of style reported this provision in the form in which it now appears[34] if one except an immaterial verbal alteration, later made.[35]

As with the judiciary provisons of Article III. of the Constitution, which remained unconceived so long as the national legislature was regarded as the proper body to negative unconstitutional State laws, so also was it with Article VI. Its seed is to be found not in the Virginia plan but in the New Jersey resolutions offered on June 15th. The sixth was as follows:

"Res'd. that all acts of the United States in Congress made by virtue and in pursuance of the powers hereby and by the articles of confederation

[25] Ibid., p. 47.
[26] Ibid., p. 164.
[27] Farrand, Vol. II., pp. 21–2.
[28] Farrand, Vol. I., p. 232.
[29] Ibid., p. 244.
[30] Farrand, Vol. II., p. 186.
[31] Ibid., p. 428.
[32] Ibid., p. 430.
[33] Ibid., p. 431.
[34] Ibid., p. 576.
[35] Ibid., p. 621.

vested in them, and all treaties made and ratified under the authority of the United States shall be the supreme law of the respective States so far forth as those acts or treaties shall relate to the said States or their citizens, and that the judiciary of the several States shall be bound thereby in their decisions, anything in the respective laws of the individual States to the contrary notwithstanding; and that if any State, or any body of men in any State shall oppose or prevent ye carrying into execution such acts or treaties, the federal Executive shall be authorized to call forth ye power of the Confederated States, or so much thereof as may be necessary to enforce and compel an obedience to such Acts, or an observance of such treaties."[36]

On July 17th the sixth resolution of the Virginia plan was defeated, and Luther Martin of Maryland moved the following resolution which was unanimously adopted:

"That the legislative acts of the United States made by virtue and in pursuance of the articles of union, and all treaties made and ratified under the authority of the United States, shall be the supreme law of the respective States, as far as those acts or treaties shall relate to the said States, or their citizens and inhabitants—and that the judiciaries of the several States shall be bound thereby in their decisions, anything in the respective laws of the individual States to the contrary notwithstanding."[37]

The committee of detail reported the section in the following form:

"The acts of the Legislature of the United States made in pursuance of this Constitution, and all treaties made under the authority of the United States shall be the supreme law of the several States, and of their citizens and inhabitants; and the judges in the several States shall be bound thereby in their decisions; anything in the Constitution or laws of the several States to the contrary notwithstanding."[38]

On August 23rd the first clause was changed to read: "This Constitution and the laws of the United States made in pursuance thereof."[39] On August 25th the words "or which shall be made" were inserted to cover treaties preëxisting. So modified, the provision received unanimous approval.[40] It remained thereafter unaltered by the Convention except by its action in approving the form given to it by the committee of style.[41]

The general plan of the Constitution would seem to be simple. The Federal power is divided into the legislative, the executive, and the judicial. The legislative, limited to certain enu-

[36] Farrand, Vol. I., p. 245.
[37] Farrand, Vol. II., pp. 28–9.
[38] Ibid., p. 183.
[39] Ibid., p. 389.
[40] Ibid., p. 417.
[41] Ibid., p. 603.

merated subjects, is vested in Congress composed of two houses, one intended to be representative of the several States and the other of the people at large. The executive power is committed to the President; the judicial power is established in the Supreme Court, and in such inferior courts as may be ordained by Congress. The treaty-making power occupies an anomalous position. It is given to the President acting in conjunction with two-thirds of the Senate, and the judicial power is declared to extend to cases arising under treaties. Finally there is inserted the solemn declaration that the Constitution, the laws of the United States, and all treaties, shall be supreme law above the constitution and laws of each State. The amendments to the Constitution neither expressly nor apparently affect the treaty-making power or its exercise. The first ten were adopted immediately after the ratification of the Constitution, and of these all but the last two were intended and have been interpreted to operate as restraints on Federal action. These two constitute a specific reservation to the States of all powers not delegated to the United States nor prohibited to the States by the Constitution.

When one comes to deal with the problems arising out of the exercise of the treaty-making power, it is essential to appreciate one basic fact: that the treaty-making power is in its essence a power to deal with *parties*—all other powers granted to the Federal government or reserved to the States, are powers to deal with *subjects*. About to enter into the consideration of controverted problems, one seeks for words with which to emphasize and throw into high relief this determining consideration. Always must it be borne in mind as a significant factor in the problem, and to recognize it, is often to find the answer. A treaty is a contract made with another sovereignty. It is the fact that the contract is made with a sovereign nation—that is, made with a certain *party*—which constitutes it a treaty. On the other hand, it is the nature of the *subject* legislated upon which brings it within the power of Congress, or relegates it to the States. Attempts to reconcile, or rather to make mutually consistent, the treaty clauses of the Constitution and, for example, those clauses giving power of legislation to Congress, must fail, unless there is borne constantly in mind this fundamental distinction between the powers granted. If there be given to *A* the power to contract with *X*, and to *B* the power to make regulations on certain subjects affecting *X*, and to *C* the power to make regulations on other subjects affecting *X*; then what shall result when the provisions of an agreement made by *A* with *X* conflict with regulations of *B* or of *C*?

The fundamental nature of the questions which underlie an examination into the treaty-making power of the United States is best appreciated by the algebraic statement of the problem just attempted. It will be well to restate it in equivalent concrete forms. These are:

First: When a treaty deals with a subject upon which Congress is authorized to legislate, is such treaty valid? or perhaps we should rather ask, what is its status?

Second: When a treaty deals with a subject upon which the States as opposed to Congress are authorized to legislate, is such treaty valid? or perhaps we should rather ask, what is its status?

On the correct answer to these two fundamental questions must depend any understanding of the status and efficacy of the treaty-making power of the United States. The Federal government as an entity can alone make treaties. Such is the emphatic provision of the Constitution. There is therefore no distribution of the treaty-making power between the Federal government on the one hand and the several States, on the other, as is the case with the executive, the judicial, and the legislative power. An executive act may be by a State governor or by the President, a court decree may be that of a State or a Federal court, a statute may be the act of a State legislature or of Congress. If a *treaty* is to be made, it is the United States alone which must make it; no State may make it or join in it. In this sense therefore the power of the United States to make treaties is unlimited. There remains however a field of controversy of far more intricate and important significance; the field already indicated, created when the treaty made with a sovereign party (or individual rights maintained or secured by the treaty) impinges on certain *subjects* committed to Congress, it may be, or reserved to the States, as subjects of legislation. Two forces then enter the same field. Shall either dominate wholly? Shall each prevail in part? Is compromise possible?

It will therefore be the main purpose of this essay to examine inductively the *data* available for the solution of these two problems: the power of President and Senate, first, as opposed to Congress; and, second, as opposed to the several States. Finally, when the true relationships shall have been realized, an understanding of the methods of enforcing rights recognized or granted by treaty should naturally follow. But before an examination of the fundamental problems relating to the exercise of the treaty-making power be attempted, one must pause for a preliminary observation, even though it be *a priori* in its nature. The subject of treaties is rarely touched upon by essayists or text-book writers without a statement being made to the effect that a treaty may not be made to change the nature of our government, alter its departmental structure, or operate to deprive one department of a delegated power. A treaty could not, it is repeatedly said, provide that hereafter a particular State should have three senators. The reason for this position set forth in one form or another is always substantially to the effect that a power granted under an instrument must not be so construed as to change the instrument, or, in a more exaggerated instance, to destroy it. That argument—although not without the appearance and perhaps some reality of validity—misses the mark.

On altogether simple lines the Constitution of the United States was evolved. Certain fundamental principles were adopted and formulated; applications of those principles, details of organization were left to time and the nation that was to come. There was established the executive department, the judicial, the legislative. To this last were committed certain subjects of legislation—all others being reserved to the States. The power of this new government to treat with other sovereignties remained. It was confided to the President and Senate acting by a two-thirds majority of those present. Then, by express provision, the power to enter into any treaty was prohibited to the States. Why was not the treaty-making power expressly inhibited from nullifying the other provisions of the

Constitution? The answer is because neither its framers nor its numerous contemporary critics ever imagined the possibility of such an event. It is urged that they were right. A treaty-making power is a power to make treaties. And provisions looking to the accomplishment of an internal change in the government of one sovereign party to a treaty, are not and could not be subjects, properly speaking, of a treaty. To the minds which framed the Constitution and within the intendment of that instrument, treaties must only contain provisions which in the usual and normal intercourse of nations should properly become the subjects of treaties. It would seem to be unnecessary, if not misleading, to seek any further reason why a treaty may not make the President the presiding officer of the Supreme Court, or deprive the State of Nevada of its Senators. A *colorable* exercise of a power—and the word assumes too much—is not a valid exercise of the power. There is no judicial decision to such effect; but the *a priori* assertion may be ventured, that a treaty must be a treaty within the meaning of that word in international usage.

I.

The first problem respecting the treaty-making power of the United States having a wholly political character arose early in its history. In 1794, the British treaty was signed. France was at war with Great Britain, and the general sentimental affection of the American people for France was conceived by many to be outraged. The treaty was, *inter alia*, a treaty of commerce, and it was considered to operate unequally. A storm of protest burst forth which reëchoed over the country in resolutions denouncing the treaty. In a meeting held at Richmond it was declared that the treaty was "insulting to the dignity, injurious to the interests, dangerous to the security, and repugnant to the Constitution of the United States."[42] The resolutions adopted by the legislature of Virginia were couched in more parliamentary language, but were to the same effect. Nevertheless, on February 29th, 1796, Washington proclaimed the treaty as being the supreme law of the land. And on March 1st, he

[42] 112 U. S., p. 753.

transmitted a copy thereof to Congress. The House was dominated by the party opposed to Washington and the Federalists. John Marshall was then a member of the House, and in his "Life of Washington" has summarized the positions taken.

"By the friends of the administration, it was maintained," he writes, "that a treaty was a contract between two nations, which, under the constitution, the President, by and with the advice and consent of the Senate, had a right to make, and that it was made when, by and with such advice and consent, it had received his final act. Its obligations then became complete on the United States, and to refuse to comply with its stipulations, was to break the treaty, and to violate the faith of the nation.

"By the opposition it was contended, that the power to make treaties, if applicable to every object, conflicted with powers which were vested exclusively in Congress. That either the treaty-making power must be limited in its operation so as not to touch objects committed by the constitution to Congress, or the assent and co-operation of the House of Representatives must be required to give validity to any compact so far as it might comprehend those objects. A treaty, therefore, which required an appropriation of money, or any act of Congress to carry it into effect, had not acquired its obligatory force until the House of Representatives had exercised its powers in the case. They were at full liberty to make or to withhold such appropriation, or other law, without incurring the imputation of violating any existing obligation, or of breaking the faith of the nation."[43]

A resolution passed requesting the President to lay before the House the papers relating to the treaty.

"It was," says Marshall, "a subject for serious reflection, that in a debate unusually elaborate, the House of Representatives had claimed a right of interference in the formation of treaties, which, in the judgment of the President, the Constitution had denied them."[44]

Washington's reply is of the greatest importance and is appended in full in the notes.[45]

"Having been," he said, "a member of the General Convention, and knowing the principles on which the Constitution was formed, I have ever entertained but one opinion upon this subject; and from the first establishment of the Government to this moment, my conduct has exemplified that opinion. That the power of making treaties is exclusively vested in the President, by and with the advice and consent of the senate, provided two-thirds of the

[43] Marshall's "Life of Washington," 1st ed., Vol. V., Chap. VIII., pp. 651–2.

[44] *Id.*, p. 654.

[45] See note 4.

senators present concur; and that every treaty so made and promulgated, thenceforward becomes the law of the land."

Washington further pointed out that this had been the construction which had obtained in the State conventions; and that the proposition "that no treaty should be binding on the United States which was not ratified by a law" had been explicitly rejected in the Federal Convention.

"A just regard to the Constitution and to the duty of my office," he concluded, "forbid a compliance with your request."

One month after the receipt of this message, the House passed an appropriation for carrying the treaty into effect.[46] Previously, however, they had answered the President in resolutions disclaiming the power to interfere in making treaties, but asserting their right to determine on the expediency of carrying into effect whatever treaty stipulations be made on subjects committed to Congress. The language of the resolution is appended in note 5.

The position taken by the House in 1796, accurately summarized by Marshall, has been persistently maintained. The treaty of 1815 with Great Britain was a commercial treaty providing also that no tariff discrimination should obtain. The existing laws embodied such discrimination and the Senate adopted a declaratory act in which they provided that such laws should be "taken to be of no force and effect." The declaratory nature of this act was distasteful to the House, and that body passed a new bill reënacting the treaty provisions. In the course of the debate, Mr. King of Massachusetts said:

"Whenever a treaty or convention does, by any of its provisions, encroach upon any of the enumerated powers vested in the Constitution in the Congress of the United States, or any of the laws by them enacted in execution of those powers, such treaty or convention, after being ratified, must be laid before Congress, and such provisions cannot be carried into effect without an act of Congress."[47]

And he added as an instance a treaty which would affect "duties on imports, enlarging or diminishing them." A conference committee

[46] Annals of Congress, 4th Congress, First Session, p. 1291.
[47] Annals of Congress, 14th Congress, 1st Sess., p. 538.

was appointed. In the report to the House of its conferees they say:

"[The Committee] are persuaded that the House of Representatives does not assert the pretension that no treaty can be made without their assent; nor do they contend that in all cases legislative aid is indispensably necessary, either to give validity to a treaty, or to carry it into execution. On the contrary, they are believed to admit, that to some, nay many treaties, no legislative sanction is required, no legislative aid is necessary.

"On the other hand the committee are not less satisfied that it is by no means the intention of the Senate to assert the treaty-making power to be in all cases independent of the legislative authority. So far from it, that they are believed to acknowledge the necessity of legislative enactment to carry into execution all treaties which contain stipulations requiring appropriations, or which might bind the nation to lay taxes, raise armies to support navies, to grant subsidies, to create States, or to cede territory; if indeed this power exists in the government at all. In some or all of these cases, and probably in many others, it is conceived to be admitted, that the legislative body must act, in order to give effect and operation to a treaty; and if in any case it be necessary, it may confidently be asserted that there is no difference in principle between the Houses; the difference is only in the application of the principle. For if, as has been stated, the House of Representatives contend that their aid is only in some cases necessary, and if the Senate admit that in some cases it is necessary, the inference is irresistible, that the only question in each case that presents itself is, whether it be one of the cases in which legislative provision is requisite for preserving the national faith or not."[48]

And they added relative to the point in dispute:

"The Senate believe legislation unnecessary. The House regard it as indispensable."

The Senate conferees reported:

"Even a declaratory law . . . is a matter of mere expediency, adding nothing to the effect of the treaty, and serving only to remove doubts hereafter that existed."[49]

Finally an amended declaratory act passed both houses of Congress.

In 1844, a proposed reciprocity treaty with Prussia was rejected by the Senate, after a report by a committee antagonistic to President Tyler, in which the constitutionality of the treaty was denied. This action of the Senate finds its explanation, it is believed, in the extraordinary political conditions created by the accession to the

[48] Ibid., pp. 1019–20.

[49] Ibid., p. 160.

presidency of the Vice-President, a southern Democrat, after the death of President Harrison, a Whig.[50]

Again in 1868, the House of Representatives raised the question as to its duties and rights respecting an appropriation for the payment to Russia of the purchase price of Alaska under the treaty of 1867. At first the House, in the Bill passed by that body, recited the alleged necessity of assent by them, and then assumed to give such assent. The Senate rejected the Bill and threw it into conference. One of the House conferees in explanation of his report said:

"The Committee on the part of the Senate stated freely and frankly that they could in no event consent to the preamble and that the Senate would not consent, and that they held that the House was bound to carry out the stipulations of all treaties, and that when a treaty provided for the payment of money for any purpose, that such stipulation created a debt, and that the House has no discretion in relation to the payment of the same, a doctrine of course utterly at variance with the law and with the principles asserted in the preamble as it passed the House; and it is manifestly impossible to reconcile opinions so utterly at variance upon so important a question. A majority of the Committee on the part of the House could in no event consent to any such doctrine so utterly subversive of the rights and constitutional prerogatives of the House."[51]

The Bill was finally passed containing the following recital:

"Whereas said stipulations cannot be carried into full force and effect except by legislation to which the consent of both Houses of Congress is necessary."[52]

In 1887, a proposed extension of the Hawaiian treaty had been negotiated, and ratified by the Senate. The original treaty of 1875 had provided that it should not become effective "until a law to carry it into operation shall have been passed by the Congress of the United States of America." The question of the prerogatives of the House in the matter was raised in that body and referred to the judiciary committee. In its report that committee said:

"The President, by and with the advice and consent of the Senate, cannot negotiate a treaty which shall be binding on the United States, whereby

[50] See Senator Cullom's analysis: *Congressional Record*, Vol. 35, Part II., p. 1081.

[51] *Congressional Globe*, 40th Cong., 2nd Sess., Part V., p. 4393.

[52] *Congressional Globe*, 40th Cong., 2nd Sess., Part V., p. 4394.

duties on imports are to be regulated, either by imposing or remitting, increasing or decreasing them, without the sanction of an act of Congress; and that the extension of the term for the operation of the original treaty or convention with the government of the Hawaiian Islands, proposed by the supplementary convention of December 6, 1884, will not be binding on the United States without like sanction, which was provided for in the original treaty and convention, and was given by act of Congress."[53]

The report does not seem to have been adopted by the House, and no Act of Congress extending the provisions of the treaty of 1875 was passed.[54]

In 1897, the tariff act known as the Dingley Act was passed. By the third section thereof the act purported to "authorize" the president to negotiate commercial reciprocity agreements on certain articles therein enumerated, and provided that he might suspend after the making of such agreement the operation of the tariff act. The fourth section purported to prescribe the method and effect of such agreements. It provided that whenever the president "by and with the advice and consent of the Senate . . . , shall enter into commercial treaty or treaties" concerning duties "and when any such treaty shall have been duly ratified by the Senate and approved by Congress, and proper proclamation made accordingly, then and thereafter the duties" shall be accordingly collected.

In 1902, Senator Cullom reviewed in the Senate the history of the exercise of the treaty-making power His speech is marked by its accurate fulness and persuasive logic, and thus concludes:

"The authority of the House [of Representatives] in reference to treaties has been argued and discussed for more than a century, and has never been settled in Congress and perhaps never will be. The House, each time the question was considered, insisted upon its powers, but nevertheless has never declined to make an appropriation to carry out the stipulation of a treaty, and I contend that it was bound to do this, at least as much as Congress can be bound to do anything when the faith of the nation had been pledged. And this appears to me to be the only case in which any action by the House is necessary, unless the treaty itself stipulates, expressly or by implication, for such Congressional action."[55]

[53] *Congressional Record,* Vol. 18, Part III., p. 2721. Language given Vol. 35, Part II., p. 1182.

[54] U. S. Stat. at Large, Vol. 30, pp. 203-4.

[55] *Congressional Record,* Vol. 35, Part II., p. 1083.

The House responded with the following resolution:

"Whereas, it is seriously claimed that under the treaty-making power of the government, and without any action whatever on the part of the House of Representatives, or by Congress, reciprocal trade agreements may be negotiated with foreign governments that will of their own force operate to supplant, change, increase, or entirely abrogate duties on imports collected under laws enacted by Congress and approved by the executive for the purpose of raising revenue to maintain the government: Now, therefore, be it

"Resolved by the House of Representatives that the Committee on Ways and Means be directed to fully investigate the question of whether or not the President, by and with the advice and consent of the Senate, and independent of any action on the part of the House of Representatives, can negotiate treaties with foreign governments for the purpose of raising revenue are modified or repealed, and report the result of such investigation to the House."[56]

This resolution was allowed to die in Committee.

In 1902, a treaty was signed with Cuba under which a preferential duty on imports into the United States was granted. The treaty provided that it should "not take effect until the same shall have been approved by Congress."[57] An act was then passed by Congress entitled "An Act to carry into effect a Convention between the United States and the Republic of Cuba," which concluded with the following proviso:

"That nothing herein contained shall be held or construed as an admission on the part of the House of Representatives, that customs duties can be changed otherwise, than by an act of Congress, originating in said House."[58]

In 1911, a Canadian reciprocity tariff was negotiated, and it is significant that on the part of the United States, no treaty was signed, but that an act of Congress was passed of which the third section is as follows:

[Be it enacted] "That for the purpose of further readjusting the duties on importations into the United States of article or articles the growth, product, or manufacture of the Dominion of Canada, and of the exportation into the Dominion of Canada of article or articles the growth, product, or manufacture of the United States, the President of the United States is authorized and requested to negotiate trade agreements with the Dominion of Canada wherein mutual concessions are made looking toward freer trade

[56] *Congressional Record,* Vol. 35, Part II., p. 1178.

[57] Compilation of Treaties in force, 1904, p. 225.

[58] 33 Stat. at Large, 3.

relations and the further reciprocal expansion of trade and commerce: Provided, however, that said trade agreements before becoming operative shall be submitted to the Congress of the United States for ratification or rejection."

The Presidents of the United States have uniformly supported the view of Washington. In addition to maintaining this attitude in the instances above set forth, we may cite the following examples. In 1835, President Jackson vetoed a bill for the compromise of claims allowed by the commissioners under a treaty. He said:

"The Act is, in my judgment, inconsistent with the division of powers in the Constitution of the United States, as it is obviously founded on the assumption that an act of Congress can give power to the Executive or to the head of one of the Departments to negotiate with a foreign government."[59]

In 1877, President Grant vetoed congressional resolutions directing the Secretary of State to convey to certain republics the good wishes of Congress on the ground that in the executive alone was vested the right to conduct all correspondence with other sovereignties.[60]

It would seem to be idle to enter into a long discussion of the constitutional problem presented if the House of Representatives should refuse to pass an appropriation necessary to carry a treaty into effect. It is a problem political and national in its character and not one for judicial arbitrament or determination. The question presented, however, is simple enough and readily yields to analysis. A treaty agreeing to pay money is none the less a treaty, whether or no the money be paid. It constitutes an executory contract and raises an obligation on the part of the United States to perform its contract. Congress could repudiate this obligation, just as a corporation by its board of directors could refuse to honor its duly executed obligation. But the power to make a valid treaty would be untouched by such repudiation: the United States would remain bound in international law. Congress, however, has never yet in its history refused to recognize the obligation resting upon it, and it is unlikely it ever will. If it should, the offended nation would have whatever redress would be open to it under the principles of international law. The courts of the United States could not determine such a controversy of purely national and political import.

[59] Richardson's Messages of the Presidents, Vol. III., p. 146.
[60] Id., Vol. VII., pp. 430–2.

So far as the question is raised by the quotations above made as to the power of the President and Senate to enter into commercial treaties and so affect the tariff laws, it will be seen that this question is one which may involve individual rights and so become the subject of judicial determination. Its further consideration will therefore be postponed till the inductive study of the decisions of the Supreme Court of the United States be had.[61]

The acquisition or cession of territory, however, by the United States, involves problems of wholly national and political import. The power of the United States to *acquire* territory by the exercise of the treaty-making power is firmly established and has been exercised in a series of treaties. In 1803 Louisiana was ceded by France; in 1819 Florida by Spain; in 1848 California and New Mexico by Mexico; in 1867 Alaska by Russia; and in 1899 Porto Rico and the Philippine Islands by Spain.

The exercise of the treaty-making power relative to the acquisition of Florida came before the Supreme Court in American Insurance Company *vs.* Canter,[62] and was judicially sanctioned.

> "The Constitution," said Mr. Chief Justice Marshall, in delivering the opinion of the Court, "confers absolutely on the government of the Union, the powers of making war, and of making treaties; consequently, that government possesses the power of acquiring territory, either by conquest or by treaty."[63]

A long series of cases recognizes without question and discusses this power to acquire territory by treaty. The extent and operation of this power receives the most thorough criticism in the Insular Cases.[64] In those cases there was not directly in issue the extent of the treaty-making power with reference to the acquisition of

[61] *Infra,* 100–105.

[62] 1 Peters, 511 (1828).

[63] 1 Peters, p. 542.

[64] These are: De Lima *vs.* Bidwell, 182 U. S., 1 (1901), Downes *vs.* Bidwell, 182 U. S., 244 (1901). Directly connected with these cases, but establishing no additional principles are: Dooley *vs.* United States, 182 U. S., 222 (1901), Dooley *vs.* United States, 183 U. S., 151 (1901), Fourteen Diamond Rings, 183 U. S., 176 (1901). More recently the same principles have been reënunciated in Lincoln *vs.* United States, 197 U. S., 419 (1905), 202 U. S., 484 (1906), Pearcy *vs.* Stranahan, 205 U. S., 257 (1907), United States *vs.* Heinszen, 206 U. S., 370 (1907).

territory or otherwise. None of the six judges who directly expressed themselves even questioned the manner of the exercise of the treaty-making power in the cases at bar. There was no possible occasion for such criticism. By the treaty the determination of the civil rights and political status of the inhabitants of the islands was left to Congress, and Congress by a series of acts appropriated money, ratified the treaty, and proceeded to provide for the government of the acquired territory. By reason, however, of the comments of the members of the Court, these cases will repay careful and detailed examination. One must beware of seizing upon the remarks of any one of the judges without the most careful reference to its connection with his course of argument and to the issue presented. This is always a wise caution; it is here a vital one; for, in these cases, four judges agreed in the main, one with the other; four others, while agreeing one with the other, absolutely repudiated the reasonings and conclusions of the first four; while the ninth judge, by alternately voting with each group, determined the decision in both cases. The facts were simple and are as follows:

On April 11th, 1899, the treaty ceding Porto Rico to the United States was ratified and proclaimed. On April 12th, 1900, the Foraker Act was passed, creating civil government for the Island, and providing for the collection of tariff duties on imports therefrom into the United States. In DeLima *vs.* Bidwell the question was as to the application of the existing United States tariff to imports between the date of the ratification of the treaty and the time when the Foraker Act took effect. In Downes *vs.* Bidwell the question was as to the constitutionality of the Foraker Act, which admittedly did not comply with the provision of the Constitution that "all duties, imports, and excises shall be uniform throughout the United States." The Chief Justice and Justices Harlan, Brewer, and Peckham were of the opinion that when Porto Rico was ceded to the United States, and, by the terms of the treaty and the action of Congress, a civil government was therein created, the provisions of the Constitution at once applied; that the island could not be termed foreign territory after the ratification of the treaty; that consequently the existing tariff law attempted to be enforced in DeLima *vs.* Bidwell had no application; and that, once Porto Rico became organized territory of the United States, the provisions of the Constitution including the restriction imposing uniformity of taxation, applied, and the Foraker Act, attempted to be enforced in Downes *vs.* Bidwell, was unconstitutional and void. To this Justices McKenna, Shiras, White, and Gray rejoined that "Porto Rico occupied a relation to the United States between that of being a foreign country absolutely and of being domestic territory absolutely"; that Congress was only empowered to act in any case subject to the applicable limitations of the Constitution; that Porto Rico had not been incorporated into the United States so as to bring it within the provisions of Article I., Section 9, of the Constitution; that therefore Porto Rico could not become domestic territory without the action of Congress: and consequently that the existing tariff act applied in DeLima *vs.* Bidwell and the Foraker Act in Downes *vs.* Bidwell. Mr. Justice Brown was of the opinion, however, that a country could not be domestic for one purpose and foreign for another; and that Porto Rico was wholly domestic territory. He thought, however, that Article I., Section 9, had no application to the islands which could not be regarded as part of the United States within the meaning of that clause, but should rather be spoken of as "a territory appurtenant and belonging to the United States." His vote therefore determined the decisions in the two cases alternately in favor of and against the two groups consisting each of four justices. It is submitted that the position of Mr. Justice Brown is in substance with the four who prevailed in Downes *vs.* Bidwell. In the first place, the *effect* of the decisions is that Congress has the power henceforth to legislate for territory acquired by treaty, without being subject to customary restrictions on such legislation provided in the constitution. In the second place, while the language of Mr. Justice Brown to the effect that territory acquired by treaty forthwith becomes domestic and cannot for any purposes be regarded as foreign, may seem to be flatly opposed to the position of Mr. Justice McKenna and Mr. Justice White, as set forth in their respective opinions; yet when he grants (as in Downes *vs.* Bidwell) that though "domestic territory," the Constitution is not applicable as a whole, the difference is seen to be verbal rather than substantial. Indeed, Mr. Justice McKenna and those who concurred with him, might, without departure from the principles enunciated by him, have agreed in the reversal in DeLima *vs.* Bidwell, basing their action on the fact that the status of Porto Rico was not that of foreign territory within the meaning of the existing tariff act. An analysis shows that the decisions in Fleming *vs.* Page[65] and in Cross *vs.* Harrison[66] were the influential determining cases. Mr. Justice Brown concludes his prevailing opinion in Downes *vs.* Bidwell with this paragraph:

> "Patriotic and intelligent men may differ as to the desirableness of this or that acquisition, but this is solely a political question. We can only consider this aspect of the case so far as to say that no construction of the Constitution should be adopted which would prevent Congress from considering each case upon its merits, unless the language of the instrument imperatively demands it. A false step at this time might be fatal to the development of what Chief-Justice Marshall called the American Empire. Choice in some cases, the natural gravitation of small bodies toward large ones in others, the result of a successful war in still others, may bring about conditions which would render the annexation of distant possessions desirable. If those possessions are inhabited by alien races, differing from us in religion, customs, laws, methods of taxation and modes of thought, the administration of government and justice, according to Anglo-Saxon principles may for a time be impossible; and the question at once arises whether large concessions ought not to be made, that, ultimately, our own theories may be carried out, and the blessings of a free government under the Constitution extended to them. We decline to hold that there is any thing in the Constitution to forbid such action."[67]

Nothing could illustrate better than the above quotation the essentially political and economic nature of the problems presented. Reading the lengthy opinions in these cases (the reports of which cover 391 pages), one appreciates the broad character of the outlook of the Justices who decided them. But it is as statesmen truly learned in the law that they write, handling with high sincerity and high seriousness the history of constitutional law to illustrate, support, and make to prevail, their political and economic convictions. It could not be, should not be, otherwise. But the fact

[65] 9 How., 603 (1850).
[66] 16 How., 164 (1853).
[67] 182 U. S., pp. 286–7.

must be recognized. We are not in a world where legal precedent, formal logic, and academic considerations control.

We recur to the bearings of these cases upon the subject of our essay. One point is determined: that the treaty-making power can be exercised to acquire territory.[68] The *decision* goes no further with respect to the interpretation of the treaty-making power. But Mr. Justice White in his concurring opinion in Downes *vs.* Bidwell does express himself as follows:

> "It seems to me impossible to conceive that the treaty-making power by a mere cession can incorporate an alien people into the United States without the express or implied approval of Congress. . . . If the treaty-making power can absolutely, without the consent of Congress, incorporate territory, and if that power may not insert conditions against incorporation, it must follow that the treaty-making power is endowed by the Constitution with the most unlimited right, susceptible of destroying every other provision of the Constitution; that is, it may wreck our institutions."[69]

It should be observed of these remarks: first, that in the treaty under discussion it was expressly provided that Congress should determine the civil rights and political status of the inhabitants and that consequently the situation discussed by Mr. Justice White was not presented in the case before him; second, that four justices disagreed positively with this view,[70] one, Mr. Justice Brown, impliedly,[71] and one, Mr. Justice Gray, did not express himself. It should be further pointed out that in using the word "incorporate" Mr. Justice White used it in a special sense: that is, as equivalent

[68] In Wilson *vs.* Shaw, 204 U. S., 24 (1907), it is said: "It is too late in the history of the United States to question the right of acquiring territory by treaty," p. 32.

[69] 182 U. S., pp. 312–3.

[70] It might perhaps be superfically thought that since in the case at bar the ratification by Congress of the action of the treaty-making power was complete, the four dissenting judges could not necessarily be said to have differed with Mr. Justice White on the point in question. But since they admitted that the treaty was valid, and held that on *its ratification by the Senate,* the Constitution, and especially Art. 1, Sec. 8, was *ipso facto* extended to Porto Rico, it follows that this position was irreconcilably opposed to the views of Mr. Justice White.

[71] Such is the implication from the position of Mr. Justice Brown in DeLima *vs.* Bidwell, where he held that Porto Rico became by the treaty domestic territory.

to creating the territory acquired such part of the United States that all the provisions of the Constitution became *ipso facto* applicable. The right to acquire the territory was assumed: Mr. Justice White maintained that it was for Congress to determine its status and that of its inhabitants when so acquired, and that the treaty-making power had no such power.

It is submitted that too much emphasis should not be given to the language of Mr. Justice White. The circumstances under which he wrote do not require it—indeed, they rather militate against the binding force of his words. His argument that the exercise of the power "may wreck our institutions," simply states his political preference that a majority of each House of Congress shall have this power rather than the President and two-thirds of the Senate. There is, however, this forceful consideration back of Mr. Justice White's words, that it is not the function of the treaty-making power to legislate concerning the internal workings of government; and if "incorporation" were pushed to its fullest meaning, it might well be that the treaty-making power would exceed its functional offices if by the language of a treaty, it attempted, *propriore vigore,* to create a State. Certainly, if the treaty-making power should covenant that a State shall forthwith be carved out of a new territory acquired by treaty, such undertaking would have the force, neither more nor less, of a covenant to pay money. The contract might or might not be performed by Congress. The history of the exercise of the treaty-making power shows, however, as Mr. Justice White points out, that it has always been solicitous to reserve for the subsequent decision and action of Congress any and all questions of internal governmental legislation. The exigencies of party government and a proper regard for the dignity of the nation, would seem to unite in preventing the problem discussed from ever arising in the actual future history of the United States.

In one form, however, these very exigencies of property government have manifested themselves and created a precedent with respect to the acquisition of territory by the United States. When the question of the annexation of Texas was a subject of violent political controversy, a treaty was signed on April 12th, 1844, providing for its annexation. In the Senate were many irreconcilable opponents of the extension of slavery to which they believed this treaty would conduce, and on June 8th, it was rejected by a vote of 35 to 16.[72] After the presidential election favorable to annexation, a joint resolution was introduced, which, after a long and bitter debate, passed in both houses of Congress by a narrow majority.[73] Almost every possible view of the constitutional problems involved were taken by members of Congress in debate: it was said that a treaty was equivalent to a declaration of war on Mexico and unconstitutional, and that the joint resolution lacked any semblance of constitutional sanction, being really a negotiation with a foreign nation. The truth was and is, that annexation was deemed by the pro-slavery party, to be a vitally necessary measure, and they accomplished it in the only way they could, lacking as they did a two-thirds majority in the Senate, where the vote they mustered was 27 to 25.[74] Even this majority was obtained, as Dr. von Holst has conclusively shown, by attaching an amendment to the joint resolution authorizing the President to proceed by treaty, accompanied by representations that the President would adopt this alternative. But rapidly developing political conditions necessitated haste, and the promises on which a majority of senatorial votes had been secured, were disregarded.[75]

This precedent was followed in the annexation of Hawaii. Numerous treaties had been negotiated which had failed of ratification, and finally a joint resolution, reciting the assent of Hawaii by a treaty signed by both parties, but not ratified by the Senate, was passed by both Houses of Congress. Precisely two-thirds of the Senators present voted for the resolution but from the debates it would appear that a ratification of the treaty by the Senate could not have been secured.[76] It may therefore be accepted as politically

[72] *Congressional Globe,* Vol. 12, p. 698.

[73] Ibid., Vol. 14, p. 362 in Senate, p. 372 in House.

[74] See note 6.

[75] "Constitutional History of the United States," 1826–1896, Chap. VII.; 1846–1850, Chap. III.

[76] *Congressional Record,* Vol. 31, Part VII. Vote in Senate taken July 6, 1898, p. 6712.

determined constitutional law that acquisition of territory may be secured by act of Congress as well as by treaty. And in the case of Hawaii *vs.* Mankichi[77] the method adopted in the acquisition of Hawaii received express recognition and implied sanction by the Supreme Court. "The Treaty," said Mr. Justice Harlan, "was not formally ratified, but its object was accomplished by the passage of the Joint Resolution of July 7, 1898."[78]

The right of the treaty-making power to *cede* territory of the United States has been the subject of academic discussion, and in a few instances of judicial *dicta.* In Fort Leavenworth R. R. Co. *vs.* Lowe,[79] Mr. Justice Field, delivering the opinion of the Court, said as follows:

> "The jurisdiction of the United States extends over all the territory within the States, and, therefore, their authority must be obtained, as well as that of the State within which the teritory is situated, before any cession of sovereignty or political jurisdiction can be made to a foreign country. And so when questions arose as to the northeastern boundary, in Maine, between Great Britain and the United States, and negotiations were in progress for a treaty to settle the boundary, it was deemed necessary on the part of our government to secure the co-operation and concurrence of Maine, so far as such settlement might involve a cession of her sovereignty and jurisdiction as well as title to territory claimed by her, and of Massachusetts, so far as it might involve a cession of title to lands held by her."[80]

The point at issue in the case was whether the legislature of the State might cede its jurisdiction to the United States, and the opinion of the Court is to the effect that the right to cede to the general government was governed by wholly different considerations from the right to cede, if any existed, to a foreign nation. In Geofroy *vs.* Riggs,[81] the Court took occasion to remark:

> "The treaty-making power, as expressed in the Constitution, is in terms unlimited except by those restraints which are found in that instrument against the action of the government or of its departments, and those arising from the nature of the government itself and of that of the States. It would not be contended that it extends so far as to authorize what the Constitution forbids, or a change in the character of the government or in that of one of the States, or a cession of any portion of the territory of the latter, without its consent."[82]

[77] 190 U. S., 197 (1903).
[78] 190 U. S., p. 228.
[79] 114 U. S., 525 (1885).
[80] 114 U. S., pp. 540–1.
[81] 133 U. S., 258 (1890).
[82] 133 U. S., p. 267.

In Downes *vs.* Bidwell,[83] which case we have already fully considered, Mr. Justice White reviewed at considerable length the argument that territory might be ceded by the treaty-making power. He showed that Jefferson absolutely denied this right, and concluded:

"True, from the exigency of a calamitous war or the necessity of a settlement of boundaries, it may be that citizens of the United States may be expatriated by the action of the treaty-making power, impliedly or expressly ratified by Congress. But the arising of these particular conditions cannot justify the general proposition that territory which is an integral part of the United States may, as a mere act of sale, be disposed of."[84]

This question of the right of the treaty-making power to cede territory is wholly a political question, and when, if ever, it arises for determination, it will necessarily be determined upon wholly political considerations. If it be found necessary or advisable for the United States government to cede territory, the manner of the ceding will be immaterial. Whatever the National government does as a government will, it is apprehended, be recognized by the Supreme Court as a political act, and as a thing accomplished.

After the absolute prohibition contained in the first clause of Article I., Section 10, of the Constitution to the effect that no State shall enter into any treaty, the second clause forbids a State, *inter alia,* from entering into any agreement or compact with another State, or with a foreign power, without the consent of Congress. The meaning of this second clause is the subject of some academic interest. The difficulty is that an "agreement or compact with a foreign power" is a precise and accurate definition of a treaty, and the making of any treaty, with or without the consent of Congress, is forbidden to any State. In the absence of any judicial interpretation of this clause, the following explanation is submitted. There are two clauses on the subject because the Articles of Confederation had two, and the applicable text therein contained was the basis of the draft of the Constitution. There were two clauses in the Articles of Confederation because the first was concerned with treaties with foreign powers by the United States, and the second was concerned

[83] 182 U. S., 244 (1901).

[84] 182 U. S., p. 317.

with treaties among the States. When the committee of detail drafted their report, they retained the second clause because they desired to regulate adjustments between States. Accordingly, they used the words "agreement or compact" in lieu of "treaty, confederation, or alliance" because these sovereign acts were by the first clause absolutely denied to the States. The committee left in existence the power of the States to make arrangements and adjustments having no political significance, but, to guard against any abuse, required the consent of Congress. It was not unnatural that some draftsman added to the words "with another State," the phrase "or with a foreign power." They remain, however, redundant.

The decisions upon the force and effect of this second clause are strictly not relevant to the subject of this essay since they involve only the mutual relations of the States. In the thought, however, that they may serve to give a more complete understanding of the constitutional clauses under discussion, their significance may be briefly indicated. In Green *vs.* Biddle,[85] the validity of a compact made between Virginia and Kentucky came before the Supreme Court, and was sustained on the ground that it had been recognized by Congress. In Poole *vs.* Fleeger,[86] a compact between North Carolina and Tennessee was likewise sustained. In the more recent case of Virginia *vs.* Tennessee[87] the second clause of Article I., Section 10, of the Constitution, so far as it relates to agreements or compacts between States, receives an exhaustive examination and interpretation. It was held that the consent of Congress would be essential, "according as the establishment of the boundary line may lead or not to the increase of the political power or influence of the States affected, and thus encroach or not upon the full and free exercise of Federal authority."[88] In the case before the court, the consent of Congress was said to have been by implied ratification. In Wharton *vs.* Wise,[89] and in Stearns *vs.* Minnesota[90] the principles of construction enunciated in Virginia *vs.* Tennessee were again carefully examined, and applied.

[85] 8 Wheat., 1 (1823).
[86] 11 Peters, 185 (1837).
[87] 148 U. S., 503 (1893).
[88] 148 U. S., p. 520.
[89] 153 U. S., 155 (1894).
[90] 179 U. S., 223 (1900).

The question of the applicability to the treaty-making power of the first eight amendments to the Constitution (appended hereto as note 7) is one which should in this connection be considered. An examination of the Insular Cases will show that the question of the applicability of these amendments and of the other constitutional restrictions on State action, to the new possessions of the United States, revealed considerable divergence in opinion among the justices who decided these cases. Before these decisions it had been held that the amendments (the sixth and seventh were particularly in controversy) controlled the action of the United States in the District of Columbia, in the Indian Territory, and in the Territories generally.[91] After, however, Porto Rico, Hawaii, and the Philippines had been acquired, although the prior cases have been approved, a disposition has been manifested to apply a different principle toward determining the applicability of the constitutional restraints on Federal action. In Hawaii *vs.* Mankichi[92] the appellee had been convicted of manslaughter on an indictment not found by a grand jury, and by a vote of a petit jury of 9 to 3. This had been the usual course of procedure in Hawaii prior to annexation. The joint resolution of Congress had provided:

"The municipal legislation of the Hawaiian Islands, not enacted for the fulfillment of the treaties so extinguished, and not inconsistent with this joint resolution nor contrary to the Constitution of the United States nor to any existing treaty of the United States, shall remain in force until the Congress of the United States shall otherwise determine."

It was held that this resolution failed to state the *intention* of Congress, which could not have been, said the court, "to interfere with the existing practice when such interference would result in imperilling the peace and good order of the islands."[93] Mr. Justice White and Mr. Justice McKenna added their conviction that the constitutional provisions could not apply *in toto* upon annexation, but that the language of the congressional resolution "clearly

[91] Callan *vs.* Wilson, 127 U. S., 540 (1888), Cook *vs.* United States, 138 U. S., 157 (1891), American Publishing Company *vs.* Fisher, 166 U. S., 464 (1897), Thompson *vs.* Utah, 170 U. S., 343 (1898).

[92] 190 U. S., 197 (1903).

[93] 190 U. S., p. 214.

referred only to the provisions of the Constitution which were applicable and not to those which were inapplicable."[94] The Chief Justice and Justices Harlan, Brewer, and Peckham dissented. Said Mr. Justice Harlan in a learned and earnest opinion:

> [The principle underlying the decision of the majority of the Court] "would place Congress above the Constitution. It would mean that the benefit of the constitutional provisions designed for the protection of life and liberty may be claimed by some of the people subject to the authority and jurisdiction of the United States, but cannot be claimed by others equally subject to its authority and jurisdiction. . . . It would mean that, if the principles now announced should become firmly established, the time may not be far distant when, under the exactions of trade and commerce, and to gratify an ambition to become the dominant political power in all the earth, the United States will acquire territories in every direction, which are inhabited by human beings, over which territories, to be called 'dependencies' or 'outlying possessions,' we will exercise absolute dominion, and whose inhabitants will be regarded as 'subjects' or 'dependent peoples,' to be controlled as Congress may see fit, not as the Constitution requires, nor as the people governed may wish. Thus will be engrafted upon our republican institutions, controlled by the supreme law of a written constitution, a colonial system entirely foreign to the genius of our Government and abhorrent to the principles that underlie and pervade the Constitution. It will then come about that we will have two governments over the peoples subject to the jurisdiction of the United States, one existing under a written Constitution, creating a government with authority to exercise only powers expressly granted and such as are necessary and appropriate to carry into effect those so granted; the other, existing outside of the written Constitution, in virtue of an unwritten law to be declared from time to time by Congress, which is itself only a creature of that instrument."[95]

In Dorr *vs.* United States,[96] the decision in Hawaii *vs.* Mankichi is approved and followed.[97] The court lays down the following principle as controlling:

> "Until Congress shall see fit to incorporate territory ceded by treaty into the United States, we regard it as settled by that decision that the territory is to be governed under the power existing in Congress to make laws for such territories and subject to such constitutional restrictions upon the powers of that body as are applicable to the situation."[98]

[94] 190 U. S., p. 221.

[95] 190 U. S., pp. 238–40.

[96] 195 U. S., 138 (1904).

[97] See also the case of Rassmussen *vs.* United States, 197 U. S., 516 (1905), wherein the constitutional provisions were declared to be applicable to Alaska.

[98] 195 U. S., p. 143.

These decisions certainly find their sanction in political rather than in historical considerations. The question of the government of essentially colonial territory is a *political* not a *legal* question. The Supreme Court of the United States have therefore declared Congress to be the power which must judge and determine the applicability of constitutional provisions. Wise such action may be politically; but logically analyzed, to do this is to put Congress, the creature of the Constitution, above the Constitution.

The relation between the foregoing decisions and the applicability of the first eight amendments to the treaty-making power is not immediate. Yet, it will be readily concluded that if territory may be acquired by the treaty-making power without subjecting the government of that territory to constitutional provisions except by the action of Congress, such provisions can hardly be said to restrain the treaty-making power. The case of In re Ross[99] is of interest to us here. Therein, an English subject serving as a seaman on an American vessels, was tried for murder before a consular court sitting in Japan under the provisions of a treaty with that country, and was convicted. The trial was not in accordance with constitutional requirements. The Supreme Court held that since he was an American seaman, his nationality was immaterial, and that the Constitution was not ordained for countries outside the United States and could have no operation in another country. Said the Court:

"The treaty-making power vested in our government extends to all proper subjects of negotiation with foreign governments. It can, equally with any of the former or present governments of Europe, make treaties providing for the exercise of judicial authority in other countries by its officers appointed to reside therein. . . .

"The framers of the Constitution, who were fully aware of the necessity of having judicial authority exercised by our Consuls in non-christian countries, if commercial intercourse was to be had with their people, never could have supposed that all the guarantees in the administration of the law upon criminals at home were to be transferred to such consular establishments, and applied before an American who had committed a felony there could be accused and tried."[100]

[99] 140 U. S., 453 (1891).
[100] 140 U. S., pp. 463-5.

It is also interesting to note in this connection that rights to administer the estates of aliens dying here, have been by certain treaties granted by the United States to foreign consuls. No cases arising from these treaty provisions have reached the Federal courts, but they have been the subject of State recognition.[101]

Having regard to the decisions following the "Insular Cases," and bearing in mind the essential political and national character of the problems involved, it may be fairly concluded that when the question arises whether treaty provisions are subject to the constitutional restrictions on Federal action contained in the body of the Constitution and in the first eight amendments, the Supreme Court will judge of each case according to what it has called "the applicability" of the provision in question. And it may not be amiss to add that political considerations will be as potent as legal in determining that "applicability."

II.

The first question presented, as we have seen, when one examines into the fundamental nature of the treaty-making power is: When a treaty deals with a subject upon which Congress is authorized to legislate, is such treaty valid? or perhaps we should rather ask, what is its status?

There is an anomaly in the treaty-making power of the United States created by the Constitution which we must at this juncture consider. A treaty is, primarily, and with most nations solely, a contract with another sovereignty. In the United States, however, by the provisions of the Constitution it may have the force of a legislative enactment. In Article VI. it is provided:

> "This Constitution, and the laws of the United States which shall be made in pursuance thereof, and all treaties made, or which shall be made under the authority of the United States, shall be the supreme law of the

[101] On this point, see Matter of Lombrasciano, 77 N. Y. Supp., 1040 (1902), Matter of Fattosini, 67 N. Y. Supp., 1119 (1900), *In re* Wyman, 191 Mass., 276 (1906), Roca *vs.* Thompson, 157 Cal., 552 (1910). An appeal from this last case is pending in the Supreme Court of the United States. It would seem that it should be reversed, unless the interpretation given to the Italian treaty requires a different decision.

land; and the judges in every State shall be bound thereby, anything in the Constitution or laws of any State to the contrary notwithstanding."

This language is unique in the efficacy it would seem to give to provisions in treaties made under the authority of the United States, and its bearing is important on the question under discussion: namely, the status of treaties made respecting subjects committed to Congress for legislation. It is apparent that the courts are contemplated as the forum wherein the treaties are to be recognized as the supreme law of the land. It is apparent likewise that it is *individual* rights secured by treaties which the courts are to be open to enforce. With *political* questions arising under treaties, the judiciary could have nothing to do. Thus, this clause of the Constitution is not applicable to the problem of the necessity of congressional action when an appropriation is essential to make payment for territory purchased under treaty. The judiciary could not assume to force action by Congress, nor to usurp its functions. Neither is the clause applicable with respect to the acquisition or cession of territory. These national questions are political, and are not properly for the judiciary.

We turn therefore away from the examination of these solely political problems to that of individual rights—though political considerations will still intrude themselves. The true line of approach is through the proper interpretation and application of Article VI. of the Constitution. Professor Mikell is very clear and precise in his view of the meaning and effect of this article.

"So far," he says, "as the domestic or intraterritorial effect of the exercise of any of the powers committed by the Constitution to Congress are concerned, Congress alone has any power in the premises. But Congress has no power to treat with foreign nations, hence when any of these powers vested in Congress are to be exercised in agreement with a foreign power, the *agreement* with such foreign nation must first be completed by the treaty-making power, but this *agreement*, though it is a treaty in the meaning of that word as used in international law, is not a treaty in the sense intended by the Constitution when it says a treaty is the supreme law of the land. To be that it must be sanctioned by an act of Congress."[102]

[102] "The Extent of the Treaty-making Power of the President and Senate of the United States," by William E. Mikell, *U. of P. Law Review* and *American Law Register,* Vol. 57, p. 456.

Again, this same position is more conservatively suggested by another essayist who says, speaking of the Supreme Court of the United States:

> "It is still open for that Court to hold that no treaty dealing with matters entrusted to Congress is self-executing."[103]

If such statement be accurate, it is not because the Supreme Court has failed to discuss the question. In a series of cases about to be considered, the interpretation and application of Article VI. of the Constitution were flatly before the court. This analysis should determine the openness of the question whether or not treaties have the force of law when dealing with subjects committed to Congress.

Before entering upon this analysis, however, it may be well to record a contemporary interpretation of this clause which has come down to us. George Mason was a member of the Federal Convention from Virginia and was one of those who declined to sign the Constitution. He issued a short pamphlet giving his objections to that instrument, among which he included the operation of the treaty-making power. On this point he said:

> "By declaring all treaties supreme laws of the land, the Executive and the Senate have, in many cases, an exclusive power of legislation; which might have been avoided by proper distinctions with respect to treaties, and requiring the assent of the House of Representatives, where it could be done with safety."[104]

Mason was a Virginian of distinction and earnestly opposed the ratification of the Constitution by his State. He spoke frequently in the Virginia Convention, and neither in his speeches nor anywhere else in those debates, nor in the debates in the Federal Convention, is there to be found a suggestion that Mason's interpretation of the clauses establishing the treaty-making power was not the interpretation of all.

United States *vs*. Schooner Peggy[105] seems to have been the

[103] "The Extent and Limitations of the Treaty-making Power under the Constitution," by Chandler P. Anderson, *American Journal of International Law,* Vol. 1, Part II (1907), p. 654.

[104] Farrand, Vol. II., p. 639.

[105] 1 Cranch, 103 (1802).

earliest case in which the Supreme Court interpreted and applied the Sixth Article of the Constitution to an existing treaty. Therein, in accordance with the Act of Congress of July 9th, 1798, a decree of condemnation had been pronounced by the Circuit Court on September 23rd, 1800. On October 2nd, 1800, a writ of error was allowed to the Supreme Court. A treaty with France was signed September 30th, 1800. Mr. Chief Justice Marshall delivered the opinion of the Court, and held that the treaty operated at once *propriore vigore* to set aside the condemnation, which had not, while the writ of error was pending, become definitive within the meaning of the treaty. The Chief Justice said:

> "The Constitution of the United States declares a treaty to be the supreme law of the land. Of consequence, its obligation on the Courts of the United States must be admitted. It is certainly true that the execution of a contract between nations is to be demanded from, and, in the general, superintended by, the executive of each nation; and, therefore, whatever the decision of this Court may be relative to the rights of parties litigating before it, the claim upon the nation, if unsatisfied, may still be asserted. But yet where a treaty is the law of the land, and as such affects the rights of parties litigating in Court, that treaty as much binds those rights, and is as much to be regarded by the Court, as an act of Congress."[106]

It will be observed that the Act of 1798 was passed by Congress in the exercise of either or both of its powers to declare war and to regulate commerce. The treaty with France therefore was declared by this case to operate as a repeal of an act upon a subject expressly committed to Congress.

In Foster & Elam *vs.* Neilson,[107] the question of the effect to be given a treaty provision under Article VI. of the Constitution came again before the Supreme Court. It was a case of great importance, argued by Mr. Webster, among others, and resulted in an unanimous decision delivered by Mr. Chief Justice Marshall. The arguments are reported at length, and the assumptions underlying them have also their significance. The action was one in the nature of ejectment seeking to recover lands lying east of the Mississippi in what was at one time known as West Florida. The defendant relied on want of title in the plaintiff. He had set up a title derived

[106] Ibid., p. 109.
[107] 2 Peters, 253 (1829).

from a grant by the King of Spain dated in 1804, subsequent to the treaty of cession of Louisiana. The first question at issue was the extent of the cession. It was claimed that this did not extend to what was called West Florida, and it was shown that this had long been a controverted point on which Spain, France, and the United States had disputed until adjusted by the treaty with Spain signed February 22, 1819. It was urged that this dispute should now be judicially determined. The Acts of Congress respecting this territory including West Florida are recited by the Chief Justice, who then disposes of this first issue in the following words:

> "If those departments which are entrusted with the foreign intercourse of the nation, which assert and maintain its interests against foreign powers, have unequivocally asserted its rights of dominion over a country of which it is in possession, and which it claims under a treaty; if the Legislature has acted on the construction thus asserted, it is not in its own Courts that this construction is to be denied. A question like this respecting the boundaries of nations, is, as has been truly said, more a political than a legal question, and in its discussion, the Courts of every country must respect the pronounced will of the Legislature."[108]

The second point of controversy in this case was the effect to be given the treaty of 1819 above referred to. Did it or did it not, the Chief Justice proceeds to consider, operate to confirm all grants made by the King of Spain after the treaty of 1800 and prior to January 24th, 1818. The language of the treaty on this point was as follows:

> "All the grants of land made before the 24th of January, 1818, by his Catholic Majesty, or by his lawful authorities, in the said territories ceded by his Majesty to the United States, shall be ratified and confirmed to the persons in possession of the lands, to the same extent that the same grants would be valid if the territories had remained under the dominion of his Catholic Majesty."

Prior to the execution of this treaty, Congress had passed an act purporting to annul such grants, and after its execution by a series of acts it confirmed certain grants, among which was not, however, the plaintiff's. After quoting the extract from the treaty given above, the Chief Justice said:

> "Do these words act directly on the grants, so as to give validity to those

[108] Ibid., p. 309.

not otherwise valid; or do they pledge the faith of the United States to pass acts which shall ratify and confirm them?

"A treaty is in its nature a contract between two nations, not a legislative act. It does not generally effect, of itself, the object to be accomplished; especially so far as its operation is intra-territorial; but is carried into execution by the sovereign power of the respective parties to the instrument.

"In the United States a different principle is established. Our Constitution declares a treaty to be the law of the land. It is, consequently, to be regarded in Courts of Justice as equivalent to an Act of the Legislature, whenever it operates of itself without the aid of any legislative provision. But when the terms of the stipulation import a contract, when either of the parties engages to perform a particular act, the treaty addresses itself to the political, not the judicial department; and the legislature must execute the contract before it can become a rule for the Court.

"The article under consideration does not declare that all the grants made by his Catholic Majesty before the 24th day of January, 1818, shall be valid to the same extent as if the ceded territories had remained under his dominion. It does not say that those grants are hereby confirmed. Had such been its language, it could have acted directly on the subject, and would have repealed those Acts of Congress which were repugnant to it; but its language is that the grants shall be ratified and confirmed to the persons in possession, etc. By whom shall they be ratified and confirmed? This seems to be the language of contract; and if it is, the ratification and confirmation which are promised must be the Act of the Legislature. Until such Act shall be passed, the Court is not at liberty to disregard the existing laws on the subject."[109]

A decree was therefore entered adverse to the title of the plaintiff.

This case constitutes, therefore, a decision, first, that treaties must, if properly worded to convey such intention, "be regarded in Courts of Justice as equivalent to an act of the Legislature"; secondly, that they may, however, "import a contract only"; thirdly, that in the case at bar, the language used required Congress to execute the contract by the passage of an act before it could become a rule for the Court. There is nothing of the nature of *obiter dicta* in the decision of the Court. The grounds of the decision are expressly stated. It is, moreover, worthy of note that in the arguments of counsel the interpretation given in the court's opinion to Article VI. of the Constitution is assumed by counsel—one of whom was Mr. Webster—to whose interest it would have been to argue that the treaty "must be sanctioned by an Act of Congress" to

[109] Ibid., pp. 314–5.

become "a treaty in the sense intended by the Constitution when it says a treaty is the supreme law of the land." No better opportunity to enunciate this doctrine could have been presented. By Act of March 26th, 1804, Congress had provided that all such grants for lands as constituted the plaintiff's title, "are hereby declared to be, and to have been from the beginning, null, void and of no effect in law or equity." And yet the Court said: Had the treaty provided "that those grants are hereby confirmed," "it would have acted directly on the subject, and would have repealed those Acts of Congress which were repugnant to it." The act was passed in 1804 presumably under Article IV., Section 3, of the Constitution: "The Congress shall have power to dispose of and make all needful rules and regulations respecting the territory or other property belonging to the United States." The treaty was made *fifteen years* thereafter, and yet the Court held that it could have operated, by a slight change in phraseology sufficient to show an intention that its provisions should operate forthwith, as a repeal of the acts of Congress upon a subject of law so local and individual in its nature as the subject of land titles. To say that this case went off on the interpretation of the treaty, is to deal with the shadow of things.

It is to do more; it is to ignore the authority and significance of the numerous other cases decided shortly thereafter with reference to this same Spanish treaty. In United States *vs.* Percheman,[110] a case similar to that of Foster & Elam *vs.* Neilson, it was brought to the attention of the Court, that in the Spanish original of the treaty, the language used was equivalent to a confirmation by force of the treaty itself. Said Mr. Chief Justice Marshall:

"When we observe that in the counterpart of the same treaty, executed at the same time by the same parties, they are used in this sense, we think the construction proper, if not unavoidable.

"In the case of Foster *vs.* Elam, 2 Peters, 253, this Court considered considered these words as importing contract. The Spanish part of the treaty was not then brought to our view, and we then supposed that there was no variance between them. We did not suppose that there was even a formal difference of expression in the same instrument, drawn up in the language of each party. Had this circumstance been known, we believe it would have produced the construction which we now give to the article.

[110] 7 Peters, 51 (1833).

"This understanding of the article, must enter into our construction of the acts of Congress on the subject."[111]

After the death of Marshall in 1835, there followed a series of cases concerning these Spanish grants, in which was discussed the case of Foster & Elam *vs.* Neilson. The important ones are Strother *vs.* Lucas,[112] Garcia *vs.* Lee,[113] and Pollard *vs.* Kibbe.[114] Differences of opinion developed among the judges but each of them in explicit language adopted and approved the doctrine of Foster & Elam *vs.* Neilson that a treaty when made self-executing by its terms has the force of a legislative act. Thus in Garcia *vs.* Lee, Mr. Chief Justice Taney in delivering the opinion of the Court, unanimous upon this point,[115] said:

"If, therefore, this was a new question and had not already been decided in this Court; we should be prepared now to adopt all of the principles affirmed in Foster & Elam *vs.* Neilson, with the exception of the one since over-ruled in the case of the United States *vs.* Percheman, as hereinbefore stated."[116]

In arguing Foster & Elam *vs.* Neilson, it had been said:

"The plaintiffs invoke the aid of treaties. They place their claim upon the language of treaties which the Constitution has made the law of the land, and which cannot be annulled by the executive, or by the legislature."[117]

Apparently, therefore, doubt existed generally as to whether Congress by the passage of an act could in effect repeal the provisions of a treaty as operative local law.[118] The question was brought squarely before Mr. Justice Curtis sitting at circuit in 1855 in

[111] Ibid., p. 89.

[112] 12 Peters, 410 (1838).

[113] Ibid., 511 (1838).

[114] 14 Peters, 353 (1840).

[115] The single dissent of Mr. Justice Baldwin, as is apparent from his long opinion in Pollard *vs.* Kibbe, was based on the fact that he thought the interpretation put upon the treaty in United States *vs.* Percheman should be followed out further than the remaining members of the Court had determined in Garcia *vs.* Lee.

[116] 12 Peters, p. 522.

[117] 2 Peters, p. 277.

[118] Writing in *The Federalist,* Jay had said: "The proposed Constitution has not in the least extended the obligation of treaties. They are just as binding and just as far beyond the lawful reach of legislative acts now as they will be at any future period or under any form of government."

Taylor *vs.* Morton.[119] Congress had passed a customs act alleged to be in contravention of an existing treaty with Russia; and the judge held that it was wholly immaterial to inquire whether the statute departed from the treaty, inasmuch as it was the prerogative of Congress to determine whether a treaty should be kept or abrogated, and that the will of Congress expressed in a statute was obligatory on the judiciary, whether the departure from the treaty was accidental or designed, or the reasons therefor, if designed, were good or bad.

This question reached the Supreme Court in 1870 in the case of The Cherokee Tobacco,[120] wherein an act of Congress was in conflict with the existing treaty with the Cherokee nation. Said the Court:

> "Undoubtedly one or the other must yield. The repugnancy is clear and they cannot stand together. . . . The effect of treaties and acts of Congress, when in conflict, is not settled by the Constitution. But the question is not involved in any doubt as to its proper solution. A treaty may supersede a prior Act of Congress (Foster & Elam *vs.* Neilson is here quoted in the margin), and an Act of Congress may supersede a prior treaty (Taylor *vs.* Morton is here quoted in the margin). In the cases referred to these principles were applied to treaties with foreign nations."[121]

The Court therefore held that they applied equally to treaties with Indian tribes, and that the statute must prevail over the provisions of an earlier treaty. There are several interesting points to note here. The first is that Foster & Elam *vs.* Neilson is quoted as establishing the principle that "a treaty may supersede a prior act of Congress." Surely if it may do that, it is not necessary in order that it should become effective as a law of the land that it "be sanctioned by an act of Congress." In the case under discussion, the Act of Congress was passed under the power "to regulate commerce with foreign nations, and among the several States, and with the Indian tribes." There had been an effective treaty regulating commerce. Was it invalid as it dealt with a subject expressly committed to Congress? Such an idea never entered the minds of the Court. In truth, while constitutional interpretation was forming

[119] 2 Curtis, 454 (1855).
[120] 11 Wall., 616 (1870).
[121] 11 Wall, pp. 620–1.

into that body we now know as constitutional law, the recognition of treaties as embodying the supreme law of the land is seen as universal. The assumption of this principle of interpretation underlies every argument, every decision, every reason enunciated as the ground of decision. The query in some minds, as for example, those of counsel in Foster & Elam *vs.* Neilson quoted above, was quite different. They questioned the *effectiveness* of an act of Congress in conflict with a prior treaty.

Following The Cherokee Tobacco case came The Head Money Cases;[123] and the question therein was whether an act of Congress was valid which imposed on ship owners a small tax for each immigrant brought into the United States, and provided that the proceeds should be used for the benefit of immigrants as a class. The Court remarked:

"We had supposed that the question here raised was set at rest in this Court by the decision in The Cherokee Tobacco."[123]

And the Court held:

"We are of opinion that, so far as a treaty made by the United States with any foreign nation can become the subject of judicial cognizance in the Courts of this Country, it is subject to such acts as Congress may pass for its enforcement, modification, or repeal."[124]

On the subject of the status of treaties under the Constitution, the Court lays down the following controlling principles:

"A treaty is primarily a compact between independent nations. It depends for the enforcement of its provisions on the interest and the honor of the governments which are parties to it. If these fail, its infraction becomes the subject of international negotiations and reclamations, so far as the injured party chooses to seek redress, which may in the end be enforced by actual war. It is obvious that with all this, the judicial Courts have nothing to do and can give no redress. But a treaty may also contain provisions which confer certain rights upon the citizens or subjects of one of the nations residing in the territorial limits of the other, which partake of the nature of municipal law, and which are capable of enforcement as between private parties in the Courts of the country. . . . A treaty, then, is a law of the land as an act of Congress is, whenever its provisions prescribe a rule by which the rights of the private citizen or subject may be determined. And

[122] 112 U. S., 584 (1884).
[123] Ibid., p. 597.
[124] Ibid., p. 599.

when such rights are of a nature to be enforced in a Court of justice, that Court resorts to the treaty for a rule of decision for the case before it as it would to a statute."[125]

To say, in a case where the Act of Congress under discussion was sustained as a regulation of commerce, that "a treaty is a law of the land as an act of Congress is," is flatly inconsistent with the doctrine that a treaty must to receive recognition "be sanctioned by an act of Congress." And the opinion quoted was that of Mr. Justice Miller acquiesced in by the whole Court.

The case of United States *vs.* 43 Gallons of Whiskey[126] has been passed over for the moment. Therein the question was as to the effect of a treaty with the Chippewa Indians proclaimed May 5, 1864. By Article VII. thereof, it was provided that the laws of the United States respecting the sale of liquors in the Indian country should be in full force throughout the country thereby ceded. This ceded territory had become part of the State of Minnesota. The Court sustained the efficacy of the provisions in the treaty and said:

"The Constitution declares a treaty to be the supreme law of the land; and Chief-Justice Marshall, in Foster & Elam *vs.* Neilson, has said, 'that a treaty is to be regarded, in Courts of justice, as equivalent to an Act of the Legislature, whenever it operates of itself, without the aid of any legislative provision.' No legislation is required to put the Seventh Article in force; and it must become a rule of action, if the contracting parties had power to incorporate it in the treaty of 1863. About this there would seem to be no doubt."[127]

This is another case where a united court concurred in Mr. Chief Justice Marshall's view respecting the meaning of Article VI. of the Constitution and the consequent efficacy of treaty provisions even when not "sanctioned by an Act of Congress."

It will be best to consider together the Chinese Exclusion Cases, and therefore the case of United States *vs.* Rauscher[128] next deserves attention. It arose under the provisions of an extradition treaty and decides that under its proper construction a person demanded and received from Great Britain in accordance with its provision, cannot be tried for a crime other than the one for which he was extradited. In the course of the opinion the language of

[125] Ibid., pp. 598–9.

[126] 93 U. S., 188 (1876).

[127] Ibid., p. 196.

[128] 119 U. S., 407 (1886).

Mr. Chief Justice Marshall in Foster & Elam *vs.* Neilson and of Mr. Justice Miller, already quoted above, is unanimously approved and set forth in full.[129]

The cases of Bartram *vs.* Robertson[130] and Whitney *vs.* Robertson[131] will be next considered. These grew out of a treaty made January 30th, 1875, with the King of the Hawaiian Islands providing for the importation free of duty into the United States of certain produce of these islands. It was held in the former case that the existing treaty with Denmark, and in the latter case that the existing treaty with the Dominican Republic, did not by the provisions therein contained against discrimination in favor of products of other countries, operate to cause the existing tariff to be lowered in favor of those nations. The ground given in Bartram *vs.* Robertson for this decision was that the treaty stipulations relied on, "even if conceded to be self-executing by the way of a proviso or exception to the general law imposing the duties, do not cover concessions like those made to the Hawaiian Islands for a valuable consideration." In Whitney *vs.* Robertson the former case is quoted with approval, and the same ground is given for the decision. The Court then proceeds to state as a second controlling consideration the fact that the Act of Congress under which the duties were collected on importations from San Domingo, was subsequent in date to the treaty. On this point the Court quoted with approval Taylor *vs.* Morton, and Head Money Cases, and said:

> "If the treaty contains stipulations which are self-executing, that is, require no legislation to make them operative, to that extent they have the force and effect of a legislative enactment. Congress may modify such provisions, so far as they bind the United States, or supersede them altogether. By the Constitution a treaty is placed on the same footing, and made of like obligation, with an Act of legislation. Both are declared by that instrument to be the supreme law of the land, and no superior efficacy is given to either over the other."[132]

This is the language of Mr. Justice Field speaking for a united Court in a case involving the comparative efficacy of treaty provisions and an Act of Congress respecting *duties*. Can it be said

[129] Ibid., pp. 418–9.
[130] 122 U. S., 116 (1887).
[131] 124 U. S., 190 (1888).
[132] Ibid., p. 194.

that the Court which decided this case, thought it open to them to hold that no treaty on this subject *could* be self-executing? To so suggest is to make nonsense of the language quoted: "By the Constitution a treaty is . . . made of like obligation with an Act of legislation." The judge is speaking of treaties and acts respecting duties on foreign commerce. Is it possible to maintain that the Court thought that a treaty made self-executing in its terms had no efficacy in a case respecting duties?

The Chinese Exclusion Cases had popular interest and political significance. Necessarily, the ability of the counsel who argued them was high; all that could be said was presumably said in arguing this long succession of cases before the Supreme Court. Yet nowhere creeps in a suggestion that the provisions of the treaties with China dealing with and regulating commerce and immigration, are ineffective as laws; indeed, the cases are suffused with the light of the contrary assumption and constitute direct and positive decisions recognizing and establishing the efficacy of treaty provisions *propriore vigore*.

In 1881, a treaty with China was ratified looking to the regulation by the United States of the immigration of Chinese laborers. In 1882 Congress passed a regulating Act, and in 1884 a supplementary Act under which it required of Chinese about temporarily to leave, to secure a certificate which should be the only evidence permissible to establish a right of reëntry. Afterwards, in 1888, Congress passed an Act absolutely forbidding the return to the United States of any Chinese who had departed or who should depart. In 1884, in the case of Chew Heong *vs.* United States,[133] the Court held that the Act of 1884 should not be interpreted to bar out Chinese who had left the country before the Act, and therefore could not be in possession of the required certificate. The chief ground of this decision was that the treaty and the Act had the same authority and should therefore, if possible, be so construed as to be mutually consistent; so as to avoid the necessary alternative of holding that the later law repealed by implication the treaty.

"A treaty," said the Court, "that operates of itself without the

[133] 112 U. S., 536 (1884).

aid of legislation is equivalent to an Act of Congress, and while in force constitutes a part of the Supreme power of the land. Foster *vs.* Neilson."[134] Mr. Justice Field dissented on the ground that the act was too plain to permit of any interpretation consistent with the treaty. As to the principle regulating the subject, he said:

"A treaty is in its nature a contract between two or more nations, and is so considered by the writers on public law; and by the Constitution it is placed on the same footing and made of like obligation as a law of the United States. Both are declared in that instrument to be the supreme law of the land, and no paramount authority is given to either over the other.

"Some treaties operate in whole or in part by their own force, and some require legislation to carry their stipulations into effect. . . . If the treaty relates to a subject within the power of Congress and operates by its own force, it can only be regarded by the Courts as equivalent to a legislative act. Congress may, as with an ordinary statute, modify its provisions, or supersede them altogether."[135]

Here is language directly contrary to the modern essayist's idea of the openness of the question whether a treaty may deal with a subject committed to Congress. "*If*," says Mr. Justice Field, and on that point the whole Court concurred, "*the treaty relates to a subject within the power of Congress and operates by its own force, it can only be regarded by the courts as equivalent to a legislative act.*"

After Congress had, in 1888, as above stated, unqualifiedly legislated against the return of Chinese laborers who had once left this country, the Supreme Court in Chae Chan Ping *vs.* United States,[136] sustained the constitutionality of this statute. Mr. Justice Field delivered the opinion of the Court, and said:

"It must be conceded that the Act of 1888 is in contravention of express stipulations of the treaty of 1868 and of the supplemental treaty of 1880, but it is not on that account invalid or to be restricted in its enforcement. The treaties were of no greater legal obligation than the Act of Congress. By the Constitution, laws made in pursuance and treaties made under the authority of the United States are both declared to be the supreme law of the land, and no paramount authority is given to one over the other. . . . If the treaty operates by its own force, and relates to a subject within the powers of Congress, it can be deemed in that particular only the equivalent of a legislative Act, to be repealed or modified at the pleasure of Congress. In either case the last expression of the sovereign will must control."[137]

[134] Ibid., p. 540.
[135] Ibid., pp. 562–3.
[136] 130 U. S., 581 (1889).
[137] Ibid., p. 600.

These Chinese Exclusion Cases are followed by innumerable others dealing with one aspect or another of the treaties and the statutes concerning the subject. Every decision approves the cases analyzed above, and, inwoven with the reasoning on which they are based, appears the reiteration of the equal efficacy of treaty provision and statute law upon a subject within the power of Congress. The proposition that a treaty provision has no force until "sanctioned by an act of Congress" would have met with impatient astonishment if uttered to the judges who decided these cases.

In Geofroy *vs.* Riggs[138] there is a most interesting and positive holding that a treaty may operate of its own force to repeal an act of Congress. The question presented was, in the language of the Court: "Can citizens of France take land in the District of Columbia by descent from citizens of the United States?" On February 27th, 1801, by Act of Congress it was provided "that the laws of the State of Maryland as they now exist shall be and continue in force in that part of the said District which was ceded by that State to the United States and by them accepted." After examining the law of Maryland at that date, the Supreme Court held that it established the disability of aliens to inherit. But, said the Supreme Court, the treaty with France of 1853 provided that the President shall recommend to the several States the passage of acts conferring the right of holding real estate upon Frenchmen; the word "States" must have been used as equivalent to political communities; since there could be no plausible motive for discrimination between the States, on the one hand, and the District of Columbia and the Territories, on the other, the intention of the treaty must have been to give French citizens the right of acquiring real estate by descent. Accordingly, the right of the French claimants was sustained. The Act of 1801 was passed by Congress in pursuance of its constitutional power "to exercise exclusive legislation in all cases whatsoever, over such district (not exceeding ten miles square) as may, by cession of particular States, and the acceptance of Congress, become the seat of the government of the United States."[139] Yet the decision of this case is indisputably

[138] 133 U. S., 258 (1889).

[139] Article I., Sec. 7.

and unqualifiedly that the treaty operated of its own force to supersede the Act of Congress.

In Nishimura Ekiu *vs.* United States,[140] the constitutionality of an Act of Congress forbidding certain classes of aliens to land, was challenged, but was sustained. The Court in its opinion recognized the adequacy of the treaty-making power to deal with the subject.

> "It belongs," the Court said, "to the political department of the government, and may be exercised either through treaties made by the President and Senate, or through Statutes enacted by Congress, upon whom the Constitution has conferred power to regulate commerce with foreign nations, including the entrance of ships, the importation of goods, and the bringing of persons into the ports of the United States."[141]

The case of United States *vs.* Lee Yen Tai[142] arose out of the treaty with China of 1894, and the contention was made that that treaty repealed or superseded the existing Acts of Congress. The Court recited with approval the authorities analyzed above, and held that the purpose to abrogate a treaty by a statute must clearly appear, that in the case at bar the statute and treaty were "in absolute harmony" and consequently that interpretation was certified to the lower court.[143] Is it possible for one moment to maintain that this decision is consistent with the thought that the treaty could *not* have superseded the prior acts? The Court say: first, if the treaty be inconsistent with the continued existence of the acts, they are to be regarded as repealed; second, there is no inconsistency. The first proposition is as absolutely a decision of the Court as the latter. Again, in the very recent case of Johnson *vs.* Browne,[144] we have again the question presented of whether a treaty has operated to repeal a prior statute. The decision was to the effect that they were readily reconcilable. It was a case of extradition, but there is no hint of distinction upon this ground.

In DeLima *vs.* Bidwell, in the opinion reported as that of the Court, we have an emphatic modern reiteration and approval of the authorities just analyzed. After quoting from the constitutional provision, the Court say:

> "It will be observed that no distinction is made as to the question of

[140] 142 U. S., 651 (1892).

[141] Ibid., p. 659.

[142] 185 U. S., 213 (1902).

[144] 205 U. S., 309 (1907).

supremacy between laws and treaties, except that both are controlled by the Constitution. A law requires the assent of both houses of Congress, and, except in certain specified cases, the signature of the President. A treaty is negotiated and made by the President, with the concurrence of two thirds of the Senators present, but each of them is the supreme law of the land."[145]

The authorities are then quoted with approval.[146]

In Fok Yung Yo *vs.* United States,[147] the treaty of 1894 with China, under consideration in United States *vs.* Lee Yen Tai, came again before the United States Supreme Court. By Article 3 it was "agreed that Chinese laborers shall continue to enjoy the privilege of transit across the territory of the United States in the course of their journey to or from other countries, subject to such regulations by the Government of the United States as may be necessary to prevent such privilege of transit from being abused." On December 8th, 1900, the Secretary of the Treasury, acting under this treaty, issued regulations to the collectors of customs. A collector, acting under these regulations, refused to permit the plaintiff to land. His action was sustained by the Supreme Court, who recited the paragraph of the treaty quoted above and said:

"We regard this as explicitly recognizing existing regulations, and as assenting to their continuance, and to such modification of them as might be found necessary to prevent abuse. It dealt with the subject specifically, and was operative without an Act of Congress to carry it into effect."[148]

This is certainly a decision that a provision in a treaty leaving it to the executive to regulate commerce in certain particulars, is valid without an act of Congress, and that regulations made under it are enforceable.

Inasmuch as the Supreme Court has spoken so often, so uniformly, so positively, upon the question discussed in the preceding cases, it would seem almost a work of supererogation to inquire how many treaties have been made regulating commerce, and put into effect without any act of Congress. In Baldwin *vs.* Franks,[149] decided in 1887, Mr. Justice Fields recited a list. There are, he said,

"clauses found in some treaties with foreign nations, stipulating that the subjects or citizens of those nations may trade with the United States, and,

[145] 182 U. S., p. 195.
[146] See note 9.
[147] 185 U. S., 296 (1902).
[148] 185 U. S., p. 303.
[149] 120 U. S., 678 (1887).

for that purpose, freely enter our ports with their ships and cargoes, and reside or do business here. Thus the treaty of commerce with Italy of February 26, 1871, provides that 'Italian citizens in the United States, and citizens of the United States in Italy, shall mutually have liberty to enter, with their ships and cargoes, all the ports of the United States and of Italy respectively, which may be open to foreign commerce. They shall also have liberty to sojourn and reside in all parts whatever of said territories.' Article 1, 17 Stat. 845. Those stipulations operate by their own force; that is, they require no legislative action for their enforcement. Treaty of Commerce with Great Britain in 1815, Article 1, 8 Stat. 228; renewed and continued for ten years by Article 4 of the treaty of 1818, 8 Stat. 249; and continued indefinitely by Article 1 of the treaty of 1827, 8 Stat. 361; treaty with Bolivia of May 13, 1838, Article 3, 12 Stat. 1009; treaty with Costa Rica of July 10, 1851, Article 2, 10 Stat. 917; treaty with Greece of December, 1837, Article 1, 8 Stat. 498; treaty with Sweden and Norway of July 5, 1827, Article 1, 8 Stat. 346.

"The right or privilege being conferred by the treaty, parties seeking to enjoy it take whatever steps are necessary to carry the provisions into effect. Those who wish to engage in commerce enter our ports with their ships and cargoes; those who wish to reside here select their places of residence, no congressional legislation being required to provide that they shall enjoy the right and privileges stipulated."[150]

During the period covering the cases which we have analyzed many justices sat upon the bench of the Supreme Court of the United States; yet not one dissented when it was repeatedly held that a treaty may by its terms be made self-executing and is then to have the force of an act of Congress; that this principle was true even when the subject dealt with was one committed by the Constitution to the legislation of Congress; that where provisions of treaties and statutes conflict and there fails the effort to reconcile them (always the duty of a Court when possible), the latest in point of date must prevail. These principles have become part of constitutional law. Such is the conclusion written for us by the long line of cases, the analysis of which we have just concluded. And yet it is said by one essayist today that the question is open for the Supreme Court "to hold that no treaty dealing with matters entrusted to Congress is self-executing";[151] and for another essayist to maintain "that so far as the domestic and intra-territorial effect of the exercise

[150] Ibid., pp. 703–4.

[151] C. P. Anderson, *American Journal of International Law*, Vol. I., Part II., p. 654.

of any of the powers committed by the Constitution to Congress are concerned, Congress alone has any power in the premises," and no treaty has any domestic force "in the sense intended by the Constitution when it says a treaty is the supreme law of the land." "To be that," adds Professor Mikell, "it must be sanctioned by an Act of Congress."[152] How is it possible—the question obtrudes itself—for these views to be put forward? One superficial explanation might be that, in an essay on this subject covering fifty-nine printed pages, Professor Mikell has deemed it unnecessary to discuss a single one of the cases analyzed above, beginning with United States *vs.* Schooner Peggy, and Foster & Elam *vs.* Neilson, decided in 1801 and 1829 respectively, and ending with Johnson *vs.* Browne, decided in 1907.[153] And it will hardly be proper to do otherwise than assume that the members of Congress who spoke on the subject were familiar with these cases. But the determining reason lies deeper and resides in a confusion of thought and an overlooking of a distinction already indicated. Article VI. of the Constitution deals with *individual* rights secured by treaty provisions and not with *national* questions. In this national aspect, it is to the political side of the government that questions respecting treaties address themselves, and with those, as we have seen, the Courts can have nothing to do: Article VI. of the Constitution has no application. So with the acquisition and cession of territory; so with treaties undertaking in the form of a contract that something shall be done. It is for Congress to meet the national obligation, or, in a grave issue, to exercise its discretion in repudiating the undertaking of the government and disavowing its treaty obligations. So formally and avowedly in 1798 did Congress act respecting the treaties with France, so in effect did Congress act, as has been seen, in regard to the treaty with China. And it is likewise true that in questions of tariff duties, affecting the nation vitally and creating as well individual rights and

[152] *American Law Register,* Vol. 57, p. 456.

[153] Of them, Mr. Mikell only mentions one—Geofroy *vs.* Riggs—as authority for a definition, two others—The Cherokee Tobacco, and Head Money Cases—to make from them quotations in a note, and two more—Whitney *vs.* Robertson, and Taylor *vs.* Morton—as authority for the fact that an act of Congress may repeal a treaty.

obligations, there is a natural resolution of forces in favor of joint action by the treaty-making power and by Congress. Party government tends that way; a sense of responsibility toward the people and of delicacy toward the other contracting nation, would wish to avoid any possible friction. Today it has become a matter almost of legislative precedent, that Congress shall fix duties when questions of reciprocity arise.[154] The present action of the government with respect to Canadian reciprocity above set forth is a conspicuous and opportune example. This is legislative precedent of high significance as to future political action: it is no more. The validity of treaty provisions dealing with this and kindred subjects is sustained and controversy thereon foreclosed by the series of cases examined. Apart from the undeviating current of declared doctrine on the subject, the cases of United States *vs.* Schooner Peggy,[155] and of Geofroy *vs.* Riggs[156] are judgments that certain Acts of Congress were superseded by treaty provisions, while the case of Fok Yung Yo *vs.* United States[157] gives to a treaty the effect of a statute. If a treaty be neither of wholly national import nor executory in its nature, and assume to create and declare individual rights and obligations, then those rights and obligations must, if the treaty itself is to have the force of law, have the same validity as though created by legislative action and receive recognition in the courts. There is no escape from this position. Assume the premise that Article VI. of the Constitution means what it says, and logic itself writes the conclusion. But if legislative action were necessary to give treaty provision the force of law intraterritorially, then not the *treaty* but the *legislative act* would be "the supreme law of the land," Article VI. *qua treaties,* means nothing, and the statement, that a treaty to be the supreme law of the land "must be sanctioned by an act of Congress" lacks logical coherence. As well say that a recommendation in a President's message is "the supreme law of the land when sanctioned by an act of Congress." Either treaty provisions can, without further action, give to the rights created and declared thereby the force of law, or they cannot. If not, they cannot be called "the supreme law of the land."

[154] *Supra,* pp. 38–42.
[155] *Supra,* pp. 76–78.
[156] *Supra,* pp. 95–97.
[157] *Supra,* p. 101.

It is judicial utterance and judicial precedence which will determine the validity of a treaty dealing with subjects committed to the legislation of Congress, and the Supreme Court will beyond peradventure follow the long line of its recorded decisions. But if the opinions of members of Congress come with such authority to some, why is it not wisest to listen to one who himself signed the Constitution and lived among the men and the events which created it? On the floor of the House on January 10, 1816, Charles C. Pinckney thus spoke:

"I lay it down as an incontrovertible truth, that the constitution has assumed (and indeed how could it do otherwise) that the government of the United States might and would have occasion, like the other governments of the civilized world, to enter into treaties with foreign powers, upon the various subjects, involved in their mutual relations; and further, that it might be, and was proper to designate the department of the government in which the capacity to make such treaties should be lodged. It has said accordingly, that the president, with the concurrence of the senate, shall possess this part of the national sovereignty; it has, furthermore, given to the same magistrate, with the same concurrence, the exclusive creation and control of the whole machinery of diplomacy. He ouly, with the approbation of the senate, can appoint a negotiator, or take any step towards a negotiation. The constitution does not, in any part of it, even intimate that any other department shall possess either a constant or an occasional right to interpose in the preparation of any treaty, or in the final perfection of it. The president and senate are explicitly pointed out as the sole actors in that sort of transaction.

"The prescribed concurrence of the senate, and that too by a majority greater than the ordinary legislative majority, plainly excludes the necessity of congressional concurrence. If the consent of congress to any treaty had been intended, the constitution would not have been guilty of the absurdity of putting a treaty for ratification to the president and senate exclusively, and again to the same president and senate, as portions of the legislature. It would have submitted the whole matter at once to Congress; and the more especially, as the ratification of a treaty by the senate, as a branch of the legislature, may be by a smaller number than a ratification of it by the same body, as a branch of the executive government. If the ratification of any treaty by the president, with the consent of the Senate, must be followed by a legislative ratification, it is a mere nonentity. It is good for all purposes, or for none. And if it be nothing in effect, it is a mockery by which nobody would be bound. The President and senate would not themselves be bound by it; and the ratification would at last depend, not upon the will of the president and two thirds of the senate, but upon the will of a bare majority of the two branches of the legislature, subject to the qualified legislative control of the President.

"Upon the power of the President and senate, therefore, there can be no doubt. The only question is, as to the extent of it; or, in other words, as to the subject upon which it may be exerted. The effect of the power, when exerted within its lawful sphere, is beyond the reach of controversy. The constitution has declared, that whatsoever amounts to a treaty made under the authority of the United States, shall immediately be supreme law. It has contradistinguished a treaty as law, from an act of congress as law. It has erected treaties, so contradistinguished, into a binding judicial rule. It has given them to our courts of justice, in defining their jurisdiction, as a portion of the lex terra, which they are to interpret and enforce. In a word, it has communicated to them, if ratified by the department which it has specially provided for the making of them, the rank of law—or it has spoken without meaning. And, if it has elevated them to that rank, it is idle to attempt to raise them to it by ordinary legislation.

"It is clear, that the power of congress, as to foreign commerce, is only what it professes to be in the constitution, a legislative power—to be exerted municipally, without consultation or agreement with those with whom we have an intercourse of trade. It is undeniable, that the constitution meant to provide for the exercise of another power relatively to commerce, which should exert itself in concert with the analogous power in other countries; and should bring about its results, not by statute enacted by itself, but by an international compact called a treaty; that it is manifest, that this other power is vested by the constitution in the president and senate, the only department of the government which it authorizes to make any treaty, and which it enables to make all treaties; that if it be so vested, its regular exercise must result in that which, as far as it reaches, is law in itself—and, consequently, repeals such municipal regulations as stand in its way; since it is expressly declared by the Constitution, that treaties regularly made, shall have, as they ought to have, the force of law."[158]

III.

The second fundamental question presented, as we have seen, by an analysis of the functions of the treaty-making power, is: When a treaty deals with a subject upon which the State as opposed to Congress are authorized to legislate, is such treaty valid? or rather, what is its status?

An historical and inductive study of the cases upon a given subject is beyond doubt the best method of approach toward its comprehension, when the question is one having its origin in judicial precedent. But when the question be primarily one of interpretation of a written instrument, it becomes clear that the facts sur-

[158] Elliott's Debates, Vol. IV., pp. 276–8, Ed. of 1830.

rounding the creation of that instrument must first be analyzed and understood before an attempt be made to follow the judicial interpretation thereof.

The language of the Constitution is as follows:

"All treaties made, or which shall be made, under the authority of the United States, shall be the supreme law of the land; and the judges in every State shall be bound thereby, anything in the Constitution or laws of any State to the contrary notwithstanding."[159]

These plain and precise words of the Constitution have not sufficed to impress their apparent meaning upon the minds of many. Accordingly the essayist already quoted thus concludes his discussion of the question now before us: The doctrine that the treaty-power "is supreme over the reserved rights of the States is by no means established in our jurisprudence."[160]

One may venture the surmise that were the question free from *political* significance, no such effort to escape the evident meaning of English words would be conceived to be possible. But the question *has* its political aspect, has always had it; and the doubt of political opponents born of their wishes has again been uttered.

It is easy for the lawyer to fall into the error of regarding the Constitution as a neutral document susceptible of diverse interpretation according as its critic be a States-right advocate or a Federalist. *Any* document viewed through political eyes is susceptible of such treatment: the political critic is capable in the interests of party of any brutality of interpretation. And it is true that the existence of a political aspect to all constitutional questions has always and necessarily been realized by the Supreme Court. But what is *not* always borne in mind is the historical fact that the advocates and opponents of an effective Federal government, superior within the scope of its activities to the State governments, fought out their differences at the time of the creation of the Constitution, and the advocates won.. Here and there through the Constitution are concessions made to the opponents: the Senate with its equality of State representation guaranteed to be inviolable, the slavery clauses, the first ten amendments. But in its fundamental essentials the Consti-

[159] Article VI., Clause 2.
[160] *American Law Register,* Vol. 57, p. 554.

tution was written by Federalists who well knew what they wished to achieve. There were the three activities of the new nation, the legislative, the executive, the judicial; and into its hands were placed, as Patrick Henry complained, the purse and the sword:[161] it was given the power to tax, it could command an army to do its will. To guard these powers a new judiciary—the Federal—was created, to whom was committed the interpretation of this Constitution—a power never before in the world's history vested in any court. Not adventitiously nor by the caprice of smiling fate, did those words, constituting treaties and acts of Congress the supreme law of the land, come into the Constitution. Against persistent, bitter, and all but successful opposition, the Federalists wrote them into the Constitution; and once there, by the mouth of that great Federalist John Marshall, they were interpreted to mean precisely what they said.

Under the Articles of Confederation any effective government was demonstrated to be impossible to the United States. Among the existing difficulties stood out prominently two: lack of means to secure money for the general government; neglect of the several States to recognize the provisions of treaties negotiated by the United States.

Congress had unanimously ratified the treaty of peace with Great Britain in 1783. By its provisions, "The great and principal objects," to use the language of the Supreme Court in afterwards construing it,

> "were *three* on the part of Great Britain, to wit, 1st: a recovery by British Merchants, of the value in sterling money of debts contracted, by the citizens of America, before the treaty. 2nd: Restitution of the confiscated property of real British subjects, and of persons residents in districts in possession of the British forces, and who had not borne arms against the United States; and a conditional restoration of the confiscated property of all other persons: and 3rdly: A prohibition of all future confiscations, and prosecutions."[162]

The Court continues:

> "The following facts were of the most public notoriety, at the time when the treaty was made, and therefore must have been very well known to

[161] Elliott's Debates, Vol. II., p. 539, Ed. of 1854.
[162] Ware *vs.* Hylton, 3 Dallas, p. 238.

the gentlemen who assented to it. 1st. That British debts, to a great amount, had been paid into some of the State Treasuries, or loan offices, in paper money of very little value, either under laws confiscating debts, or under laws authorizing payment of such debts in paper money, and discharging the debtors. 2nd. That tender laws had existed in all the States; and that by some of those laws, a tender and a refusal to accept, by principal or factor, was declared an extinguishment of the debt. From the knowledge that such laws had existed there was good reason to fear that similar laws, with the same or less consequences, might be again made (and the fact really happened), and prudence required to guard the British creditor against them. 3rd: That in some of the States property, of any kind, might be paid, at an appraisement, in discharge of any execution. 4th: That laws were in force in some of the States, at the time of the treaty, which prevented suits by British creditors. 5th: That laws were in force in other of the States, at the time of the treaty, to prevent suits by any person for a limited time. All these laws created legal impediments, of one kind or another, to the recovery of many British debts, contracted before the war; and in many cases compelled the receipt of property instead of gold and silver."[163]

And the Court held it to be the very evident intendment of the language used in the treaty to effectuate the three objects already set forth. This case of Ware *vs.* Hylton in which these foregoing observations are found, will be examined later in detail.[164] The judge merely recited facts of universal knowledge. Under the Articles of Confederation Congress indeed had the exclusive power to make treaties, but nowhere was any power vested in the Federal government to *enforce* the provisions of treaties. State after State either passed new acts violative of the treaty of peace, or proceeded to enforce existing acts equally obnoxious. Dr. McMaster observes:

"The open contempt with which, in all parts of the country, the people treated the recommendation of Congress concerning the refugees and the payment of the debts, was no more than any man of ordinary sagacity could have foretold."[165]

And elsewhere the same historian states:

"There were some Articles [of the treaty] which the people had long before made up their minds never should be carried out."[166]

[163] Ware *vs.* Hylton, 3 Dallas, p. 238.

[164] *Infra,* pp. 135–146.

[165] "A History of the People of the United States," John B. McMaster, Vol. I, p. 130.

[166] Ibid., p. 107.

The situation was intensified by the fact that Great Britain had refused to surrender the posts along the western frontier, and had supported her refusal by alleging the treatment of British creditors contrary to the provisions of the treaty. The diplomatic efforts of John Adams as minister to Great Britain to secure an evacuation of these posts, and a treaty of commerce, were rendered abortive and even pathetic by the ever fatal demonstration that whatever the Confederation might do, the several States would undo.[167] Said *The Federalist:*

> "The treaties of the United States, under the present confederation, are liable to the infraction of thirteen different legislatures and as many different courts of final jurisdiction, acting under the authority of these legislatures. The faith, the reputation, the peace of the whole Union, are thus continually at the mercy of the prejudices, the passions and the interests of every member, of which these are composed. Is it possible, under such circumstances, that the people of America will longer consent to trust their honor, their happiness, their safety, on so precarious a foundation."[168]

Washington's well-known words, quoted in his life by Marshall, expressed a recognition of the conditions: Foreign nations, he said, with whom we wish to enter into treaty,

> "must see and feel that the Union, or the States individually, are sovereign as best suits their purposes:—in a word, we are a nation to-day, and thirteen to-morrow. Who will treat with us on such terms?"[169]

In the debates in the Federal Convention, Madison in objecting to the New Jersey plan said:

> "Will it prevent those violations of the law of nations and of treaties which if not prevented must involve us in the calamities of foreign wars? The tendency of the States to these violations has been manifested in sundry instances. The files of Congress contain complaints already, from almost every nation with which treaties have been formed. Hitherto indulgence has been shown to us. This cannot be the permanent disposition of foreign nations. A rupture with other powers is among the greatest of national calamities. It ought therefore to be effectually provided that no part of the nation shall have it in its power to bring them on the whole. The existing confederacy does (not) sufficiently provide against this evil. The proposed amendment to it does not supply the omission. It leaves the will of the States as uncontrouled as ever."[170]

[167] Ibid., Vol. I., Chap. III.

[168] *The Federalist,* No. 22.

[169] Marshall's "Life of Washington," 1st Ed., Vol. V., Chap. 2, p. 73.

[170] Farrand, Vol. I., p. 316.

In the debates in the State conventions which ratified the Constitution, the same unanimous recognition of existing conditions is manifest. In Connecticut, Oliver Ellsworth said:

"Another ill consequence of this want of energy is, that treaties are not performed. The treaty of peace with Great Britain was a very favorable one for us. But it did not happen perfectly to please some of the States, and they would not comply with it. The consequence is, Britain charges us with the breach, and refuses to deliver up the forts on our northern quarter."[171]

In Massachusetts, Samuel Adams rose to say of the Constitution, the adoption of which he had long opposed:

"Sir, there are many parts of it I esteem as highly valuable, the article which empowers Congress to regulate commerce, to form treaties, etc. For want of this power in our national head, our friends are grieved, and our enemies insult us. Our embassador at the Court of London is considered as a mere cipher, instead of the representative of the United States."[172]

The President of the Virginia Convention spoke as follows:

"The moment of peace showed the imbecility of the Federal government: Congress was empowered to make war and peace; a peace they made, giving us the great object independence, and yielding us a territory that exceeded my most sanguine expectations. Unfortunately a single disagreeable clause, not the object of the war, has retarded the performance of the treaty on our part. Congress could only recommend its performance, not enforce it; our last assembly (to their honor be it said) put this on its proper ground—on honorable grounds—it was as much as they ought to have done. This single instance shews the imbecility of the confederation; the debts contracted by the war were unpaid; demands were made on congress; all that congress was able to do, was to make an estimate of debt, and proportion it among the several states; they sent on the requisitions from time to time, to the states for their respective quotas. These were either complied with partially, or not at all; repeated demands on congress distressed that honorable body; but they were unable to fulfill those engagements which they so earnestly wished. What was the idea of other nations respecting America? What was the idea entertained of us by those nations to whom we were so much indebted? The inefficacy of the general government warranted an idea that we had no government at all."[173]

The language of Governor Randolph answers these rhetorical questions:

"We become contemptible in the eyes of foreign nations; they discarded

[171] Elliott's Debates, Vol. II., Ed. of 1854, p. 189.
[172] Elliott's Debates, Vol. I., p. 131.
[173] Elliott's Debates, Vol. II., p. 58.

us as little wanton bees who had played for liberty, but who had no sufficient solidity or wisdom to secure it on a permanent basis, and were therefore unworthy of their regard. It was found that congress could not even enforce the observance of treaties. That treaty under which we enjoy our present tranquility was disregarded."[174]

Madison, a delegate to the Federal Convention, and a signer of the Constitution, thus pictured the existing conditions:

"The confederation is so notoriously feeble, that foreign nations are unwilling to form any treaties with us—they are apprised that our general government cannot perform any of its engagements; but, that they may be violated at pleasure by any of the States. Our violation of treaties already entered into, proves this truth unequivocally. No nation will therefore make any stipulations with congress, conceding any advantages of importance to us; they will be the more averse to entering into engagements with us, as the imbecility of our government enables them to derive many advantages from our trade, without granting us any return. But were this country united by proper bands, in addition to other great advantages, we could form very beneficial treaties with foreign states. But this can never happen without a change in our system. Were we not laughed at by the Minister of that nation, from which we may be able yet to extort some of the most salutary measures for this country? Were we not told that it was necessary to temporize till our government acquired consistency? Will any nation relinquish national advantages to us? You will be greatly disappointed, if you expect any such good effects from this contemptible system."[175]

Universal was the desire for amelioration of the existing conditions, and out of that desire and the conflict of opinion came the Constitution. It was debated by the Convention which framed it, it was discussed by publicists and individuals, it was again debated in each of the State conventions which considered its ratification. Yet nowhere, so far as a careful search has revealed, was there a question raised but that the meaning and intended effect of the words in the Constitution respecting the status of treaties, was, that a provision in any treaty properly expressed operated in despite of any State enactment as municipal and local law within that State and overrode all and any constitution, statute, or common law in derogation thereof. Men opposed the wisdom of this constitutional provision; they united in recognizing its novel, almost revolutionary significance.

[174] Ibid., p. 50.

[175] Ibid., p. 128.

There is nothing surprising in this unanimity of contemporary interpretation. Every one knew that the great majority of the nation concurred in the necessity of making treaty provisions supreme over the caprice of State legislatures: the method to be adopted had been an object of controversy. Early, in the constitutional convention, as we have seen,[176] a resolution had been presented granting to Congress the power, *inter alia,* "to negative all laws passed by the several States contravening in the opinion of the national legislature the Articles of Union or any treaties subsisting under the authority of the Union." This resolution had been defeated and the following substituted and adopted:

"*Resolved,* that the legislative acts of the United States, made by virtue and in pursuance of the Articles of union, and all treaties made and ratified under the authority of the United States, shall be the supreme law of the respective States, as far as those acts, or treaties, shall relate to the said States, or their citizens and inhabitants;—and that the judiciaries of the several States shall be bound thereby in their decisions—anything in the respective laws of the individual States to the contrary, notwithstanding."[177]

This resolution, modified considerably as to style and somewhat extended in substance, became the clause in the Sixth Article of the Constitution. In Professor Farrand's book on "The Record of the Federal Convention" are to be found the *memoranda* of the committee of detail, of which Professor Farrand says:

"With a few additions from other sources, it is possible to present a nearly complete series of documents representing the various stages of the work of the Committee."[178]

Among these documents is the following tentative provision afterwards embodied in the Sixth Article of the Constitution:

"All laws of a particular State, repugnant hereto, shall be void, and in the decision thereon, which shall be vested in the supreme judiciary, all incidents without which the general principles cannot be satisfied shall be considered as involved in the general principle."[179]

Those who opposed the adoption of the treaty-making power in its extent and supremacy, and those who favored it, united in the recognition of the purpose, meaning, and effect of the language

[176] *Supra,* pp. 17–19.
[177] Farrand, Vol. II., pp. 28–9.
[178] Ibid., p. 129.
[179] Ibid., p. 144.

used in the Sixth Article of the Constitution. That was a thing admitted. Accompanying the transmission of the Constitution to Congress was a letter unanimously approved by the Convention, and signed by George Washington, as its President. In that letter it is said:

> "The friends of our country have long seen and desired, that the power of making war, peace, and treaties, that of levying money and regulating commerce, and the correspondent executive and judicial authorities should be fully and effectually vested in the general government of the Union."[180]

In the essay already quoted, Professor Mikell, after urging that the treaty-making power of the United States cannot operate to affect State law upon any subject not expressly committed to Congress, continues:

> "The issue has been much obscured by the specious plea that it is intolerable that a State should enact laws in conflict with a treaty and by taking away rights guaranteed to foreigners, under such treaty, give just cause of offense to a foreign nation, and even possibly imperil the peace of the whole Union."[181]

It is interesting to note that, in this view, Washington, Madison, Randolph, Pendleton, Ellsworth, Hamilton, Adams, by the quotations above made, and all who under their guidance voted for the Constitution, made use of this "specious plea." It is just possible that a student of those four years of American history from the Treaty of peace in 1783 to the creation of the Constitution in 1787, might conclude that the condition of affairs then existing because of State disregard of treaties, was superior to the conditions wrought by the Constitution. But it is very clear that none of the statesmen who had suffered through those days shared this conclusion. Yet, consideration as to whether Washington, Hamilton, Madison, Randolph, Adams, and the others were right or wrong, does *not* reach the precise issue. And that issue is: What do the treaty clauses in the Constitution *mean?* It cannot be gainsaid that treaties were not effective law supreme over State enactments under the Confederation; it cannot be gainsaid that Washington and the contemporary statesmen who created the Constitution thought (how-

[180] Ibid., p. 666.
[181] *American Law Register,* Vol. 57, p. 554.

ever speciously) this condition wrong; it cannot be gainsaid that they wrote the clause under discussion into the Constitution and advocated its adoption; it cannot be gainsaid that contemporaneously and as a reason for its adoption they interpreted it as creating a condition of affairs under the Constitution exactly contrary to that existing under the Confederation; namely, a condition where treaties would be supreme and forever beyond the power of any State to infringe. The only issue therefore that can be logically raised is: Is the language of the Constitution so ambiguous, so capable of diverse construction, that one can fairly say that, whatever the intention of its framers, it fails to express such intention? Or to put this question concretely: When the Constitution says: "All treaties . . . shall be the supreme law of the land; and the judges in every State shall be bound thereby, anything in the Constitution or laws of any State to the contrary notwithstanding"—are these words so ineffective to carry their meaning that it may still be said that treaties attempting to deal with any subjects not committed to Congress have no operative force within the several States? If so, the failure of the statesmen of America to express their thought would be without a parallel in history. But it is not so. The language is clear; if not the contemporary *intention* of its authors, certainly its contemporory *interpretation* must control.

In the debates in the Pennsylvania Convention, James Wilson thus combined a realization of existing conditions, a statement of the remedy to be applied, and an interpretation of the treaty-provisions of the Constitution as adequate to that end:

"The judicial power extends to all cases arising under treaties made, or which shall be made by the United States. I shall not repeat at this time, what has been said with regard to the power of the States to make treaties; it cannot be controverted, that when made, they ought to be observed. But it is highly proper that this regulation should be made, for the truth is, and I am sorry to say it, that in order to prevent the payment of British debts, and from other causes, our treaties have been violated, and violated too by the express laws of several States in the Union. Pennsylvania, to her honor be it spoken, has hitherto done no act of this kind; but it is acknowledged on all sides, that many states in the Union have infringed the treaty; and it is well known that when the minister of the United States made a demand on Lord Carmarthen, of a surrender of the western posts, he told the minister with truth and justice: 'the treaty under which you claim those possessions, has not been performed on your part; until that is done, those possessions will not be delivered up.' This clause, sir, will shew the world that we make the faith of treaties a constitutional part of the character of the United States; that we secure its performance no longer nominally, for the judges of the United States will be enabled to carry into effect, let the legislatures of the different states do what they may."[152]

It will be noted at greater length hereafter but it should be noted now that these words were spoken of an existing treaty, of existing State laws, and of a subject *not* committed to Congress but reserved to the States.

Wilson had signed the Constitution as a delegate to the Federal convention. But the opponents of the extent and supremacy of the treaty-making power united in a similar interpretation of the constitutional clauses. Luther Martin was a delegate from Maryland and refused to sign the Constitution. To his State legislature he gave an account of the proceedings and of the reason for his actions. Of the Federal judicial power he said:

"These courts, and these only, will have a right to decide upon the laws of the United States, and all questions arising upon their construction, and in a judicial manner to carry those laws into execution; to which the courts both superior and inferior of the respective states and their judges and other magistrates are rendered incompetent. To the courts of the general government are also confined all cases in law or equity, arising under the proposed Constitution, and treaties made under the authority of the United States. . . . Whether therefore, any laws or regulations of the Congress, or any acts of its president or other officers are contrary to, or not warranted by, the Constitution, rests only with the judges who are appointed by Congress to determine; by whose determinations *every state*[153] must be *bound*."[154]

George Mason, one of the delegates from Virginia to the Federal Convention, thus wrote in a letter giving his reasons for declining to sign the Constitution:

"By declaring all treaties supreme laws of the land, the executive and the Senate have, in many cases, an exclusive power of legislation, which might have been avoided, by proper distinctions with respect to treaties, and requiring the assent of the House of Representatives, where it could be done with safety."[155]

[152] Elliott's Debates, Vol. III., pp. 280–1.

[153] Italics are in original.

[154] Elliott's Debates, Vol. IV., p. 45, Ed. of 1830.

[155] Ibid., Vol. I., p. 495, Ed. of 1854.

Richard Henry Lee, another delegate from Virginia, gave similar reasons:

"In the new Constitution, the President and Senate have all the executive, and two thirds of the legislative power. In some weighty instances (as making all kinds of treaties, which are to be the laws of the land), they have the whole legislative and executive powers."[186]

Patrick Henry was a violent opponent of the adoption of the Constitution in the Virginia debates. The reporter says that he urged that

"the power of making treaties, by this Constitution, ill-guarded as it is, extended farther than it did in any country in the world.—Treaties were to have more force here than in any part of christendom. For he defied any gentleman to shew anything so extensive in any strong energetic government in Europe. Treaties rest, says he, on the laws and usages of nations. To say that they are municipal, is, to me, a doctrine totally novel. To make them paramount to the Constitution, and laws of the states, is unprecedented. I would give them the same force and obligation they have in Great Britain, or any other country in Europe. Gentlemen are going on in a fatal career; but I hope they will stop before they concede this power unguarded and unaltered."[187]

In the North Carolina convention, Mr. Bloodworth thus opposed the supremacy assigned to the acts of Congress and to the treaty-making power:

"This clause will be the destruction of every law which will come in competition with the laws of the United States. Those laws and regulations which have been, or shall be made in this state, must be destroyed by it if they come in competition with the powers of Congress."[188]

To him Governor Johnston thus replied:

"The Constitution must be the supreme law of the land, otherwise it will be in the power of any one state to counteract the other states, and withdraw itself from the Union. The laws made in pursuance thereof by Congress, ought to be the supreme law of the land, otherwise any one state might repeal the laws of the Union at large. Without this clause, the whole Constitution would be a piece of blank paper. Every treaty should be the supreme law of the land; without this, any one state might involve the whole Union in war."[189]

[186] Ibid., Vol. I., p. 503, Ed. of 1854.
[187] Ibid., Vol. II., p. 368.
[188] Ibid., Vol. III., p. 160.
[189] Ibid., Vol. III., p. 166.

In the Virginia convention George Nicholas quoted from Blackstone a passage to show the status of treaties in Great Britain, and adds:

> "The president and senate have the same power of making treaties; and when made they are to have the same force and validity. They are to be the supreme law of the land here—this book shews us they are so in England. Have we not seen in America that treaties were violated, though they are in all countries considered as the supreme law of the land? Was it not therefore necessary to declare in explicit terms, that they should be so here?"[190]

Later in these Virginia debates Mr. Corbin, assuming the unanimous interpretation, argued for the wisdom of the clause:

> "It is as clear, as that two and two make four, that the treaties made are to be binding on the states only. Is it not necessary that they should be binding on the states? Fatal experience has proven that treaties would never be complied with, if their observance depended on the will of the states; and the consequences would be constant war. For, if any one state could counteract any treaty, how could the United States avoid hostility with foreign nations? Do not gentlemen see the infinite dangers that would result from it, if a small part of the community could drag the whole confederacy into war?"[191]

Such were the conditions out of which were evolved the treaty clauses of the Constitution; such was the universal contemporary analysis of their purpose, significance, and import.

It has been noted that the clause assuming to insure supremacy to treaty provisions, past and future, was adopted to cover existing practical controversies. Did none of them—the question asks itself—reach the courts, and result in an authoritative declaration interpreting these discussed clauses? What did the courts decree when British creditors sought to recover debts, and British claimants of land sought to recover possession, in reliance on existing treaty provisions? The answer is that the case of Ware *vs.* Hylton[192] recognized in 1796 the rights of British creditors, and the case of Fairfax *vs.* Hunter,[193] decided in 1812, determined that the title of an alien was saved by the treaty of peace.

It has been noted that in debating the constitutional provision on the subject, James Wilson had said:

[190] Ibid., Vol. II., pp. 372–3.
[191] Ibid., Vol. II., p. 375.
[192] 3 Dallas, 199 (1796).
[193] 7 Cranch, 603 (1812).

"I am sorry to say it, that in order to prevent the payment of British debts, and from other causes, our treaties have been violated, and violated too by the express laws of several States in the Union. . . . This clause, sir, will show the world that we make the faith of treaties a constitutional part of the character of the United States; that we secure its performance no longer nominally, for the judges of the United States will be enabled to carry into effect, let the legislatures of the different states do what they may."[194]

In the Virginia debates, Governor Randolph had likewise expressly adverted to this concrete cause to be subserved directly by the adoption of the Constitution.

"I come now to what will be agitated by the judiciary. They are to enforce the performance of private contracts. The British debts, which are withheld contrary to treaty, ought to be paid."[195]

The Constitution was adopted, a British creditor brought suit, and on appeal the case was argued in the Supreme Court by John Marshall on behalf of the debtor. In a volume of reports comprising 519 pages and covering a period of over five years the report of this case is allotted 87 pages; the opinions of the court cover over 64 pages. This is conclusive evidence of the contemporary estimate of its importance. The suit arose on a bond given by Virginian citizens, and was brought in the Federal court for the District of Virginia. The facts material in the present discussion, in addition to the citizenship of the parties and the notorious fact of war, were these. In 1774, the bond was dated. In 1777, an Act of Virginia was passed entitled "An Act for Sequestering British Property," and providing that full discharge of the debt should be created by the payment of the sum due to the commonwealth. In 1780, payment in accordance with the act was made by the defendant. In 1783, the treaty of peace was made. In 1788, the Constitution was declared operative by Congress. Marshall thus divided his argument. I. That the Virginia Act was effective as a bar (ignoring for the moment the treaty) because (*a*) the State had the power to create a bar; and (*b*) the State had by the Act exercised its power; II. That the treaty did not remove the bar. Marshall argued (*a*) that the Act had operated in 1780 to extinguish the debt, that therefore in 1783 there was no debt and no creditor upon whom

[194] Elliott's Debates, Vol. III., pp. 280–1.

the treaty might operate when it provided "that creditors on either side shall meet with no lawful impediment to the recovery of the full value, sterling money, of all *bona fide* debts heretofore contracted"; (*b*) that the treaty should not be interpreted to repeal an act known to the commissioners who framed the treaty, without express language of repeal; (*c*) that the treaty, if it operated to deprive the debtor of a right which had vested in 1780 three years before the date of the treaty, was beyond the power of Congress.

The judgment of the Court was in favor of the creditor. Four of the five judges delivered their opinions. All concurred in upholding the power of Virginia to pass the Act of 1777 and in its efficacy apart from treaty stipulation. Mr. Justice Iredell alone dissented on the ground that while the treaty operated to repeal the Virginia statute, it could not properly be interpreted as operating to annul acts done under it while in force and prior to its repeal.

It will be observed that the annulment of the Virginia statute might logically be maintained in either or both of two ways: First, because of the operation to that extent of the treaty by virtue of the Articles of Confederation and of the assent thereto by Virginia as a State; second, by the supreme efficacy given to the treaty by the Constitution. A careful study of the opinions of Mr. Justice Chase and of Mr. Justice Paterson[196] shows that they placed their decision upon *both* grounds; Mr. Justice Wilson placed his concurrence on the first, and was silent as to the second; Mr. Justice Iredell denied the validity of the first ground, and acquiesced emphatically in the validity of the second (dissenting in the interpretation he gave to the treaty). Said Mr. Justice Chase upon the second ground:

"If doubts could exist before the establishment of the present national government, they must be entirely removed by the 6th article of the Constitution, which provides 'That all treaties made, or which shall be made, under the authority of the United States, shall be the supreme law of the land; and

[195] Ibid., Vol. II., p. 352.

[196] The acquiescence of Mr. Justice Paterson in the first ground is shown by these words: "If the Legislature had authority to make the act, the Congress could, by treaty, repeal the act, and annul everything done under it," at p. 249. His acquiescence in the second ground is shown by his rather technical opinion having as its object the sustaining of the demurrer to the second plea which demurrer relied wholly on the constitutional provision.

the judges in every State shall be bound thereby, anything in the Constitution, or laws, of any State to the contrary notwithstanding.' There can be no limitation on the power of the people of the United States. By their authority the State constitutions were made, and by their authority the Constitution of the United States was established; and they had the power to change or abolish the State Constitutions, or to make them yield to the general government, and to treaties made by their authority. A treaty cannot be the supreme law of the land, that is of all the United States, if any act of a State legislature can stand in its way. If the Constitution of a State (which is the fundamental law of the State, and paramount to its legislature) must give way to a treaty, and fall before it; can it be questioned, whether the less power, and act of the state legislature, must not be prostrate? It is the declared will of the people of the United States that every treaty made, by the authority of the United States, shall be superior to the Constitution and laws of any individual State; and their will alone is to decide.—If a law of a State, contrary to a treaty, is not void, but voidable only by a repeal, or nullification by a State legislature, this certain consequence follows, that the will of a small part of the United States may control or defeat the will of the whole. The people of America have been pleased to declare, that all treaties made before the establishment of the National Constitution, or laws of any of the States, contrary to a treaty, shall be disregarded.

"Four things are apparent on a view of the 6th Article of the National Constitution. 1st. That it is retrospective, and is to be considered in the same light as if the Constitution had been established before the making of the treaty of 1783. 2nd. That the Constitution, or laws, of any of the States so far as either of them shall be found contrary to that treaty are by force of the said article, prostrated before the treaty. 3rd. That consequently the treaty of 1783 has superior power to the Legislature of any State, because no Legislature of any State has any kind of power over Constitution, which was its creator. 4thly. That it is the declared duty of the State judges to determine any Constitution, or laws of any State, contrary to that treaty (or any other) made under the authority of the United States, null and void. National or Federal judges are bound by duty and oath to the same conduct."[197]

Mr. Justice Wilson was of the opinion that the treaty, being made by Virginia as a State, annulled the confiscation.[198] Mr. Justice Iredell expressly disagreed with the other members of the Court as to the efficacy of the treaty provision independent of the Constitution, and held that the treaty could only become effective "by a repeal of the statutes of the different States."[199] With respect to the appli-

[197] 3 Dallas, pp. 235–7.

[198] See note 10.

[199] See note 11.

cability and force of the constitutional provisions Mr. Justice Iredell continued:

"The article in the Constitution concerning treaties I have always considered, and do now consider, was in consequence of the conflict of opinions I have mentioned on the subject of the treaty in question. It was found in this instance, as in many others, that when thirteen different legislatures were necessary to act in unison on many occasions, it was in vain to expect that they would always agree to act as Congress might think it their duty to require. . . . Similar embarrassments have been found about the treaty. This was binding in moral obligation, but could not be constitutionally carried into effect (at least in the opinion of many) so far as acts of legislation then in being constituted an impediment, but by a repeal. The extreme inconveniences felt from such a system dictated the remedy which the Constitution has now provided, 'that all treaties made or which shall be made under the authority of the United States, shall be the supreme law of the land; and that the judges in every state shall be bound thereby, anything in the Constitution or laws of any state to the contrary notwithstanding.' Under this Constitution therefore, so far as a treaty constitutionally is binding, upon principles of moral obligation, it is also by the vigour of its own authority to be executed in fact. It would not otherwise be the supreme law in the new sense provided for, and it was so before in a moral sense.

"The provision extends to subsisting as well as to future treaties. I consider therefore that when this Constitution was ratified, the case as to the treaty in question stood upon the same footing, as if every act constituting an impediment to a creditor's recovery had been expressly repealed, and any further act passed, which the public obligation had before required, if a repeal alone would not have been sufficient."[200]

Such, so far as expressed, were the *rationes decidendi* of the judges who sat in this case. The judgment in itself deserves, however, the most scrupulous examination. It is given in the report of the case and sustains the demurrer to the second plea. Now, that demurrer was to the effect that after the incurring of the debt, and after the passage of the Virginia act, and after the treaty of peace,

"it was by the Constitution of the United States of America, among other things, expressly declared, that treaties which were then made, or should thereafter be made, under the authority of the United States, should be the supreme law of the land, anything in the said Constitution, or of the laws of any state, to the contrary notwithstanding;"[201]

and that the plaintiff was within the protection of this treaty and the Constitution. And this demurrer was sustained.

[200] 3 Dallas, pp. 276–7.
[201] 3 Dallas, p. 204.

This case is examined by Professor Mikell with the conclusion that it "is no authority for the broad proposition that the treaty-making power is not limited by the reserved rights of the States"[202] —a conclusion based, first, on the fact that the treaty under discussion was one entered into under the Confederation and therefore that "it might well be that greater force should be allowed to" such a treaty; and secondly, on the constitutional provision that States shall not impair contracts. This first conclusion is contrary to (*a*) the judgment itself of the Court and (*b*) the opinions of the justices; (*c*) the historical facts respecting treaties made under the Confederation; (*d*) the interpretation given to this case in the subsequent decisions of the Supreme Court. The second conclusion is curious; for when Virginia passed the Confiscation Act, the Constitution was of course not in force. Professor Mikell must mean that as a confiscation by a State statute cannot now occur, the treaty only deprived Virginia of the power of doing something later forbidden by the Constitution; and hence not a State right today. But this is only to say that the question then before the Supreme Court in Ware *vs.* Hylton could not recur in just that form. But in what way could the *form* matter? The principles and considerations involved would be precisely identical, and the authority of this case equally cogent.[203]

But there is yet a further consideration demonstrating that there is involved in the very tissue of the decision in Ware *vs.* Hylton a recognition of the force and supremacy of the treaty provisions of the Constitution. *Whence else came to the court the power to record its judgment?* Assume the treaty of peace to be valid under the Confederation, as manifestly it was, assume it to be binding on Virginia as a State; in what sense was it binding? Surely by force of international law and not by virtue of any power in Congress to enforce its provisions. Could Congress, by a judiciary it did not possess, by a resolution it had no power to enforce, give to the individual British creditor redress? Could such creditor successfully appeal to a State court? By a fundamental canon of American law

[202] *American Law Register,* Vol. 57, p. 540.

[203] See note 12.

the question whether a treaty be in force is a *political* question for the executive and legislative, not the judicial power. The only remedy afforded a creditor was given by the Constitution which created a judiciary and laid upon it the obligation to enforce treaty-provisions as the law of the land, supreme over State action. The very entry of a judgment in Ware *vs.* Hylton affirmed by its entry the efficacy of the Constitution and the supremacy of treaties over States' rights: except by virtue of the Constitution no judgment could have been entered. It was a subject of curious interest, it is a subject of historical study today, to determine how far the treaty of peace operated of itself to repeal various State statutes in conflict therewith. In international law, it would seem that Mr. Justice Chase was right and Mr. Justice Iredell wrong. If the several States chose to pass statutes and authorize executive acts at variance with the treaty of peace, a grave breach was made in international law, but as binding municipal and local law the treaty was dead. But the question has no practical value. It was the Constitution and the Constitution alone which gave the force of local law to the treaty, and in the Federal judiciary created an effective method for its enforcement. When that judiciary acted, its act was necessarily done under the Constitution and constituted a recognition and example of its existence and its supreme efficacy.[204]

One year later there came before the Supreme Court a case involving one question—

"whether a paper money payment of a British debt into the treasury of Maryland, during the war, by virtue of a law of the State, was a bar to the creditor's recovery at this time."[205]

The reporter adds:

"And the solemn adjudication in Ware *vs.* Hylton et al., ant. p. 199, having settled that point, Dallas, for the defendant in error, submitted the case, without argument, to the Court, who, in general terms, reversed the

[204] If the suggestion be offered that a distinction is possible between "treaties made" and "treaties to be made" as the words are used in Article VI, of the Constitution, and that the former are to be given more force than the latter, the only answer is to say that such suggestion lacks any sanction either in precedent or in reason.

[205] Clerke *vs.* Harwoode, 3 Dallas, 342 (1797).

judgment of the High Court of Appeals, and affirmed the judgment of the general Court."

This case has been generally ignored; it is significant. It came before the Supreme Court of the United States on writ of error to the Supreme Court of Appeals of Maryland, where judgment adverse to the claimant was reversed. In so setting aside the action of the highest judicial agency of the State, and its declaration that the treaty was not binding on its citizen, the United States Supreme Court by its action unequivocally demonstrated that it acted by virtue of the Constitution, and gave effectiveness to the treaty-provisions thereof. If any one could be found to claim that in Ware *vs.* Hylton, the Federal court only acted as a Virignia court might have done, and so its judgment did not necessarily derive its virtue from the Constitution, this case of Clerke *vs.* Harwood shows that no such limitation to the significance of Ware *vs.* Hylton is possible. It cannot be gainsaid that the judgments in these causes, once they be fully analyzed and understood, determine completely and finally the supremacy of treaty provisions over State law.

The decision in Ware *vs.* Hylton was prefigured in the constitutional debates; likewise was it with the decision in Fairfax *vs.* Hunter.[206] In the Virginia debates Mr. Mason spoke vehemently upon the subject.

> "I am personally endangered," he said, "as an inhabitant of the Northern Neck. The people of that part will be obliged, by the operation of this power, to pay the quit rents of their lands. Whatever other gentlemen may think, I consider this as a most serious alarm. . . . Lord Fairfax's title was clear and undisputed. After the revolution we taxed his lands as private property. After his death an act of Assembly was made, in 1782, to sequester the quit rents due at his death, in the hands of his debtors. Next year an act was made restoring them to the executor of the proprietor. Subsequent to this the treaty of peace was made, by which it was agreed, that there should be no further confiscations. But after this an act of Assembly passed, confiscating this whole property. As Lord Fairfax's title was indisputably good, and as treaties are to be the supreme law of the land, will not his representatives be able to recover all in the Federal court? How will gentlemen like to pay additional tax on lands in the Northern Neck? This the operation of this system will compel them to do."[207]

[206] 7 Cranch, 603 (1812).

[207] Elliott's Debates, Vol. II., pp. 387–8.

The situation had, however, become complicated when there came before the Supreme Court the title of Lord Fairfax to these lands in the Northern Neck of Virginia. Fairfax died in 1781, a citizen of Virginia; in 1782, statutes were passed reciting his death and the devolution of the estate upon alien enemies, sequestering the quit rents in the tenants' hands, and providing for making entries upon vacant lands within the Northern Neck. After the treaty of peace, an Act was passed in 1785 which recited that no mode had been adopted to enable those who had made entries in accordance with the Act of 1782 to obtain titles, and which then enacted that grants should be given by the Commonwealth. The defendant claimed under a State patent issued pursuant to this Act. Under the will of Lord Fairfax, those estates were devised to one Denny Fairfax, a British subject. Denny Fairfax himself died during the pendency of the suit. Mr. Justice Story delivered the opinion of the Court. He held, first, that the title of Lord Fairfax in 1781 was free from doubt and in this followed the State decisions. He held, secondly, that at common law Denny Fairfax, taking as devisee and not as heir-at-law, "had a complete, though a defeasible title by virtue of the devise." He held, thirdly, that the common law had not been altered by reason of the Virginia statutes. Inasmuch therefore as those acts rendered necessary by the common law to vest title in the Commonwealth had been unperformed, the defeasible title remained in Denny Fairfax. Mr. Justice Story then continued:

"The real fact appears to have been, that the legislature supposed that the Commonwealth were in actual seizin and possession of the vacant lands of Lord Fairfax, either upon the principle that an alien enemy could not take by devise, or, the belief that the Acts of 1782, ch. 8, and ch. 33, had already vested the property in the Commonwealth. In either case it was a mistake. . . .

"Now, we cannot yield to the argument that Denny Fairfax had no title, but a mere naked possession or trust estate. In our judgment, by virtue of the devise to him he held a fee simple in his own right. At the time of the commencement of this suit (in 1791) he was in complete possession and seizin of the land. That possession and seizin continued up to and after the treaty of 1794, which being the supreme law of the land, confirmed the title to him, his heirs and assigns, and protected him from any forfeiture by reason of alienage.

"It was once in the power of the Commonwealth of Virginia, by an inquest of office or its equivalent, to have vested the estate completely in itself or its grantee. But it has not so done and its own inchoate title (and of course the derivative title, if any, of its grantee) has by the operation of the treaty, become ineffectual and void."[208]

The comments of Professor Mikell upon the case are interesting. "In Fairfax *vs.* Hunter, decided in 1812," he writes,

"Justice Story did indeed say that the treaty of 1794 would have the effect of rendering void the title to land claimed under an act of the legislature of Virginia. All that he said on this point, however,—and it is comprised in a few lines of a long opinion,—is dictum, for he had already shown, in ten pages of his opinion, that the acts of the legislature did not, in fact, vest any title to the land of the claimant. The question of the power of the President and Senate to make such a treaty was not argued in this case."[209]

One might readily say that where a case is put upon two grounds, each of which is adequate to sustain the judgment, the reasons adduced in support of one ground—though it be the last in point of expression—cannot logically or properly be characterized as *dicta*. But in this instance it happens that the efficacy of the treaty of 1794 was essential to the judgment reached. Professor Mikell's zeal has led him into error. To begin with, if rights under the treaty and the Constitution were not directly in issue and denied by the State court, in what possible way does Professor Mikell think the Supreme Court had jurisdiction by writ of error? Does he really think that the Supreme Court intended to say to the State Supreme Court: You have erred in interpreting your own statutes; they show the claimant against Fairfax had no title, on that ground alone we reverse? The Supreme Court, as is clear the moment one begins to think about it, would have no jurisdiction on the very face of its opinion to render such a judgment. The point of Mr. Justice Story's detailed examination of the Virginia acts is to show that the title of Denny Fairfax rose to such dignity as to be saved by the treaty of 1794. Mr. Justice Johnson's dissent on this point throws light on the real significance of the Court's decision but Mr. Justice Story's words in themselves show his thought:

"The title of Hunter under the grant of 1789," he says, "cannot be con-

[208] 7 Cranch, pp. 626–7.

[209] *American Law Register*, Vol. 57, p. 542.

sidered as more extensive than the title of the Commonwealth, viz.: a title inchoate and imperfect; to be consummated by an actual entry under an inquest of office, or its equivalent, a suit and judgment at law by the grantee."[210]

It was recognized by the court that " . . . a suit and judgment at law by the grantee" had occurred in the State courts, and jurisdiction to review by writ of error existed only to enforce rights preserved by the treaty. Mr. Justice Story concluded his opinion with these words:

"It becomes unnecessary to consider the argument as to the effect of the death of Denny Fairfax pending the suit, because admitting it to be correctly applied in general, the treaty of 1794 completely avoids it. The heirs of Denny Fairfax were made capable in law to take from him by descent, and the freehold was not, therefore, on his death, cast upon the Commonwealth."[211]

Here is a positive upholding of the efficacy of the treaty of 1794, essential to the decision. It is most clear under the Virginia law, already analyzed in this case, that upon the death of an alien his land *qua* his heirs-at-law escheated to the Commonwealth. Laconically, Mr. Justice Story dismissed this contention as avoided by the treaty of 1794. Apart from that, it was demonstrably sound. Why was the Court so brief? Because, first, it had already so decided upon the main contention; secondly, it seemed to that Court, familiar with the causes and conditions which had written the treaty clauses into the Constitution, to be unnecessary to dwell upon the plain words of Article VI. of the Constitution then unanimously interpreted as meaning what they said.

But Professor Mikell has one more objection to urge to the binding force of this decision. "The question of the *power* of the President and Senate to make such a treaty was not argued in this case."[212] Doubtless it was not. It was necessary that a century should first pass over the nation, and wipe out the memory of the humiliating years under the Confederation, the efforts of America's early statesmen to cause them to pass and to render it ever impossible for them to recur in her future history, their success in creating

[210] 7 Cranch, p. 626.
[211] Ibid., pp. 627–8.
[212] *American Law Register*, Vol. 57, p. 542.

the Constitution, the words they spoke in its interpretation, the outcry and revolt against the policy of this very treaty of 1794, but never against its binding though hateful efficacy. May one ask if Ben Jonson's words respecting his contemporary Shakespere lose their force because it was not suggested to him that Shakespere was Bacon?

In Chirac *vs.* Chirac,[213] Mr. Chief Justice Marshall delivered the opinion of the court. The essential facts were that a holder of real estate in Maryland had died in 1799 leaving as heirs-at-law certain French citizens. The decedent had acquired the land while a French citizen and had been naturalized after the adoption of the Constitution. It was held that the treaty with France of 1778 protected his title until he became a citizen of the United States. His death, however, occurred prior to the treaty of 1800; and on this point the Chief Justice said:

> "Had John Baptiste Chirac, the person from whom the land in controversy, descended, lived until this treaty became the law of the land, all will admit that the provisions which have been stated would, if unrestrained by other limitations, have vested the estate of which he died seised in his heirs."[214]

It was held that inasmuch as the law of Maryland protected such an estate for ten years, the treaty operated at once upon its execution to vest an absolute title in the French heirs, which was not lost by the subsequent abrogation of the treaty. The discussion of the meaning and effect of the Maryland acts and of the French treaties by Mr. Chief Justice Marshall is long and necessarily complex; he disposes of the fundamental question now examined in the sentence quoted from his opinion above by one phrase: "*all will admit.*" Professor Mikell says of this case also:

> "The question of the power of the Federal government to make such a treaty was not argued by counsel or discussed by the Court."[215]

Can any one really believe that an argument on this point would have effaced from Marshall's memory the days through which he had

[213] 2 Wheat., 259 (1817).
[214] Ibid., p. 274.
[215] *American Law Register,* Vol. 57, p. 542.

lived, and have served to alter the judicial history of the United States?

In Orr *vs.* Hodgson,[216] the efficacy of the treaties of 1783 and 1794, to protect British titles from forfeiture, came before the Supreme Court. The case was one in equity to enforce a contract for the sale of lands. The defense was lack of title. One Lucy Paradise, the elder, by birth a Virginian, inherited the land by devise, and in 1769, married in England John Paradise, a British subject. They had one child, Lucy, the younger. She married in England, in 1787, a Venetian subject by whom she had two sons. She died in Venice in 1800. In 1787 John Paradise and his wife Lucy, the elder, came to Virginia, but returned in 1789, where he died in 1796. After his death Lucy, the elder, came to Virginia in 1805, and exercised the right of ownership over the land in controversy till her death, intestate, in 1814. She left surviving two nieces, parties to the suit, and two grandsons in Venice. The defect in the title urged of importance to us was that Lucy Paradise, the elder, by marrying a British subject and remaining in England till long after the Revolution because a British subject. Upon this point the Court held:

> "Admitting that Lucy Paradise did so become an alien, it is material to inquire, what effect the treaty of peace of 1783 had upon her case; and upon the best consideration that we can give to it, we are of opinion that the Sixth Article of that treaty completely protected her estate from forfeiture, by way of escheat for the defect of alienage."[217]

The Court then proceeds to examine the effect of the provisions of the treaty of 1794, and concludes:

> "It follows, that in this view also, her title was completely confirmed, free from the taint of alienage; and that by the express terms of the treaty, it might lawfully pass to her heirs."[218]

The Court concluded that, as a British treaty could not operate to protect Venetian citizens, the title vested in the nieces. One will note that the constitutional provision is here applied both to a

[216] 4 Wheat., 453 (1819).
[217] Ibid., p. 462.
[218] Ibid., p. 464.

treaty made under the Confederation and to a treaty made under the Constitution.[219]

In Hughes *vs.* Edwards,[220] a bill in equity was filed by British subjects to recover a mortgage debt, or, in default of payment, to procure the sale of the mortgaged property. Among the defenses set up was that of alienage. This defense was disposed of by the Court as follows:

"This objection would not we think avail the appellants, even if the object of this suit was the recovery of the land itself, since the remedies, as well as the rights, of these aliens, are completely protected by the treaty of 1794."[221]

In Carneal *vs.* Banks,[222] a bill was filed praying the rescinding of a contract under which the respondent had agreed to convey certain land to complainant, on the ground that respondent had no title to said lands. The decree below was in favor of complainant. The various assignments of error were considered by the Supreme Court. One, based on the rescinding of the contract by the lower court by reason of a misdescription, was sustained, on the ground that such misdescription was not averred in the bill, and therefore not put in issue. The Court then continues:

"The alleged alienage of Lacassaign (through whom respondent derived title) constitutes no objection. Had the fact been proven, this Court decided, in the case of Chirac *vs.* Chirac (2 Wheat. 259), that the treaty of 1778 between the United States and France, secures the citizens and subjects of either power the privilege of holding lands in the territory of the other."[223]

[219] Of this case Professor Mikell says: "Here again the treaty in question was a treaty negotiated by the Continental Congress, not by the Senate and the President. And again the power of Congress, or of the President and Senate to make such treaty, does not appear to have been argued by counsel, nor was it discussed by the Court," pp. 542–3. On the first point, he is wrong: both treaties were construed. The second argument needs no further comments. As a matter of fact, counsel in opposition to the force of the treaties did not appear to argue the case in the Supreme Court.

[220] 9 Wheat., 489 (1824).

[221] Ibid., p. 495. Professor Mikell says of this case: "Again the question of power was not argued by counsel or examined by the Court," p. 543. The report of the case gives the name of counsel but purports to add nothing concerning the argument.

[222] 10 Wheat., 181 (1825).

[223] Ibid., p. 189.

The decree was reversed without prejudice. The language of Mr. Chief Justice Marshall is not properly to be called *dicta*. If a good ground for rescission appeared in the record, reversal would not have been proper, even though the court below had placed its decision on the wrong ground. And the reference to the fact of alienage not being proved, is immaterial; it was alleged and might have been proved on the second trial.

The case of Worcester *vs.* The State of Georgia[224] is one of both historical and constitutional importance. The Creek and Cherokee Indians occupied territory within the State of Georgia under a series of treaties recognizing their rights to such territory. The State determined to acquire these Indian lands. By its governor, supported in large measure by the legislature, it was maintained that the sovereign rights of the State of Georgia absolutely forbade any Federal interference with the expulsion of the Indians, although such expulsion were contrary to the treaty provisions. An individual had committed a murder within the Indian territory, and had been convicted in the State court, and condemned to death. A writ of error was issued by the Supreme Court of the United States. This was disregarded, and sentence was executed. Under this existing situation the case of Worcester *vs.* The State of Georgia reached the Supreme Court. The decision rendered therein established the jurisdiction of the Supreme Court of the United States to examine on writ of error the criminal process of a State and to set free a person convicted under the laws of that State on the ground that such laws were repugnant to the Constitution, laws, and treaties of the United States. Above all, it determined that treaties with Indian tribes came within the constitutional powers. It has significance for us here. The Cherokee Indians occupied a portion of Georgia. The State passed an act forbidding any one under criminal penalties to reside in that land without a license from the governor of the State or his agent. Worcester was indicted under this act. He pleaded the provision of the treaties of the United States with the Indians and of an Act of Congress, and that the Georgia statute was unconstitutional and void, being in conflict therewith. His con-

[224] 6 Peters, 515 (1832).

viction was sustained in the State court. The Supreme Court of the United States reversed and ordered his discharge. Said Mr. Chief Justice Marshall:

"The Constitution, by declaring treaties already made, as well as those to be made, to be the supreme law of the land, has adopted and sanctioned the previous treaties with the Indian nations, and consequently admits their rank among those powers who are capable of making treaties. . . .

"Will these powerful considerations avail the plaintiff in error? We think they will. He was seized, and forceably carried away, while under guardianship of treaties guaranteeing the country in which he resided, and taking it under the protection of the United States. He was seized while performing, under the sanction of the chief magistrate of the Union, those duties which the humane policy adopted by Congress had recommended. He was apprehended, tried, and condemned, under colour of a law which has been shown to be repugnant to the Constitution, laws, and treaties of the United States. Had a judgment, liable to the same objections, been rendered for property, none would question the jurisdiction of this Court."[225]

Mr. Justice McLean concurred and said:

"It has been shown, that the treaties and laws referred to, come within the due exercise of the Constitutional powers of the Federal government; that they remain in full force, and consequently must be considered as the supreme laws of the land. . . . Under the administration of the laws of Georgia, a citizen of the United States has been deprived of his liberty; and, claiming protection under the treaties and laws of the United States, he makes the question, as he has a right to make it, whether the laws of Georgia, under which he is now suffering an ignominious punishment, are not repugnant to the Constitution of the United States, and the treaties and laws made under it. This repugnancy has been shown."[226]

No recognition was given to the mandate of the Supreme Court upon its return to the State Court. That court refused to grant the writ of *habeas corpus* and Worcester continued in imprisonment. Not the slightest action was taken to enforce the mandate, or to punish its violation by either President Jackson or by Congress.[227] The explanation of this most dangerous precedent in the history of the United States is of course that it constitutes one of the series of constitutional violations springing from extreme States' rights doc-

[225] Ibid., pp. 559, 562.

[226] Ibid., p. 595.

[227] "Constitutional History of the United States," 1750–1833, von Holst, pp. 452–5.

trines which had their end in the Civil War. This case, however, has full and controlling authority as constitutional precedent today.

Many years passed before the effect of treaties upon State laws respecting inheritance again came before the Supreme Court. Accordingly, in Hauenstein *vs.* Lynham,[228] decided in 1879, the Court carefully reviews the preceding cases. Therein, a resident of Virginia, but presumably a citizen of Switzerland, had died intestate. The claimants were admittedly aliens. The Virginia court held against their claims on the ground that the provisions of the treaty with Switzerland did not, properly construed, operate to change the Virginia law, which barred the right of aliens to inherit. The Supreme Court held that this was an error in construction, and that the treaty did so operate. The Court said:

> "It remains to consider the effect of the treaty thus construed upon the rights of the parties. That the laws of the State, irrespective of the treaty would put the fund into her coffers, is no objection to the right or the remedy claimed by the plaintiffs in error. The efficacy of the treaty is declared and guaranteed by the Constitution of the United States. That instrument took effect on the 4th day of March, 1789."[229]

The Court then quotes with approval[230] the language and the decisions in Ware *vs.* Hylton, Chirac *vs.* Chirac, Carneal *vs.* Banks, Hughes *vs.* Edwards, and Orr *vs.* Hodgson; and concludes thus:

> "We have no doubt that this treaty is within the treaty-making power conferred by the Constitution, and it is our duty to give it full effect."[231]

In the case of Maiorano *vs.* B. & O. R. R. Co.,[232] the Supreme Court of Pennsylvania had held that the proper construction of an Act of that State providing that a right of action in favor of relatives should exist for damages for death by negligence did not extend its benefits to alien relatives. On appeal to the Supreme Court of the United States, that Court said:

> "The only question for our decision is whether a proper interpretation and effect were allowed to the treaty.
>
> "We do not deem it necessary to consider the constitutional limits of the treaty-making power. A treaty, within those limits, by the express words of

[228] 100 U. S., 483 (1879).

[229] Ibid., p. 488.

[230] See note 13.

[231] Ibid., p. 490.

[232] 213 U. S., 268 (1909).

the Constitution, is the supreme law of the land, binding alike National and State Courts, and is capable of enforcement, and must be enforced by them in the litigation of private rights. . . .

"We put our decision upon the words of the treaty. By a fair interpretation of them, did they directly confer upon the plaintiff the right which she seeks to maintain? We are of the opinion that they did not."[233]

Such is the unbroken series of cases decided by the Supreme Court of the United States, recognizing, stating, and enforcing the absolute supremacy of treaty provisions over State laws. No case has ever in the history of the United States been decided, which holds, for any reason or under any conditions a treaty provision to be subordinate to a State law or State right.

IV.

There remains, however, for consideration all that has been said or suggested in the way of possible or contingent limitations of the treaty-making power in favor of State rights. In this connection must be considered, first, the language of Mr. Chief Justice Taney in Prevost *vs.* Greneaux[234] and a curious statement by the same judge in Frederickson *vs.* Louisiana; and second, all that has been urged respecting the immunity of the so-called police power of the States from Federal control.

Prevost *vs.* Greneaux came before the Supreme Court in 1856. In 1848 one Francois Marie Prevost, a citizen of Louisiana, died, leaving a large estate. By the existing laws of that State a tax of ten per cent. was imposed on all property inherited by aliens not domiciled in Louisiana. In 1853 a treaty with France became effective providing:

"In all the States of the Union whose laws permit it, so long and to the same extent as the said laws shall remain in force, Frenchmen shall enjoy the right of possession personal and real property by the same title and in the same manner as the citizens of the United States. They shall be free to dispose of it as they may please, either gratuitously or for value received, by donation, testament, or otherwise, just as those citizens themselves; and in no case shall they be subjected to taxes on transfers, inheritance, or any others, different from those paid by the latter, or to taxes which shall not be equally imposed."

[233] Ibid., pp. 272–3.
[234] 19 How., 1 (1855).

In 1854 Jean Louis Prevost, a French subject residing in France, claimed as sole heir and proved his right. The State Supreme Court held

"that the right to the tax was complete, and vested in the State upon the death of Francois Marie Prevost, and was not affected by the treaty with France subsequently made."

In affirming the judgment, Mr. Chief Justice Taney said:

"We can see no valid objection to this judgment. . . . If the property vested [as was admitted] in him [the heir] at that time [the death of the decedent], it could vest only in the manner, upon the conditions authorized by the laws of the State. And, by the laws of the State, as they then stood, it vested in him, subject to a tax of ten per cent. payable to the State. And certainly a treaty, subsequently made by the United States with France, could not divest rights of property already vested in the State, even if the words of the treaty had imported such an intention. But the words of the Article, which we have already set forth, clearly apply to cases happening afterwards—not to cases where the party appeared after the treaty, to assert his rights, but to cases where the right afterwards accrued. And so it was decided by the Supreme Court of the State, and we think, rightly."[235]

There can be no question but that the remarks of Mr. Chief Justice Taney are directly contrary to the decision in Ware *vs.* Hylton.[236] Whether he recognized it to be so, inasmuch as he did not refer to that case, is questionable. But if the analysis heretofore made have any weight, it has been shown that the constitutional provision when inserted was intended to have a retroactive force, and was in Ware *vs.* Hylton given the significance and efficacy advocated by its framers and contemporary interpreters. The failure of Mr. Chief Justice Taney to appreciate the persuasive quality of the logic of that case and its binding force is characteristic of his political attitudes. His words, however, are rendered negligible by the later opinion of the Court in Hauenstein *vs.* Lynham, wherein the decision in Ware *vs.* Hylton is specifically approved and reaffirmed.

"It will be observed," said the Court, "that the treaty-making clause is retroactive as well as prospective. The treaty in question, in Ware *vs.* Hyl-

[235] Ibid., p. 7.

[236] It is also interesting to note that in Geofroy *vs.* Riggs, 133 U. S., 256 (1889), *infra* pages 75–6, the interpretation placed by the Court in a fully reasoned opinion on this French treaty of 1853 is wholly at variance with that of Mr. Chief Justice Taney.

ton, was the British treaty of 1783, which terminated the War of the American Revolution. It was made while the Articles of Confederation subsisted. The Constitution, when adopted, applied to treaties 'made and to be made.' "[237]

In Frederickson *vs.* Louisiana[238] the facts are immaterial to this discussion, but the Court after disposing of the case on other grounds, said:

"It has been suggested in the argument of this case, that the government of the United States is incompetent to regulate testamentary dispositions or laws of inheritance of foreigners, in reference to property within the States

"The question is one of great magnitude, but it is not important in the decision of this cause, and we consequently abstain from entering upon its consideration."[239]

In view of the long series of cases already decided, which have been analyzed above, these statements are surprising. The later case of Hauenstein *vs.* Lynham, however, deprives them of practical significance.

In Holmes *vs.* Jennison,[240] decided in 1840, we have voiced by Mr. Justice Baldwin that idea which has since been welcome to many: namely, that the treaty-making power is subject to what is called the police power of the State.

"It is but a poor and meager remnant of the once sovereign power of the States, a miserable shred and patch of independence, which the Constitution has not taken from them, if in the regulation of its internal police State sovereignty has become so shorn of authority, as to be competent only to exclude paupers, who may be a burden on the pockets of its citizens; unsound, infectious articles, or diseases which may affect their bodily health; and utterly powerless to exclude those moral ulcers on the body political, which corrupt its vitals and demoralize its members. If there is any one subject on which this Court should abstain from any course of reasoning, tending to expand the granted powers of the Constitution, so as to bring internal police within the law of treaty-making power of the United States, by including it within the prohibition on the States, it is the one now before us. Nay, if such construction is not unavoidable, it ought not to be given; lest we introduce into the Constitution a more vital and pestilential disease than any principle on which the relator could be rescued from the police power of Vermont, would fasten on its institutions, dangerous as it might be, or injurious its effects."[241]

We have in these words expressed in its most enthusiastic form,

[237] 100 U. S., p. 489.

[238] 23 How., 445 (1859).

[239] Ibid., p. 448.

[240] 14 Peters, 540 (1840).

[241] Ibid., p. 618.

the doctrine of the supremacy of the State police power. It had been more briefly enunciated in an earlier case, however, in which no reference was had to the treaty power. In New York *vs.* Miln[242] the Court said:

"We choose rather to plant ourselves on what we consider impregnable positions. They are these: . . . That all those powers which relate to merely municipal legislation, or what may, perhaps, more properly be called internal police, are not thus surrendered or restrained; and that, consequently, in relation to these, the authority of a State is complete, unqualified and exclusive."[243]

In the so-called License Cases[244] the States of Massachusetts, Rhode Island and New Hampshire had passed statutes in the nature of prohibition acts. Under them convictions had been had, which were sustained in the Supreme Court. It was urged that the Acts were unconstitutional attempts to regulate commerce and were in conflict with treaty stipulations; they were defended as having been passed in the exercise of the State police power. In the Rhode Island case, the brandy purchased by the indicted defendant was in the original package in which it had been imported from France. It was unanimously held that the State laws were all constitutional, and that the treaties did not by their proper construction apply. Six justices delivered opinions, differing from one another in the reasons adduced for sustaining the constitutionality of the Acts. And in subsequent opinions they again differed as to what were or what were not the *rationes decidendi* of the case. From those opinions may be collected expressions of belief in the supremacy of State police powers. Said Mr. Justice McLean:

"The Federal government is supreme within the scope of its delegated powers, and the State governments are equally supreme in the exercise of those powers not delegated by them nor inhibited to them. From this it is clear, that while the supreme functions are exercised by the Federal and State governments within their respective limitations, they can never come in conflict. And when a conflict occurs, the inquiry must necessarily be, which is the paramount law. . . .

"When in the appropriate exercise of these Federal and State powers, contingently and incidentally their lines of action run into each other; if the State power be necessary to the preservation of the morals, the health, or safety of the community, it must be maintained."[245]

[242] 11 Peters, 102 (1837).
[243] Ibid., p. 139.
[244] 5 How., 504 (1847).
[245] Ibid., pp. 587, 592.

Said Mr. Justice Daniel:

"Laws of the United States in order to be binding, must be within the legitimate powers vested by the Constitution. Treaties, to be valid, must be made within the scope of the same powers; for there can be no 'authority of the United States,' save what is derived mediately or immediately and regularly and legitimately from the Constitution. A treaty, no more than an ordinary statute, can arbitrarily cede away any one right of a State or of any citizen of a State."[246]

Mr. Justice Grier repeated the quotation from New York *vs.* Miln, already given above,[247] and concluded:

"If the right to control these subjects be 'complete, unqualified, and exclusive' in the State legislatures, no regulations of secondary importance can supersede or restrain their operations, on any ground or prerogative or supremacy. The exigencies of the social compact require that such laws be executed before and above all others."[248]

Two years later, in the so-called Passenger Cases,[249] there were declared unconstitutional, statutes of New York and Massachusetts attempting *inter alia* to levy a tax on every alien coming into the state, although the proceeds of that tax were declared to be for the purpose of creating a fund for charitable purposes connected with immigration. Four judges dissented. From their opinions additional expressions of the inviolability of the State police power may be gathered. Said Mr. Chief Justice Taney:

"The first inquiry is, whether under the Constitution of the United States, the Federal government has the power to compel the several States to receive and suffer to remain in association with its citizens, every person or class of persons whom it may be the policy or pleasure of the United States to admit. . . . If the people of the several States of this Union reserved to themselves the power of expelling from their borders any person, or class of persons, whom it might deem dangerous to its peace, or likely to produce a physical or moral evil among its citizens, then any treaty or law of Congress invading this right and authorizing the introduction of any person for description of persons against the consent of the State would be an usurpation of power which this Court could neither recognize nor enforce.

"I had supposed this question not now open to dispute."[250]

[246] Ibid., pp. 612–3.
[247] *Supra,* p. 169.
[248] 5 How., p. 632.
[249] 7 How., 283 (1849).
[250] Ibid., pp. 465–6.

Said Mr. Justice Daniel:

"Admitting this Fourteenth Article of the treaty to be in full force, and that it purported to take from the State of New York the right to tax aliens coming and commorant within her territory, it would be certaintly incompetent for such a purpose, because there is not, and never could have been, any right in any other agent than her own government to bind her by such a stipulation."[251]

Said Mr. Justice Woodbury:

"Measures which are legitimately of a police character are not pretended to be ceded anywhere in the Constitution to the general government in express terms: and as little can it be argued that they are impliedly to be considered as ceded, if they be honestly and truly police measures."[252]

Before examining into the circumstances under which the above expressions of *judicial opinion* have occurred and into the question how far the development of constitutional law has sanctioned or refuted their authority, it may be well to summarize the conclusions from our detailed analysis of *decisions*. These fundamental conclusions are three in number:

First: That a treaty provision having such expressed intention, will of its own force, operate as a Federal legislative act, and that this principle obtains even though the subject of the treaty provision be one committed by the Constitution to the legislation of Congress;

Second: That acts of Congress and treaty provisions stand under the Constitution on an equal footing, and that the last expression of the Federal will, be it by statute or by treaty, must prevail;

Third: That treaty provisions may deal with subjects not committed to the legislation of Congress, and that, when so declaratory of the Federal will, they operate of their own force to annul the constitution or law of any State in conflict therewith.

The question presented is, whether an exception exists to the third conclusion, and specifically, whether it be true that treaty provisions conflicting with the exercise of its police power by a State, are beyond the power of the Federal government, and consequently invalid. That question at perhaps tedious length but with an effort toward complete analysis we will now attempt to determine.

[251] Ibid., p. 507.

[252] Ibid., p. 524.

There is, however, a preliminary point which should be elucidated. It will have been observed that while considering the series of cases illustrating and establishing the supremacy of treaty provisions over State laws, the effect of the Tenth Amendment to the constitution was not considered. It has, however, been made of much importance by those who have advocated the supremacy of State rights, which rights they have called by virtue of this amendment, "the reserved rights of the States." The amendment is in these words:

> "The powers not delegated to the United States by the Constitution, nor prohibited by it to the States, are reserved to the States respectively, or to the people."

At the time of analyzing the cases referred to, this amendment was purposely not discussed because it was deemed to be wholly immaterial. The constitutional debates, and the political literature of that day show conclusively that the authors of the Constitution regarded the Federal government as one essentially of enumerated powers, apart from any and all amendments. The Tenth was adopted merely as declaratory of the interpretation which must properly in all events have been given to the Constitution, and to free the minds of certain persons who considered that the agreement of all parties that the Federal government was one of enumerated powers only, should be placed beyond the possibility of future and wrongful breach. It was considered to have, and it did have, no repealing or modifying force on the provisions of the Constitution itself. Throughout the debates, Federal and State, leading to the adoption of the Constitution or looking toward its amendment, one may search in vain for any suggestion that the limitations therein provided had any reference to the treaty power. The very language of the amendment would seem to establish this fact. What are the powers reserved to the States thereby? "The powers," first, says the amendment, "not delegated to the United States," and second, adds the amendment, not "prohibited by it to the States." Now, by the Constitution the power to make treaties is specifically granted to the Federal government in the Second Section of the Second Article, and specifically prohibited to the States by the Tenth Section of the First

Article. A mediaeval theologian alone—and his logic is not the kind used today—could demonstrate that with both exceptions named in the amendment specifically existing, such amendment was none the less effective in limitation of the treaty-making power. The reserved rights of the States are necessarily and by virtue of the very words of the Tenth Amendment, those rights which remain after the grant, first, of the treaty-making power, and, second, of the power to Congress to legislate upon certain subjects. The Tenth Amendment, therefore, leaves the treaty-making power of the United States unaltered and precisely as granted by the Constitution.

The most cursory examination of the judicial opinions quoted above on the supremacy of State police power, shows that this supremacy was maintained alike over treaty provision and act of Congress. No superior efficacy is claimed for act of Congress or for treaty. It is Federal supremacy which is challenged, and the manner of its manifestation is indifferent. It must of necessity be so; for in the Sixth Article of the Constitution "the laws of the United States which shall be made in pursuance" of the Constitution, and "all treaties made, or which shall be made, under the authority of the United States" are placed on equal footing, and given the same efficacy. The treaty power may deal with subjects which have been the subjects of congressional legislation; it may deal also with subjects beyond the legislation of Congress. But the question is not one of the *extent* of the treaty-making power, or of congressional action; that is determined; the treaty-making power must act upon subjects properly and customarily the subjects of treaty; congressional action must be within the constitutionally delegated powers. The question is essentially one of the *effectiveness* of treaty provision or of act of Congress when in conflict with State police power; and no more efficacy and no less can be claimed for treaty provision than for act of Congress. Inasmuch as the doctrine that the police power is an inviolable attribute of State sovereignty, and beyond the sphere of activity of Federal treaty and Federal law alike, it is essential that any analysis of the subject should extend to both manifestations of Federal activity. What is true of the *effectiveness* of one is inevitably true of the *effectiveness* of the other.

Attempts at defining the term police power have been many. We should not, however, be here tempted to essay it; for our object rather is to understand how the term has been used by others, and diversely indeed has it been used. In order to carry in mind, while reviewing the language of the courts, the various significations attached to the term, it will be well to indicate several. From one point of view—a view sanctioned by the etymological and probably historical origin of the term—the meaning given is equivalent to that of *municipal law;* all that body of law which we have come to regard as *local,* in contradistinction to what we conceive is properly national or international law. Again, viewing the subject from the peculiar point of view of the constitutional student, the term has been used, sometimes by members of the judiciary, to comprise no more and no less than the reserved powers of the States. The difficulty with this view is that it affords no means whatever of identifying those powers, but only gives to them a new name. Thirdly, the police power is said to be that power which provides for the public safety and welfare. This is perhaps the most popular view, but the difficulty is that almost any measure appropriate to be adopted, can be justified as intended to further the public welfare.

Examining into the development of the use of the term, one notes in the Federal Constitutional Convention that a resolution was proposed and rejected giving to Congress the power "to make laws binding on the people" of the United States "in all cases which may concern the common interests of the Union; but not to interfere with the government of the individual States in any matters of *internal police* which respect the government of such States only, and wherein the general welfare of the United States is not concerned."[253] Again, on the day when the Convention adjourned, a motion was made and defeated to insert in the Constitution a proviso "that no State shall, without its consent, be affected in its *internal police,* or deprived of its equal suffrage in the Senate."[254] In 1824, the great constitutional case of Gibbons *vs.* Ogden[255] was

[253] Farrand, Vol. II., p. 21.
[254] Ibid., p. 630.
[255] 9 Wheat., 1 (1824).

decided, and therein the conception of the State police power was further developed and elucidated. The question at issue was the validity of an Act of New York granting to Fulton and another exclusive rights to navigate the waters of the State in vessels propelled by fire or steam. It had been argued that the cases sustaining State statutes of quarantine were readily distinguishable. In reply to this argument, counsel argued as follows in support of the State law:

"The quarantine laws further illustrate our position. The appellant's counsel says, these are to be considered merely as laws of police; they are laws of police, but they are also laws of commerce; for such is the nature of that commerce, which we are told must be regulated exclusively by Congress, that it enters into, and mixes itself with, almost all the concerns of life."[256]

Mr. Chief Justice Marshall, in delivering the unanimous decision of the Court declaring the unconstitutionality of the New York law, so clearly and so logically stated the functions and status of the police powers of a State, that the subsequent confusion of thought upon this subject of so many judges must cause one to wonder at the possibility. It is, however, but one more illustration of the vagaries of interpretation to which fixed political convictions may lead even the judiciary. Said Mr. Chief Justice Marshall:

"Since, however, in exercising the power of regulating their own purely internal affairs, whether of trading or police, the States may sometimes enact laws, the validity of which depends on their interfering with, and being contrary to, an act of Congress passed in pursuance of the Constitution, the Court will enter upon the inquiry, whether the laws of New York, as expounded by the highest tribunal of that State, have, in their application to this case, come into collision with an Act of Congress, and deprived a citizen of a right to which that Act entitles him. Should this collision exist, it will be immaterial, whether those laws were passed in virtue of a concurrent power 'to regulate commerce with foreign nations and among the several States,' or in virtue of a power to regulate their domestic trade and police. In one case and the other, the Acts of New York must yield to the law of Congress; and the decision sustaining the privilege they confer, against a right given by a law of the Union, must be erroneous. This opinion has been frequently expressed in this Court, and is founded, as well on the nature of the government, as on the words of the Constitution. In argument, however, it has been contended, that if a law passed by a State in the exercise of its acknowledged sovereignty, comes into conflict with a law passed by

[256] Ibid., p. 112.

Congress in pursuance of the Constitution, they affect the subject, and each other, like equal opposing powers. But the framers of our Constitution foresaw this state of things, and provided for it, by declaring the supremacy not only of itself, but of the laws made in pursuance of it.

"The nullity of any Act, inconsistent with the Constitution is produced by the declaration, that the Constitution is the supreme law. The appropriate application of that part of the clause which confers the same supremacy on laws and treaties, is to such acts of the State legislatures as do not transcend their powers, but though enacted in the execution of acknowledged State powers, interfere with, or are contrary to, the laws of Congress, made in pursuance of the Constitution, or some treaty made under the authority of the United States. In every such case, the Act of Congress. or the treaty, is supreme; and the law of the State, though enacted in the exercise of powers not controverted, must yield to it."[257]

With this one decision and this one exposition of the relations between the Federal powers and the State police power, a complete understanding of the subject might well begin and end. But as an historical review is essential here, we may carry with us Marshall's words in somewhat the fashion that Matthew Arnold advised the student of poetry to store up in his mind the great utterances of great poets to serve as an infallible test.

Brown *vs.* Maryland,[258] another great constitutional case, was decided in 1827. The State statute had required all importers of foreign goods and all persons selling the same to take out a license. The statute was held unconstitutional, and imported articles were said to remain articles of commerce free from State legislation and subject only to the power of Congress to regulate commerce, so long as they remained in the original unbroken packages in which they were shipped. In the course of his opinion Mr. Chief Justice Marshall said:

"The power to direct the removal of gunpowder is a branch of the police power, which unquestionably remains and ought to remain, with the States. . . . We are not sure, that this may not be classed among inspection laws. The removal or destruction of infectious or unsound articles is, undoubtedly, an exercise of that power, and forms an express exception to the prohibition we are considering. Indeed, the laws of the United States expressly sanction the health laws of a State."[259]

[257] Ibid., pp. 209–11.

[258] 12 Wheat., 419 (1827).

[259] Ibid., p. 442.

John Marshall died in 1835, and within less than two years after his death the case of New York *vs.* Miln[260] was decided. The State had enacted, first, that the master of every vessel arriving in New York should make a report in writing of all passengers whom he had landed, or who had departed from his vessel with a view to subsequently reaching New York; and secondly, that the master of such vessel should give bond for each passenger or child thereon that none should become a charge on the city. Said the Court:

> "We are of opinion that the Act is not a regulation of commerce, but of police; and that being thus considered, it was passed in the exercise of a power which rightfully belonged to the State."[261]

Gibbons *vs.* Ogden and Brown *vs.* Maryland are formally approved and declared to be wholly consistent with the decision rendered; and in language already quoted, the Court say:

> "All these powers which relate to merely municipal legislation, or what may, perhaps, more properly be called *internal police*,[262] are not thus surrendered or sustained [by the Constitution]; . . . consequently, in relation to these, the authority of a State is complete, unqualified and exclusive."[263]

In so arguing, the Court fails to see that it is dangerously near to the logical fallacy: *petitio principii.* It will not logically do to say: The police powers belong to the reserved rights of the States—the act in question is an exercise of the police power—therefore it is constitutional. For it might well be that an act passed by a State under its power of "internal police" might operate to regulate commerce, entirely apart from the motives of its authors or the main object it subserved. As Mr. Chief Justice Marshall had simply, but with inspired penetration, said: The Federal power to regulate commerce "is co-extensive with the subject on which it acts and cannot be stopped at the external boundary of a State, but must enter its interior."[264] The question was not, could not be, whether the act in question was an exercise of the police power of the State. It might well be regarded, and properly, as such an act. The question was inevitably: Was the statute invalid, although an exercise of the police power, inasmuch as it infringed on the power of Con-

[260] 11 Peters, 102 (1837).

[261] Ibid., p. 132.

[262] Italics are in the opinion.

[263] 11 Peters, p. 239.

[264] 12 Wheat., p. 446.

gress to regulate commerce, and so was a part of the police power ceded by the States to the Federal government. The moment one defines the police power as equivalent to internal police, that moment the question of the constitutionality of a State statute becomes, not: Is the statute an exercise of the State police power? but: Does the exercise of the police power involve a conflict with powers given by the Constitution to the Federal government?

A portion of the opinion of Mr. Justice Baldwin in Holmes *vs.* Jennison has been quoted.[265] That case followed New York *vs.* Miln and contains as full and complete enunciation of the doctrine of the inviolability of State police power as exists. The action arose on the attempt made by the governor of Vermont to extradite the defendant to Canada. No treaty covered the case. The writ of error was dismissed for want of jurisdiction by a divided Court. But the difficulty with insisting on the validity of the views of Mr. Justice Baldwin therein contained as to the inviolability of State police powers, is that the opinion of Mr. Chief Justice Taney, and of the other justices who differed with Mr. Justice Baldwin,[256] has been the opinion to prevail in the history of constitutional law in the United States. To this effect was the decision in United States *vs.* Rauscher,[267] decided in 1886. Certainly, Mr. Justice Baldwin was right in thinking the act of the Governor of Vermont an exercise of State police power. But it was none the less violative of the Constitution. The true solution is that the police powers of a State are, like all other of its powers, subject to the controlling influence of all acts done in pursuance of the Federal Constitution. One cannot return too often to the language of Mr. Chief Justice Marshall in Gibbons *vs.* Ogden, where he said:

"In argument, however, it has been contended, that if a law passed by a State, in the exercise of its acknowledged sovereignty, comes into conflict with a law passed by Congress in pursuance of the Constitution, they affect the subject, and each other, like equal opposing powers. But the framers of

[265] *Supra,* pp. 167–169.

[266] A careful analysis of this case will demonstrate that Mr. Justice Baldwin's views were opposed to those of the majority of the court. On this ground, the Supreme Court of Vermont subsequently ordered the release of the prisoner—*Ex parte* Holmes, 12 Vermont, 631 (1840).

[267] 119 U. S., 407 (1886), *supra,* pp. 73–74.

our Constitution foresaw this state of things, and provided for it, by declaring the supremacy not only of itself, but of the laws made in pursuance of it.

"The nullity of any act, inconsistent with the Constitution, is produced by the declaration, that the Constitution is the supreme law. The appropriate application of that part of the clause which confers the same supremacy on laws and treaties, is to such acts of the State legislatures as do not transcend their powers, but though enacted in the execution of acknowledged State powers, interfere with, or are contrary to, the laws of Congress, made in pursuance of the Constitution, or some treaty made under the authority of the United States. In every such case, the act of Congress, or the treaty, is supreme; and the law of the State, though enacted in the exercise of powers not controverted, must yield to it."[268]

The language of three of the members of the Court in the License Cases has already been quoted.[269] These cases require examination. In them were involved statutes of Massachusetts, Rhode Island, and New Hampshire, which were in the nature of prohibition acts. In the Rhode Island case the brandy purchased by the indicted defendant was in the original package in which it had been imported from France. All were held to be the constitutional exercise by the States of their police powers. These same constitutional questions came again before the Supreme Court in a series of cases culminating in that of Leisy *vs.* Hardin,[270] and therein this New Hampshire case was specifically disapproved and overruled. The decision was that a prohibition statute, as applied to sales by an importer from another State of liquors in the original packages, was unconstitutional. It is based upon the reasoning of Mr. Chief Justice Marshall in Gibbons *vs.* Ogden and Brown *vs.* Maryland, and concludes thus:

"As the grant of the power to regulate commerce among the States, so far as one system is required, is exclusive, the States cannot exercise that power without the assent of Congress, and, in the absence of legislation, it is left for the Courts to determine when State action does or does not amount to such exercise, or, in other words, what is or is not a regulation of such commerce. When that is determined, controversy is at an end."[271]

The decision is emphasized by the dissenting reasoning of Mr. Justice Gray, with whom concurred Mr. Justice Harlan and Mr. Justice Brewer. He argued that the State statute was an exercise of the police power, and that, while it might affect commerce, yet there

[268] 9 Wheat., pp. 210–1.

[269] *Supra*, pp. 170–172.

[270] 135 U. S., 100 (1890).

[271] Ibid., p. 119.

should not be inferred from the silence of Congress upon the subject any intention that commerce should be free from the operation of laws passed by a State in the exercise of its police powers. Consequently, until Congress acted, the State statute was valid. Said Mr. Justice Gray:

"The protection of the safety, the health, the morals, the good order and the general welfare of the people is the chief end of government. *Salus populi suprema lex.* The police power is inherent in the States, reserved to them by the Constitution, and necessary to their existence as organized governments. The Constitution of the United States and the laws made in pursuance thereof being the supreme law of the land, all statutes of a State must, of course, give way, so far as they are repugnant to the national Constitution and laws. But an intention is not lightly to be imputed to the framers of the Constitution, or to the Congress of the United States, to subordinate the protection of the safety, health and morals of the people to the promotion of trade and commerce."[272]

We have thus the unanimous acquiescence by the Court in the doctrine that whenever a conflict occurs between constitutional acts of the United States and State police powers operating upon the same subject, the State police power must yield. In other words, the police power of the States is subject to treaty provision and constitutional act of Congress.[273] And if one choose, this being true, to apply no longer the term police power to the source of the State's activity, the difference is one of words only. The thought of Mr. Justice Gray was the same which Mr. Chief Justice Taney had expressed in the License Cases.

"What are the police powers of a State?" asked Mr. Chief Justice Taney. He answered: "They are nothing more or less than the powers of government inherent in every sovereignty to the extent of its dominions. And whether a State passes a quarantine law, or a law to punish offenses, or to establish Courts of Justice, or requiring certain instruments to be recorded, or to regulate commerce within its own limits, in every case it exercises the same powers; that is to say, the power of sovereignty, the power to govern men and things within the limits of its dominion. It is by virtue of this power that it legislates; and its authority to make regulations of commerce is as absolute as its power to pass health laws, except in so far as it has been restricted by the Constitution of the United States. And when the validity of a State law making regulations of commerce is drawn into question in a

[272] Ibid., pp. 132, 158.

[273] See note 14.

judicial tribunal, the authority to pass it cannot be made to depend upon the motives that may be supposed to have influenced the legislature, nor can the Court inquire whether it was intended to guard the citizens of the State from pestilence and disease, or to make regulations of commerce for the interests and convenience of trade.

"Upon this question the object and motive of the State are of no importance, and cannot influence the decision. It is a question of power."[274]

Mr. Chief Justice Taney concluded in these License Cases that Congress had passed no law upon the subject, that the federal government had entered into no treaties, that *in their absence and only in their absence* the statutes were valid.

Certain of the judges in these License Cases, however, gave voice to opinions on the supremacy of the police power which we have already quoted.

"When in the appropriate exercise," said Mr. Justice McLean, "of these Federal and State powers, contingently and incidentally their lines of action run into each other; if the State power be necessary to the preservation of the morals, the health, or safety of the community, it must be maintained."[275]

Without grave qualification of his language, Mr. Justice McLean, as is seen in Leisy *vs.* Hardin, was wrong. The language of Mr. Justice Daniel is in itself unexceptional.[276] If he meant more than his words necessarily imply, and intended to convey the idea that treaty provisions and acts of Congress were arbitrary and void if they operated upon the police powers of the State, he was out of sympathy with the subsequent development of constitutional law, as illustrated in Leisy *vs.* Hardin, and his opinion has only an historical interest for us here. The lack of really authoritative force in his words may be gathered from this additional quotation from his opinion:

"The doctrines which to me appear to have been gratuitously brought into this case are those which have been promulgated in the reasoning of this Court in the case of Brown *vs.* The State of Maryland,—doctrines (and I speak it with all due respect) which I conceive cannot, by correct induction, be derived from the Constitution, nor even from the grounds assumed for their foundation in the reasoning of the Court in that case; but which, on the contrary, appear to be wholly illogical and arbitrary."[277]

[274] 5 How., p. 582.
[275] Ibid., p. 592.
[276] *Supra,* p. 170.
[277] 5 How., p. 611.

The language used by Mr. Justice Grier needs no extended comment.[278] Like that of Mr. Justice Daniel, it sprang from certain political convictions of the times, and has not been sanctioned by the development of constitutional law.

The opinions of the dissenting judges in the Passenger Cases[279] cannot be regarded as possessed of authoritative force. It was urged by them that a tax on every alien coming into a State port was a proper exercise of the police power beyond the control of the Federal government whether operating by act of Congress or by treaty provision, because the tax was devoted to charitable uses; in one case, a marine hospital; in the other, the support of foreign paupers. The judgments were against the constitutionality of the acts, and inasmuch as the whole current of constitutional law has since moved irresistibly in this direction, these dissenting opinions, like the majority of the others we have been considering, have only an historical interest. The kind of argument which was so popular and so potent during the period from John Marshall's death to the Civil War, whose coloring influence may be seen reflected in such opinions, is well exemplified in these Passenger Cases. Said counsel for New York of the State he represented:

> "She saw with unaffected concern the prodigious strides made by this power to regulate commerce towards engrossing and consolidating the power of the Union. This may well be regarded as the mastodon of construction, starting from this bench, and in its giant strides trampling upon the rights of the States and their sovereignty. Fortunately, it is only known to the present day by its colossal bones, scattered through the reports of the early opinions of members of this Court. Its march was arrested, its life terminated, in New York *vs.* Miln. The noble ground then assumed was maintained in the License Cases."[280]

A careful reflection upon the implications underlying these words, and upon the magnitude of interstate commerce today, will do much to put a just valuation upon the opinions of many of the judges who immediately succeeded John Marshall.

We thus reach the conclusion of an analysis of the decisions

[278] *Supra*, p. 171.

[279] 7 How., 282 (1849).

[280] Ibid., pp. 378–9.

upon the *effectiveness* of act of Congress and treaty provision when in conflict with an exercise of State police power. We have seen that they do ***not*** "affect the subject, and each other, like equal opposing powers"; but that the State police power, whatever be the definition or intendment of that term, must yield. So held John Marshall in Gibbons *vs.* Ogden, and such, after avowed aberration by some judges and covert disloyalty by others to the doctrine, is the law today. The cases, with the possible exception of the Passenger Cases, have been illustrations of conflict with act of Congress and not with treaty. But by the Sixth Article of the Constitution, and by its interpretation in Gibbons *vs.* Ogden, no distinction is drawn between their equal and controlling supremacy. This is confirmed by the long line of cases holding that between statute and treaty, the latest expression of the Federal will must prevail.[281] The logic itself of the situation admits of no distinction. Marshall had said of the power to regulate commerce:

> "The power is co-extensive with the subject on which it acts, and cannot be stopped at the external boundary of a State, but must enter its interior."

So necessarily must it be with the power to make treaties. Is it thinkable that that power may be "stopped at the external boundary of a State"? Aliens "must enter its interior," as commerce does; and the power of the United States to provide for such aliens by treaty must accompany them. In our review of the causes which led to the creation of the Sixth Article of the Constitution, of the purposes it was intended to subserve, of the interpretations placed upon it by contemporaries, it was seen as a universally admitted fact, that treaty provisions had been stopped at State boundaries, and it was accordingly provided that under the Constitution the treaty power should enter the interior of the States and there operate as a supreme manifestation of the Federal will. And this was the deliberate and reiterated judgment of the Supreme Court in the cases analyzed beginning with Ware *vs.* Hylton. If, in the definition of some lawyers, no State statute under examination in these cases was an exercise of the police power, we have none the less seen that the long list of cases beginning with Gibbons *vs.* Ogden and Brown *vs.* Mary-

[281] *Supra*, 83–99.

land, and ending with the echoes of the decision in Leisy *vs.* Hardin, established, beyond all possibility of controversy, the supremacy over State police power of the constitutionally expressed Federal will, whether manifest in act of Congress or in treaty. The language of the Supreme Court in certain cases arising out of State quarantine laws perhaps best presents its recent position in this regard. Thus, we have the following authoritative utterances:

> "Definitions of the police power must, however, be taken, subject to the condition that the State cannot, in its exercise, for any purpose whatever, encroach upon the powers of the general government, or rights granted or secured by the supreme law of the land."[282]

> "While it [an alleged right of State regulation] may be a police power in the sense that all provisions for the health, comfort, and security of the citizens are police regulations, and an exercise of the police power, it has been said more than once in this Court that, even where such powers are so exercised as to come within the domain of Federal authority as defined by the Constitution, the latter must prevail."[283]

> "Generally it may be said in respect to laws of this character, that though resting upon the police power of the State, they must yield whenever Congress, in the exercise of the powers granted to it, legislates upon the precise subject-matter; for that power, like all other reserved powers of the State, is subordinate to those in terms conferred by the Constitution upon the nation."[284]

We have seen that the inefficiency of the Federal will was the acknowledged weakness of the United States under the Articles of Confederation; that that weakness was appreciated and regretted by those who formed the Constitution; that the language used in that instrument was intended by them to secure the supremacy of the Federal will; and that the Supreme Court had interpreted it accordingly. It might seem that any possible discussion of the meaning of Article VI. was thus foreclosed. But it may be well to account for the doubts and questionings which have, as we have seen, reached even to the Supreme Court. There was no uncertainty in the mind or in the utterance of Mr. Chief Justice Marshall when Gibbons *vs.* Ogden was decided. Yet in that very case he had said:

[282] New Orleans Gas Co. *vs.* Louisiana Light Co., 115 U. S., 650 (1885), p. 661.

[283] Morgan *vs.* Louisiana, 118 U. S., 455 (1886), p. 464.

[284] Gulf, Colorado & Sante Fe Ry. Co. *vs.* Hefley, 158 U. S., 98 (1895), p. 104.

"It has been contended that if a law passed by a State in the exercise of its acknowledged sovereignty, comes into conflict with a law passed by Congress in pursuance of the Constitution, they affect the subject and each other, like equal opposing powers."

Unsound that contention was declared by the Court to be. But it was in effect the contention of that powerful body which spoke through Calhoun, and which strove to dominate the Union. In the writings of that brilliant intellect, are concentrated the emotions, the reasoning, the political conceptions of the slavocracy. And in them we find an attempt at a logical basis for the doctrine we know as "State rights"—an attempt both able and sincere.[285] The States, he said, are sovereign; certain of their powers only they have delegated. All acts done by the Union beyond its delegated powers are void. It is for the States to differ from the Union with reluctance as to the exercise of such a power; but if they assert their difference, they assert it as a sovereign party to a treaty asserts its right to insist on its own interpretation. No jurisdiction lies in any Federal court, no power lies in any Federal agent, to overcome the declaration of the State, when it "nullifies" the Federal law. In the view of such a man and of the powerful party which supported him, the functions of State legislation expanded, and of Federal activities lessened. The Judiciary Act, so far as it allowed an appeal from the State Courts to the United States Supreme Court, he declared to be unconstitutional.[286] And when the tariff act of 1832 was "nullified" by South Carolina in a declaration written by Calhoun,[287] at the time vice-president of the United States, Congress hastened to compromise. Is it strange that with such ideas obtaining credence in so many minds, hesitation existed on the part of some to declare the apparent meaning of Article VI. of the Constitution to be the real meaning; that the term "police power of the States" conveyed an illusory accent of authority; and the declarations of Federal will received a qualified and timid adherence? The mandate of the

[285] See "A Discourse on the Constitution and Government of the United States." Calhoun's Works, Vol. I., p. 111. "Address to the People of South Carolina," Ibid., Vol. VI., p. 124. Letter to Governor Hamilton, Ibid., VI., p. 144.

[286] "A Discourse on the Constitution, Ibid., Vol. I., at p. 318, ff.

[287] "Address to the People of the United States," Ibid., Vol. VI., p. 193.

Supreme Court of the United States in Worcester *vs.* State of Georgia was insulted and ignored.[288] And the Federal government stood by silently assenting. Of that Federal government, Calhoun was vice-president, and Roger B. Taney, attorney general. With the death of John Marshall, that attorney general, a citizen of a slave State, was created the Chief Justice of the Supreme Court by the very President who had permitted Georgia to defy that Court. Is it a cause for wonder that doubt as to the supreme efficacy of treaty provision over State law crept into the Court over whom presided Mr. Chief Justice Taney? But today, a half-century after the Civil War, that doubt is a survival which, Professor Mikell must permit one to say, has no function to perform and has outlived its reason for existence.

V.

There is, however, a further consideration which lies before us. We have come to realize that, born in times of stress, and intended as a firm anchorage in future storms, the Constitution is pervaded and inspired by that intention. We have come to appreciate the memorable words of Marshall:

> "As men, whose intentions require no concealment, generally employ the words which most directly and aptly express the ideas they intend to convey, the enlightened patriots who framed our Constitution, and the people who adopted it, must be understood to have employed words in their natural sense, and to have intended what they have said."[289]

We have seen the Supreme Court of the United States interpret the Sixth Article of the Constitution in accordance with the purposes for which it was adopted and the plain meaning of its words. To the candid and informed mind, the supremacy of treaty provision has been placed by those decisions beyond the region of controversy. But now the question becomes relevant: *Grant the supremacy, how is it to be enforced?* It is apprehended that a series of decided cases in the Supreme Court of the United States has determined all the applicable principles of constitutional law, and pointed out the methods by which is to be enforced any treaty provision.

[288] *Supra,* pp. 158–161.

[289] Gibbons *vs.* Ogden, 9 Wheat., p. 188.

But before we turn to the examination of these decisions, it may be well to consider certain of the incidents in the diplomatic relations of the United States in which has arisen the question of its power to enforce treaty provisions. It will not be attempted to examine these occurrences from the point of view of rights and liabilities under international law, but wholly with respect to the attitude taken by the Department of State toward the subject.

On November 10, 1880, certain Chinese residents of Denver, Colorado, were injured or killed and their property destroyed by a mob moved by race hatred. In reply to the representations of the Chinese minister, the Secretary of State, Mr. Evarts, said:

> ". . . As to the arrest and punishment of the guilty persons who composed the mob at Denver, I need only remind you that the powers of direct intervention on the part of this government are limited by the Constitution of the United States. Under the limitations of that instrument, the government of the Federal Union cannot interfere in regard to the administration or execution of the munipical laws of a State of the Union, except under circumstances expressly provided for in the Constitution. Such instances are confined to the case of a State whose power is found inadequate to the enforcement of its municipal laws and the maintenance of its sovereign authority; and even then the Federal authority can only be brought into operation in the particular State, in response to a formal request from the proper political authority of the State. It will thus be perceived that so far as the arrest and punishment of the guilty parties may be concerned, it is a matter which, in the present aspect of the case, belongs exclusively to the government and authorities of the State of Colorado."[290]

The Chinese minister replied:

> "I regret to learn from your note that the powers of direct intervention on the part of the United States Government are limited by the Constitution. It appears to me that treaties as well as the Constitution, are the supreme law ot this land. The Chinese residents who were subjected to the wanton outrage of the mob, came to this country, under the right of treaties between China and the general Government of the United States, and not with Colorado or any individual State.
>
> "Thus, the case under consideration should be a question of intercourse between China and the United States, and different from that to be dealt with under the ordinary internal administration of a State. It was with this view that I had in my last note requested you to cause this case to be examined. But I fail to learn from your note the number of the guilty persons that have been arrested, and how they have been punished or dealt

[290] William M. Evarts to Chen Lan Pin, Foreign Relations, 1881, p. 319.

with, and how the general Government of the United States has exercised, or intends to exercise, its power in executing the treaty obligations to protect the Chinese."[291]

To this letter, Mr. Blaine responded:

"Your observations to the effect that treaties form a part of the supreme law of this land equally with the Constitution of the United States, is evidently based on a misconception of the true nature of the Constitution. That instrument, together with all laws which are made in pursuance thereof. and all treaties made or which shall be made under the authority of the United States, are the supreme law of the land. Such is the language of the Constitution, but it must be observed that the treaty no less than the statute law, must be made in conformity with the Constitution, and were a provision in either a treaty or a law found to contravene the principles of the Constitution, such provision must give way to the superior force of the Constitution, which is the organic law of the republic, binding alike on the government and the nation. It is under this interpretation of the Constitution that foreigners, no less than citizens, find their best guarantee for that security and protection in their persons and property which it is the aim and desire of the Government of the United States to extend to all alike."[292]

Here the matter ended. Exactly what idea, if any, Mr. Blaine intended to convey by his concluding sentences, is not clear.

On March 14, 1891, eleven Italians were killed by a mob in New Orleans, Louisiana, in a series of occurrences known as the Mafia riots. The chief of police had been previously murdered and his death was ascribed to the Mafia. The eleven Italians had been arrested on that charge, tried and acquitted. A mob thereupon killed them. Said the Secretary of State, Mr. Blaine:

"If it shall result that the case can be prosecuted only in the State Courts of Louisiana, and the usual judicial investigation and procedure under the criminal law is not resorted to, it will then be the duty of the United States to consider whether some other form of redress may be asked. It is understood that the State grand jury is now investigating the affair, and, while it is possible that the jury may fail to present indictments, the United States cannot assume that such will be the case.

"The United States did not by the treaty with Italy become the insurer of the lives or property of Italian subjects resident within our territory. No government is able, however high its civilization, however vigilant its police supervision, however severe its criminal code, and however prompt and inflexible its criminal administration, to secure its own citizens against violence promoted by individual malice or by sudden popular tumult. The foreign

[291] Chen Pan Pin to William M. Evarts, Ibid., p. 321.
[292] James G. Blaine to Chen Lan Pin, Ibid., p. 336.

resident must be content in such cases to share the same redress that is offered by the law to the citizen, and has no just cause of complaint or right to ask the interposition of his country if the Courts are equally open to him for the redress of his injuries."[293]

This case caused the greatest excitement in both countries, and the Italian minister was withdrawn. The international obligations of the United States were finally settled by an appropriation by Congress as indemnity. This course had been adopted in the Chinese riots at Denver, and has been followed in practically all of the instances of damages to or killing of aliens by mob violence.

The Act of Congress has always included a clause to the effect that the indemnity is allowed out of considerations of humanity and without reference to questions of liability.

In 1899, a mob hanged five Italians at Tallulah, Louisiana. The Italian government protested. The local grand jury failed to indict, although the facts were notorious. The Federal government indemnified the families of the victims. The incident has interest as it manifests the foreign estimate of the position of powerlessness assumed by the Federal government. The minister of the United States to Italy forwarded to the Secretary of State an extract from a newspaper printed at Rome, and said of it that it represented fairly public opinion.[294] Said the editorial article:

"A number of our confrères are astonished that in the face of a fact so abominable as the lynching of four or five human beings, it should not be possible for either to claim, or obtain, a more substantial reparation than the payment of an indemnity, more or less large, to the families of the victims. Nevertheless this is the fact, and all protests against it would be futile.

"The Constitution of the United States gives the President of the Republic no power over the internal affairs of the different States. The Governor of Louisiana has no account to render to the President of the Confederation in regard to what takes place in his State. The Governor is as powerful at home as the President is at Washington. Louisiana has its laws, its magistrates, its parliament, its customs, and if President McKinley should seek to impose his will upon it, he would receive a peremptory refusal, and not only that, but he would raise up against him the whole public opinion of America. This American Constitution is, without doubt an anomaly, above all from the European point of view. It is difficult to admit that a State should not be able to answer for the acts which take

[293] James G. Blaine to Marquis Imperiali, Foreign Relations, 1891, p. 685.

[294] Foreign Relations, 1899, p. 445.

place under the shadow of its flag. All idea of reciprocity, which is the basis of good relations, falls in prices.[295] If in a small village of Lombardy, or Piedmont, an American had been outraged, or killed unjustly, it is the Government at Rome that would have to answer for it. It is therefore incomprehensible that the Washington Government should not do the same when an Italian is injured in Louisiana or Ohio."[296]

In the case of the rights of Japanese in California in their relation to the public schools, the question took on aspects which had not hitherto characterized it. The case was not one arising out of mob violence but involved the deliberate acts of the State of California, or rather of a board of education deriving its powers from that State. There were several questions with respect to the applicability of the Japanese treaty, and its proper construction. In their essence, these questions were whether the board of education had the right under the existing treaty to tax all alien residents for school purposes, and then to direct that Japanese children must attend only one school—the Oriental school—while all other schools were open to children of other alien residents. Assuming the applicability of the treaty and its violation by the State authorities, the fundamental question was thus presented as to the validity of the treaty, and if valid, the possible methods of its enforcement. The United States government filed a bill in the Federal court in California to enforce the treaty; but the matter was adjusted, and the case discontinued, because of the rescinding of the resolution of the board of education, which had given rise to the controversy.[297] In the meantime, the then President of the United States, Mr. Roosevelt, had, impliedly disapproving the prior positions assumed by the State Department under Mr. Evarts and Mr. Blaine, thus addressed Congress in his annual message of 1906:

"I therefore earnestly recommend that the criminal and civil statutes of the United States be so amended and added to as to enable the President, acting for the United States government, which is responsible in our international relations, to enforce the rights of aliens under treaties. Even as the law now is, something can be done by the Federal government toward this end, and in the matter now before me affecting the Japanese, everything that

[295] *Sic.* Evidently a translation of *baisser le prix.*

[296] Clipping from *L'Italie* of July 25, 1899.

[297] See note 15.

it is in my power to do will be done, and all the forces, military and civil, of the United States which I may lawfully employ will be so employed. There should, however, be no particle of doubt as to the power of the National Government completely to perform and enforce its own obligations to other nations. The mob of a single city may at any time perform acts of lawless violence against some class of foreigners which would plunge us into war."[298]

This recommendation did not result in the passage of any statute upon the subject. Similar recommendations by President Harrison in 1891,[299] and by President McKinley in 1899[300] and 1900[301] were likewise disregarded by Congress.

There are at least two instances in our foreign relations where the wrong was done to those claiming the protection of the Federal government, and the position taken is instructive.

The first occurred in 1853 and is known as the Martin Koszta Case.[302] Koszta was a native of Hungary but had declared his intention of becoming a citizen of the United States. While in Turkey on business, and protected by a certificate of the United States consul issued in accordance with Turkish law, he was seized by command of the Austrian consul-general and carried on board an Austrian vessel. A sloop of war of the United States was in the harbor and its captain demanded his release. After some dispute, he was surrendered into the custody of the French consul to await the result of the diplomatic action of Austria and the United States. The United States persisted in its demand, and Koszta was released. In in re Neagle[303] the Court, approving of this action of the United States, ask of this case:

"Upon what act of Congress then existing can any one lay his finger in support of the action of our government in this matter?"[304]

And the dissenting members of the Court, likewise approving the action of the United States, say:

[298] *Congressional Record*, Vol. 41, Part II., p. 32.
[299] See note 16.
[300] See note 17.
[301] See note 18.
[302] Moore, *International Law Digest*, Vol. III., 490.
[303] 135 U. S., 1 (1890).
[304] 135 U. S., p. 64.

"We are asked:—Upon what express statute of Congress then existing can this act of the government be justified?

"We answer, that such action of the government was justified because it pertained to the foreign relations of the United States, in respect to which the federal government is the exclusive representative, and embodiment of the entire sovereignty of the nation, in its united character; for to foreign nations, and in our intercourse with them, States and state governments, and even the internal adjustment of federal power, with its complex system of checks and balances, are unknown, and the only authority those nations are permitted to deal with is the authority of the nation as a unit.

"That authority the Constitution vests expressly and conclusively in the treaty-making power . . . the President and Senate . . . by one simple and comprehensive grant: 'He [the President] shall have power, by and with the advice and consent of the Senate, to make treaties, provided two-thirds of the Senators present concur.' This broad grant makes enumeration of particular powers unnecessary. All other delegations of powers in reference to the international relations of this country are carefully and specifically enumerated and assigned, one by one, to their designated departments. In reply, therefore, to the question, what law expressly justifies such action, we answer, the organic law, the constitution, which expressly commits all matters pertaining to our diplomatic negotiations to the treaty-making power."[305]

In 1871 the steamer *Montijo* owned by citizens of the United States, was seized by certain persons who were desirous of accomplishing a revolution against the State of Panama.[306] Subsequently, the State of Panama granted amnesty to the revolutionists and assumed responsibility for damages done by them. The United States claimed damages from the United States of Colombia of which the State of Panama was a constituent part. The controversy was referred to the British consul as arbitrator. It was claimed by Colombia that no responsibility could rest on her for the acts of a revolution within the State of Panama or for the acts of that State, and that the constitution so provided. This claim was disallowed by the arbitrator who held that the treaty was

"made with the general government, and not with the separate States of which the Union is composed."

He concluded:

"In the event of the violation of a treaty stipulation, it is evident that a recourse must be had to the entity with which the international engagements

[305] Ibid., pp. 84–5.

[306] Moore, "International Arbitrations," Vol. II., pp. 1421–47.

were made. There is no one else to whom application can be directed. For treaty purposes the separate States are non-existent; they have parted with a certain defined portion of their inherent sovereignty, and can only be dealt with through their accredited representative or delegate, the Federal Government."[307]

It is now necessary to examine whether, under existing decisions of the Supreme Court, such statutes as have been recommended by three Presidents would be unconstitutional; and further, considering the suggestion of President Roosevelt, to ask what means of giving effectiveness to treaty provisions exist in the Federal government, in the absence of such statutory enactment.

In 1879 were decided three cases of great significance to us here. The first was Tennessee *vs.* Davis,[308] wherein the defendant was indicted in a State court for murder. Acting under Section 643 of the Revised Statutes of the United States, he petitioned the circuit court of the United States for removal of the prosecution to that court, alleging that the killing occurred in self-defence while he was acting as deputy collector of internal revenue by the authority of Federal laws. The question was raised as to the constitutionality of the statute. On appeal, the Supreme Court sustained its constitutionality and said:

"A more important question can hardly be imagined. Upon its answer may depend the possibility of the general government's preserving its own existence. As was said in Martin *vs.* Hunter (1 Wheat., 363), 'the general government must cease to exist whenever it loses the power of protecting itself in the exercise of its constitutional powers.' It can act only through its officers and agents, and they must act within the States. If, when thus acting, and within the scope of their authority, those officers can be arrested and brought to trial in a State court, for an alleged offense against the law of the State, yet warranted by the Federal authority they possess, and if the general government is powerless to interfere at once for their protection, —if their protection must be left to the action of the State court,—the operations of the general government may at any time, be arrested at the will of one of its members. The legislation of a State may be unfriendly. It may affix penalties to acts done under the immediate direction of the national government, and in obedience to its laws. It may deny the authority conferred by those laws. The State court may administer not only the laws of the State, but equally Federal law, in such a manner as to paralyze the operations of the government. And even if, after trial, and final judgment in the State court, the case can be brought into the United States court for

[307] Ibid., p. 1439.
[308] 100 U. S., 257 (1879).

review, the officer is withdrawn from the discharge of his duty during the pendency of the prosecution, and the exercise of acknowledged Federal power arrested.

"We do not think such an element of weakness is to be found in the Constitution. The United States is a government with authority extending over the whole territory of the Union, acting upon the States and upon the people of the States. While it is limited in a number of its powers, so far as its sovereignty extends it is supreme. No State government can exclude it from the exercise of any authority conferred upon it by the Constitution, obstruct its authorized officers against its will, or withhold from it, for a moment, the cognizance of any subject which that instrument has committed to it."[309]

In *ex parte* Siebold,[310] certain election officers appointed under the laws of Maryland were convicted in the circuit court of the United States of interfering with the deputy marshals of the United States who were acting under Federal statutes at a congressional election. The convictions were sustained and the statutes declared to be constitutional. The Court concluded:

"The views we have expressed seem to us to be founded on such plain and practical principles as hardly to need any labored argument in their support. We may mystify anything. But if we take a plain view of the words of the Constitution, and give to them a fair and obvious interpretation, we cannot fail in most cases of coming to a clear understanding of its meaning. We shall not have far to seek. We shall find it on the surface, and not in the profound depths of speculation.

"The greatest difficulty in coming to a just conclusion arises from mistaken notions with regard to the relations which subsist between the state and national governments. It seems to be often overlooked that a national government has been adopted in this country, establishing a real government therein, operating upon persons and territory and things; and which, moreover, is, or should be, as dear to every American citizen as his State government is. Whenever the true conception of the nature of this government is once conceded, no real difficulty will arise in the just interpretation of its powers. But if we allow ourselves to regard it as a hostile organization, opposed to the proper sovereignty and dignity of the State governments, we shall continue to be vexed with difficulties as to its jurisdiction and authority. . . . State rights and the rights of the United States should be equally respected. Both are essential to the preservation of our liberties and the perpetuity of our institutions. But, in endeavoring to vindicate the one, we should not allow our zeal to nullify or impair the other."[311]

[309] Ibid., pp. 262–3.

[310] Ibid., 371 (1879).

[311] Ibid., pp. 393–4.

Ex parte Clarke[312] arose in Ohio and involved constitutional questions similar to those decided in *Ex parte* Siebold. It is distinguished by a strong dissenting opinion by Mr. Justice Field.

These three cases present precisely and completely the doctrine they enunciate. On the one hand, Tennessee *vs.* Davis determines the *ineffectiveness* of State laws when attempted to be enforced against Federal laws; on the other hand, *Ex parte* Siebold illustrates the *effectiveness* of Federal law when opposed to State law. Such are the decisions in cases where *crimes* were charged and *criminal proceedings* begun. However the definition of the State police power be narrowed, it must include its agencies for the defining and the punishment of crime. Yet, in the one case, the State was held powerless to try the party whom it had indicted, and in the other, powerless to save the party acting under its authority. And the Court fully appreciated the significance of its decision.

"It is argued," says the opinion of the Court, "that the preservation of peace and good order in society is not within the powers confided to the government of the United States, but belongs exclusively to the States. Here again we are met with the theory that the government of the United States does not rest upon the soil and territory of the country. We think that this theory is founded on an entire misconception of the nature and powers of that government. We hold it to be an incontrovertible principle, that the government of the United States may, by means of physical force, exercised through its official agents, execute on every foot of American soil the powers and functions that belong to it. This necessarily involves the power to command obedience to its laws, and hence the power to keep the peace to that extent.

"This power to enforce its laws and to execute its functions in all places does not derogate from the power of the State to execute its laws at the same time and in the same places. The one does not exclude the other, except where both cannot be executed at the same time. In that case, the words of the Constitution itself show which is to yield."[313]

In Baldwin *vs.* Franks,[314] the power of the Federal government to provide for the punishment of those who violate treaty provisions is unanimously enunciated in positive terms. The case, however, did not require the determination of this question, because the acts

[312] Ibid., 399 (1879).
[313] Ibid., pp. 394-5.
[314] 120 U. S., 678 (1878).

in question, under which the defendant had been prosecuted, were declared to be inapplicable. Said the Court:

> "The precise question we have to determine is not whether Congress has the constitutional authority to provide for the punishment of such an offense as that with which Baldwin is charged, but whether it has so done.
>
> "That the treaty-making power has been surrendered by the States and given to the United States, is unquestionable. It is true, also that the treaties made by the United States and in force are part of the supreme law of the land, and that they are as binding within the territorial limits of the States as they are elsewhere throughout the dominion of the United States. . . .
>
> "That the United States have power under the Constitution to provide for the punishment of those who are guilty of depriving Chinese subjects of any of the rights, privileges, immunities, or exemptions guaranteed to them by this treaty, we do not doubt. What we have to decide, under the questions certified here from the Court below, is, whether this has been done."[315]

It will be observed that although the Court contemplated that it would be by act of Congress that the treaty rights would be protected, yet the authority in Congress to pass such an act could be derived only from the clause giving it the power generally to make all laws necessary for carrying into execution the treaty power.[316] And if the treaty power were incompetent to come into successful conflict with State police power, the act of Congress must logically have been equally powerless to carry into effect an unconstitutional treaty provision.

The foregoing cases, although they establish generally the *effectiveness* of Federal law when opposed to State law, without regard to so-called State police power, are cases where an act of Congress was under consideration. *In re* Neagle[317] illustrates the extent to which the Supreme Court has recognized and enforced the supremacy over State police power of Federal constitutional provisions. One Terry had been punished by Mr. Justice Field with imprisonment for contempt of court committed during the litigation before him. Terry had publicly announced his intention of taking Mr. Justice Field's

[315] Ibid., pp. 682, 683.

[316] Article I., Section 8, Last Clause. "To make all laws which shall be necessary and proper for carrying into execution the foregoing powers, and all other powers vested by this Constitution in the Government of the United States, or in any department or officer thereof."

[317] 135 U. S., 1 (1890).

life. The attorney-general had directed the United States marshal in California to use all possible means to prevent such a catastrophe. Neagle was appointed deputy marshal and instructed to attend upon Mr. Justice Field and endeavor to protect him from any assault by Terry. While the justice was traveling to attend court, such assault occurred, and Neagle shot and killed Terry. An arrest by the California authorities for murder followed. Neagle applied to the circuit court of the United States for a writ of *habeas corpus,* under which he was discharged. On appeal to the Supreme Court, that judgment was affirmed. The statute authorizing the granting of such a writ of *habeas corpus* provided that it should issue when the petitioner was "in custody for an act done or omitted in pursuance of a law of the United States." No statute existed which authorized the duties assumed by Neagle toward Mr. Justice Field. But said the Court:

> "In the view we take of the Constitution of the United States, any obligation fairly and properly inferrible from that instrument, or any duty of the marshal to be derived from the general scope of his duties under the laws of the United States, is 'a law' within the meaning of this phrase. It would be a great reproach to the system of government of the United States, declared to be within its sphere sovereign and supreme, if there is to be found within the domain of its powers no means of protecting the judges, in the conscientious and faithful discharge of their duties, from the malice and hatred of those upon whom their judgments may operate unfavorably. . . . We do not believe that the government of the United States is thus inefficient, or that its Constitution and laws have left the high officers of the government so defenseless and unprotected."[318]

The Court then point out that by Article II., Section 3, of the Constitution, it is provided that the President "shall take care that the laws be faithfully executed"; and they ask:

> "If an officer of the United States has been arrested on indictment found by a State Court, for riot, assault and battery, and assault with attempt to kill, the indictment now showing that the alleged offenses were committed while the officer was professing to act under a law of the United States, or under some order, process, or decree of some judge or Court thereof, this Court, on a habeas corpus, where the petition of the officer denies the offense, and avers that what is alleged as offense was done in proper execution of an order, process, or decree of a Federal Court, will *go outside the indictment,* and hear evidence to show the truth of the facts set forth by the officer."[319]

[318] Ibid., p. 59.

[319] Ibid., p. 64.

The Court then refers to the international episode of the case of Martin Koszta, and asks:

> "Upon what Act of Congress then existing can any one lay his finger in support of the action of our government in this matter?"[320]

The conclusion is that all acts done under the Constitution have the force of law.

In Logan *vs.* United States,[321] certain individuals were arrested for an alleged crime committed within the Indian territory, and therefore within the jurisdiction of the United States. While in the custody of the United States marshal, they were attacked by an armed body of men and a fight ensued, resulting in the death of two of the individuals under arrest. Sections 5508–9 of the Revised Statutes provided for the punishment of any two or more persons who should conspire and unite to deprive any person of a privilege secured to him by the Constitution or laws of the United States. Under these sections members of the attacking band were indicted in the Federal district court. The Supreme Court of the United States held that the United States was bound to protect against lawless violence persons in its custody under arrest; and that an attack upon persons so held constitute a violation of Sections 5508–9 of the Revised Statutes. Said the Court:

> "Every right, created by, arising under or dependent upon, the Constitution of the United States, may be protected and enforced by Congress, by such means and in such manner as Congress, in the exercise of the correlative duty of protection, or of the legislative powers conferred upon it by the Constitution, may in its discretion deem most eligible and best adapted to attain the object."[322]

It will be observed in this case that the jurisdiction of the United States over the subject matter arose out of the fact that the original crime was committed in the Indian Territory, and that regulations concerning it were committed to the legislation of Congress by the Constitution. Sections 5508–9 of the Revised Statutes, although general criminal statutes, were sustained because they were operative to protect rights secured by laws of Congress, passed in the

[320] Ibid., p. 64.
[321] 144 U. S., 263 (1892).
[322] Ibid., p. 293.

exercise of a power granted by the Constitution. Inasmuch as the power to make treaties is likewise specifically granted and such treaties are declared to have the force of laws, this case is of authoritative significance.

In re Debs[323] is a case which attracted universal interest. It arose out of the great Chicago strike of 1894, and was a petition for a writ of *habeas corpus* to secure the release of labor leaders sentenced for contempt. The legal points at issue were succinctly stated by the Supreme Court as follows:

"The United States, finding that the interstate transportation of persons and property, as well as the carriages of the mails, is forcibly obstructed, and that a combination and conspiracy exists to subject the control of such transportation to the will of the conspirators, applied to one of their Courts, sitting as a Court of Equity, for an injunction to restrain such obstruction and prevent carrying into effect such conspiracy. Two questions of importance are presented: First. Are the relations of the general government to interstate commerce and the transportation of the mails such as authorize a direct interference to prevent a forcible obstruction thereof? Second. If authority exists, as authority in governmental affairs implies both power and duty, has a Court of Equity jurisdiction to issue an injunction in aid of the performance of such duty"?[324]

The Court then proceeds to quote the language of Mr. Chief Justice Marshall in McCullough *vs.* Maryland:

"No trace is to be found in the Constitution of an intention to create a dependence of the government of the Union on those of the States, for the execution of the great powers assigned to it. Its means are adequate to its ends; and on those means alone was it expected to rely for the accomplishment of its ends. To impose on it the necessity of resorting to means which it cannot control, which another government may furnish or withhold, would render its course precarious, the result of its measures uncertain, and create a dependence on other governments, which might disappoint its most important designs, and is incompatible with the language of the Constitution."[325]

The two questions of law propounded are answered as follows:

"As, under the Constitution, power over interstate commerce and the transportation of the mails is vested in the national government, and Congress by virtue of such grant has assumed actual and direct control, it follows

[323] 158 U. S., 564 (1895).
[324] 158 U. S., p. 577.
[325] 4 Wheat., p. 578.

that the national government may prevent any unlawful and forcible interference therewith. But how shall this be accomplished? Doubtless, it is within the competency of Congress to prescribe by legislation that any interference with these matters shall be offenses against the United States, and prosecuted and punished by indictment in the proper courts. But is that the only remedy? Have the vast interests of the nation in interstate commerce, and in the transportation of the mails, no other protection than lies in the possible punishment of those who interfere with it? . . . There is no such impotency in the national government. The entire strength of the nation may be used to enforce in any part of the land the full and free exercise of all national powers and the security of all rights entrusted by the Constitution to its care. The strong arm of the national government may be put forth to brush away all obstructions to the freedom of interstate commerce or the transportation of the mails. If the emergency arises, the army of the nation, and all its militia, are at the service of the nation to compel obedience to its laws.

"But passing to the second question, is there no other alternative than the use of force on the part of the executive authorities whenever obstructions arise to the freedom of interstate commerce within or the transportation of the mails? Is the army the only instrument by which rights of the police can be enforced and the peace of the nation preserved? . . . The right to use force does not exclude the right of appeal to the Courts for a judicial determination and for the exercise of all their powers of prevention. Indeed, it is more to the praise than to the blame of the government, that, instead of determining for itself questions of right and wrong on the part of these petitioners and their associates and enforcing that determination by the club of the policeman and the bayonet of the soldier, it submitted all those questions to the peaceful determination of judicial tribunals, and invoked their consideration and judgment as to the measure of its rights and powers and correlative obligations of those against whom it made complaint."[326]

The Court thus concludes:

"Summing up our conclusions, we hold that the government of the United States is one having jurisdiction over every foot of soil within its territory, and acting directly upon each citizen; that while it is a government of enumerated powers, it has within the limits of those powers all the attributes of sovereignty."[327]

If therefore the Federal government has the power to act by its army, by its courts, criminal and civil, "directly upon each citizen" "over every foot of soil within this territory," under the grant to regulate interstate commerce and the transmission of the mail, can it be that the powers of that same Federal government are less whan

[326] 158 U. S., pp. 581, 582, 583.

[327] Ibid., p. 599.

called upon to perform sacred obligations incurred through treaties with other sovereignties? A dispassionate study of the cases—such as is here attempted—shows that the Federal government has full power to deal within a State with mobs who attack one under Federal arrest, and with mobs who interfere with interstate commerce. How long—such being incontrovertible law—will the American people permit its Department of State to urge that it is without power to deal with a mob which deliberately sets at naught and violates Federal treaty obligations declared by the Constitution to be the supreme law of the land?

Ohio *vs.* Thomas[328] is a case which by its facts throws into strong relief the incapacity of so-called State police power to affect the action of the Federal government. By Act of Congress a soldiers' home was established in the State of Ohio. It was conceded that the ground on which the home stood was within the jurisdiction of the State. The management of the home was entrusted by Congress to a governor and board of managers. By an Ohio statute the use of oleomargarine was permitted only under certain conditions. The management of the home furnished oleomargarine to its inmates and did not comply with the conditions of the State statute. The Governor was accordingly indicted under the statute. He was released on *habeas corpus* by the Federal circuit court, and the Supreme Court affirmed. Said the Court:

> "Whatever jurisdiction the State may have over the place or ground where the institution is located, it can have none to interfere with the provisions made by Congress for furnishing food to the inmates of the home, nor has it power to prohibit or regulate the furnishing of any article of food which is approved by the officers of the home, by the Board of Managers and by Congress. Under such circumstances the police power of the State has no application."[329]

The State statute was passed in the exercise of the State police power; yet at once it yielded to the Federal act creating a soldiers' home. Is it possible to maintain that the State police power operates to prevent Federal control over or punishment of a mob which violates treaty rights, while it lies prone before the desire of Congress to feed its old soldiers with oleomargarine?

[328] 173 U. S., 276 (1899). [329] Ibid., p. 283.

Finally, in The Employers' Liability Cases,[330] it is said of interstate commerce:

> "An obstruction of such commerce by unlawful violence may be made punishable under the laws of the United States, suppressed by the armies of the United States, or, at the instance of the United States, enjoined in its Courts."[331]

Similarly, and with no possibility of contradiction based on an examination of the Federal decisions, one may say: A violation of rights secured by treaty provisions may be made punishable under the laws of the United States, suppressed by the armies of the United States, or, at the instance of the United States, enjoined in its courts.

An examination of the proceedings of the Federal Constitutional Convention shows that such was the intention of its framers. Article II., Section 3, provides that the President "shall take care that the laws be faithfully executed." At one time in the Convention this clause stood thus in enumerating the powers of the President:

> "To call forth the aid of the militia, in order to execute the laws of the Union, *enforce treaties,* suppress insurrections, and repel invasions."

At this stage, according to Madison's journals:

> "Mr. Govr Morris moved to strike the following words out of the 18 clause 'enforce treaties,' as being superfluous since treaties were to be 'laws' . . . which was agreed to nem: contrad:"[332]

It is thus conclusively established that when the Constitution says the President shall execute "the laws," treaties, since they have the force of laws, come within this constitutional provision.

It must therefore be concluded from this survey of decided cases that an act of Congress providing for the punishment of violations of treaty provisions, or otherwise tending to secure their enforcement, would be constitutional, and that State police powers, however defined, must yield. Such statute would receive identically the same sanction as the acts enforcing the postal laws or prohibit-

[330] 207 U. S., 463 (1908).
[331] Ibid., p. 525.
[332] Farrand, Vol. II., pp. 389–90.

ing interference with interstate commerce. In the absence of such statutes, the executive has the power to call upon the army of the United States and enforce by its power any treaty provision, in precisely the same manner and under the same conditions as the executive might enforce an act of Congress. This was the emphatic decision in *in re* Debs.[333] Finally, resort may be had either by the United States or by the aggrieved party to the Federal Courts. Such right of redress is incontrovertibly established, but there is one latent practical difficulty. It is this. Treaties may and do operate, when so intended, as acts of Congress, but they are not in practice drawn as legislative acts. They deal with the enunciation of general principles; they do not express clearly and specifically the rights they purpose to confer; nor, if those rights be such as to require remedial provisions, do they contain such provisions. The case of the Mafia riots at New Orleans affords an admirable illustration of this state of things. The treaty with Italy had provided:

> "The citizens of each of the high contracting parties shall receive, in the states and territories of the other, the most constant protection and security for their persons and property, and shall enjoy in this respect the same rights and privileges as are or shall be granted to the natives, on their submitting themselves to the conditions imposed upon the natives."[334]

There was in the treaty no provision for the punishment of any person violating it, and no right of action conferred on persons injured or damaged by its violation. There remained therefore only the general promise of the United States to protect Italian citizens—a promise not made effective either by the terms of the treaty or by any act of Congress. The position taken by Mr. Blaine, that the Federal government was powerless to deal with such matters because they were committed to the States, was technically maintainable; but maintainable only because the United States had neglected either by treaty provision or by statute to adopt any means for performing the international obligation it had assumed. The power to make the Federal will supreme existed, was established by numerous decisions, and had been exercised by Congress in a series of statutes. When

[333] *Supra*, pp. 224–229.

[334] "Compilation of Treaties in Force, 1904," at p. 450—Article III. of treaty of 1871 with Italy.

the Italian suitors in the Federal court were finally denied relief against the municipality which had suffered the mob violence,[335] the reason was that neither the treaty nor any Federal statute existed to create liability. Had such statute or treaty provision existed, the decision must have been otherwise.

The United States has by certain provisions of the Revised Statutes created it a crime against the United States to combine to hinder the execution of any *law of* the United States or to deprive any *citizen* of any right secured by the Constitution or *laws* of the United States. In Baldwin *vs.* Franks,[336] despite the strong dissent of Mr. Justice Field and Mr. Justice Harlan, we have seen that these statutes were held not to apply to violations of *treaty provisions* nor to protect *aliens.* As things now are, therefore, treaties are made in a form which puts it beyond the power of the Federal executive to enforce the rights guaranteed thereunder without an amendment to existing statutes, and our diplomatic representatives are left to explain matters as they best can. The remedy is simple. Let Sections 5336, 5508, 5509, 5519 of the Revised Statutes be amended to include the words "treaties of the United States" as well as the words "laws of the United States," and to extend their protection to aliens as well as to citizens.[337] Then let the bill introduced in the Senate on March 1, 1892, and reported with approval on March 30, 1892, be enacted into law,[338] and there will end the grave danger and national disgrace which springs from guaranteeing treaty rights, the power to enforce which is not provided.

It is of course clear that the passage of statutes applicable to all treaties would best subserve the national and international interests involved. There is no constitutional reason, however, why a treaty should not, in itself, provide for the enforcement of the rights it guarantees. The third article of the treaty with Italy has been quoted above. The Italian government having in mind the New Orleans and Tallulah occurrences, might well say to the United States: You have advised us that as matters now are under your

[335] New Orleans *vs.* Abagnatto, 62 Federal, 240 (1894).

[336] *Supra,* pp. 218–220.

[337] See note 19.

[338] See note 20.

existing laws, the only redress we have for such violations as have occurred and may recur, is through the action of the local authorities, often irreconcilably prejudiced against us, and with whom we cannot directly deal. We ask therefore that the Federal government shall protect our citizens when violations of treaty rights occur as fully as it does its own when violations of Federal law occur. We propose the addition of the following clause to Article Three of the treaty between us: The high contracting parties agree that the provisions of this treaty securing protection for the persons and property of Italian citizens who may be within the United States, shall be and are hereby made supreme law within the United States; and that Sections 5336, 5508, 5509, 5519 of the Revised Statutes of the United States shall be and are hereby made applicable to violations of the provisions of this treaty in all cases where they are now applicable to violations of the laws of the United States.

To such a request, the government of the United States could hardly find reasons on which to base a refusal. If a treaty be intended to operate as "legislative act," to again use Marshall's phrase, it should obviously in its draftmanship fulfill the essentials of a legislative act. If rights of action are to be given, those rights should be precisely set forth, if violation of treaty provisions by mobs or otherwise is not to be encouraged, provisions for the punishment of violators should be added and stated with the meticulous phraseology of a criminal statute. The constitutionality of such a procedure has been seen to be demonstrated by the cases analyzed; its wisdom would seem to be obvious. If the government of the United States does not desire to grant a certain privilege, its dignity requires that such desire should be stated through its diplomatic agencies; it cannot in honor use general language purporting to convey a privilege, unless it be prepared simultaneously to provide for its recognition and enforcement.

VI.

The conclusion of the survey of the treaty-making power of the United States attempted in this essay is now reached. The decisions of the Supreme Court of the United States have been assumed to contain the materials for a final judgment. This is not the place for a demonstration of the correctness of that assumption. If in the judicial power of the United States the nation is not to find the final arbiter of the constitutionality of State and Federal acts, then the fundamental purposes of the framers of the Constitution are utterly frustrated, and with the destruction of that instrument must disappear any thought of a judicial interpretation and enforcement of the treaty-making power. During many years of the nation's life, the individual judgment of the States was set up by some as the final arbiter of constitutional acts; today, the tendency is rather toward making of Congress that supreme tribunal, or perhaps even the crowd, if the recall is to accomplish its logical end. But in this essay the final authority has been recognized to be the Supreme Court. Examining their decisions, we have seen in the making the principles of constitutional law as they affect the treaty-making power. As they have slowly formed before our eyes, these principles have become a part of our thought. Not always have the results reached been logical from the strictly academic point of view; the judges were men of political convictions and emotions, and often was it necessary to pause to consider the conditions under which they spoke, and the political doctrines which filled the air and colored—or even animated—their words. If one would for the moment forget such considerations, time and again did old-time political beliefs, given voice, surprise and warn one. In a subject where sanction for decisions is often to be found in political considerations, one must ever bear in memory the opinions of the times in which the judges wrote. The language of Mr. Justice Story in writing to a friend in 1845, is very pertinent to the thought here attempted to be expressed. He wrote:

"Although my personal position and intercourse with my brethren on the bench has always been pleasant, yet I have long been convinced that the doctrines and opinions of the 'old Court' were daily losing ground, and especially those on great constitutional questions. New men and new opinions have succeeded. The doctrines of the Constitution, so vital to the country, which in former times received the support of the whole Court, no longer maintain their ascendency. I am the last member now living of the old Court, and I cannot consent to remain where I can no longer hope to see those doctrines recognized and enforced."[339]

Those words were written when, under the influence of Calhoun, a great party was adopting his State rights views, and when southern judges filled the bench. Can one doubt that those facts should be borne in memory when the License Cases,[340] decided in 1847, are quoted as authoritative utterances respecting the true relations of Federal action and State police power? Have they really any more validity today than an old bill of sale for a negro slave could have? This is perhaps too strong a comparison; it will serve to emphasize, even if unduly, the necessity for a discriminative estimate of the value of decisions.

The main question asked in this essay by its title is the *status* of treaty provisions brought into conflict with the attempted exercise of State police powers. The answer is that, without qualification of any kind whatsoever and without limitation by any possible definition of the treaty-making power, a treaty provision as the embodied manifestation of the Federal will is supreme over any and all State enactments made in the exercise of the police power. Such was the idea of those who framed the Constitution and who believed that they had written their purpose into that instrument; such also was the idea of those who favored and those who opposed its ratification by the States. This unanimous contemporary interpretation was stated and applied by the Supreme Court of the United States and pervades and informs every word which John Marshall uttered during the years in which the fundamental canons of constitutional interpretation were evolved. On the death of that greatest English-speaking jurist of all time, the advocates of State rights, soon to become the forces of disunion, gained the ascendancy in the national councils. Members of that party to which Marshall had his whole life long opposed the authority of his office and the distinction of his character, became justices of the Supreme Court and were the men of whom Joseph Story wrote. The decisions of the Court so constituted

[339] Letter to Ezekiel Bacon, April 12, 1845, "Life and Letters of Joseph Story," Vol. II., p. 527.

[340] *Supra*, pp. 187–192.

respecting State police power, Federal control over commerce, and treaty rights, became so clouded by hazy qualifications and hesitations, that one is justified in the assertion that to political considerations alone can one look to explanations which shall clarify. The Civil War came and passed. New men succeeded to the bench of the Supreme Court. The arms of the North had brought supremacy to the Federal will. It remained unquestioned and unquestionable for years. When, in 1879, instances of its enforcement came before the Supreme Court, the supremacy of that will was, in the cases we have analyzed,[341] established in language which rings with vehement conviction. And so was the return made to the thought and logic of Marshall, who perpetuated in the records of the Supreme Court what the constitutional conventions had declared and established. That decision of 1879 persists as the law today, reiterated in 1895, when in days of financial panic, organized labor, and a sympathetic State executive, doubted the Federal power.[342] Failure to impress the Federal will, intended to be expressed in a treaty, may occur; but the cause must be sought in inadequate acts of Congress and inexplicit treaty provisions. Fortified by the principles established by Marshall and recognized by the Supreme Court today, one may conclude: A violation of rights secured by treaty provisions may be made punishable under the laws of the United States, suppressed by its armies, or enjoined in its courts.

NOTES.

Note 1.—In a letter to Senator Breckinridge of Kentucky, dated August 12, 1803, Jefferson wrote: "The Constitution has made no provision for our holding foreign territory, still less for incorporating foreign nations into our Union. The executive in seizing the fugitive occurrence which so much advances the good of their country, have done an act beyond the Constitution. The legislature, in casting behind them metaphysical subtleties, and risking themselves like faithful servants, must ratify and pay for it, and throw themselves on their country for doing for them unauthorized what we know they would have done for themselves had they been in a situation to do it." Jefferson's Works, IV., p. 500.

[341] *Supra*, pp. 212–217.

[342] *Supra*, pp. 224–229.

Note 2.—" Mr. (Madison) observed that the Senate represented the States alone, and that for this as well as other obvious reasons it was proper that the President should be an agent in treaties.

" Mr. Govr. Morris did not know that he should agree to refer the making of treaties to the Senate at all, but for the present wd. move to add as an amendment to the section, after 'treaties'—'but no treaty shall be binding on the United States which is not ratified by a law.'

" Mr. Madison suggested the inconvenience of requiring a legal ratification of treaties of alliance for the purposes of war &c. &c.

" Mr. Ghorum. Many other disadvantages must be experienced if treaties of peace and all negotiations are to be previously ratified—and if not previously, the Ministers would be at a loss how to proceed—What would be the case in G. Britain if the King were to proceed in this manner? American Ministers must go abroad not instructed by the same authority (as will be the case with other Ministers) which is to ratify their proceedings.

" Mr. Govr. Morris. As to treaties of alliance, they will oblige foreign powers to send their Ministers here, the very thing we should wish for. Such treaties could not be otherwise made, if his amendment should succeed. In general he was not solicitous to multiply and facilitate treaties. He wished none to be made with G. Britain, till she should be at war. Then a good bargain might be made with her. So with other foreign powers. The more difficulty in making treaties, the more value will be set on them.

" Mr. Wilson. In the most important treaties, the King of G. Britain being obliged to resort to Parliament for the execution of them, is under the same fetters as the amendment of Mr. Morris will impose on the Senate. It was refused yesterday to permit even the Legislature to lay duties on exports. Under the clause, without the amendment, the Senate alone can make a treaty, requiring all the rice of S. Carolina to be sent to some one particular port.

" Mr. Dickinson concurred in the amendment, as most safe and proper, tho' he was sensible it was unfavorable to the little States; which would otherwise have an equal share in making treaties.

" Docr. Johnson thought there was something of solecism in saying that the acts of a Minister with plenipotentiary powers from one body, should depend for ratification on another body. The example of the King of G. B. was not parallel. Full and complete power was vested in him—If the Parliament should fail to provide the necessary means of execution, the treaty would be violated.

" Mr. Ghorum in answer to Mr. Govr. Morris, said that negotiations on the spot were not to be desired by us, especially if the whole Legislature is to have anything to do with Treaties. It will be generally influenced by two or three men, who will be corrupted by the Ambassadors here. In such a Government as ours, it is necessary to guard against the Government itself being seduced.

" Mr. Randolph observing that almost every speaker had made objections to the clause as it stood, moved in order to a further consideration of the subject, that the motion of Mr. Govr. Morris should be postponed, and on this question

"Massts. no. Cont. no. N. J.—ay—Penna. ay. Del. ay. Md. ay. Va. ay—N. C. no. S. C. no.—Geo. no.

"On Mr. Govr. Morris motion

"Massts. no. Cont. no. N. J. no. Pa. ay—Del. no. Md. no. Va. no. N. C. divd S. C. no. Geo. no."

Note 3.—The report in detail was: "Mr. Madison then moved to authorize a concurrence of two thirds of the Senate to make treaties of peace, without the concurrence of the President—The President he said would necessarily derive so much power and importance from a state of war that he might be tempted, if authorized, to impede a treaty of peace. Mr. Butler 2ded. the motion.

"Mr. Ghorum thought the precaution unnecessary as the means of carrying on the war would not be in the hands of the President, but of the Legislature.

"Mr. Govr. Morris thought the power of the President in this case harmless; and that no peace ought to be made without the concurrence of the President, who was the general guardian of the National interests.

"Mr. Butler was strenuous for the motion, as a necessary security against ambitious and corrupt Presidents. He mentioned the late perfidious policy of the stakeholder in Holland; and the artifices of the Duke of Marlbro' to prolong the war of which he had the management.

"Mr. Gerry was of opinion that in treaties of peace a greater rather than less proportion of votes was necessary, than in other treaties. In treaties of peace the dearest interests will be at stake, as the fisheries, territories &c. In treaties of peace also there is more danger to the extremities of the Continent, of being sacrificed, than on any other occasions.

"Mr. Williamson thought that treaties of peace should be guarded at least by requiring the same concurrence as in other treaties.

"On motion of Mr. Madison and Mr. Butler

"N. H. no. Mas. no. Ct. no. N. J. no. Pa. no. Del. no. Md. ay. Va. no. N. C. no. S. C. ay. Geo. ay.

"On the part of the clause concerning treaties amended by the exception as to treaties of peace.

"N. H. ay. Mas. ay. Ct. ay. N. J. no. Pa. no. Del. ay. Md. ay. Va. ay. N. C. ay. S. C. ay. Geo. no."

Note 4.—Washington's message was as follows:

"To the Gentlemen of the House of Representatives of the United States:

"With the utmost attention I have considered your resolution of the 24th instant, requesting me to lay before your House, a copy of the instructions to the minister of the United States, who negotiated the treaty with the King of Great Britain, together with the correspondence and other documents relative to that treaty, excepting such of the said papers, as any existing negotiation may render improper to be disclosed.

"In deliberating upon this subject, it was impossible for me to lose sight of the principles which some have avowed in its discussion, or to avoid extending my views to the consequences which must flow from the admission of that principle.

"I trust that no part of my conduct has ever indicated a disposition to withhold any information which the constitution has enjoined it upon the president as a duty to give, or which could be required of him by either house of congress as a right; and with truth I affirm, that it has been, as it will continue to be, while I have the honor to preside in the government, my constant endeavor to harmonize with the other branches thereof, so far as the trust delegated to me by the people of the United States, and my sense of the obligation it imposes, to preserve, protect and defend the constitution will permit.

"The nature of foreign negotiations require caution, and their success must often depend on secrecy; and even when brought to a conclusion, a full disclosure of all the measures, demands, or eventual concessions which may have been proposed or contemplated would be extremely impolitic; for this might have a pernicious influence on future negotiations, or produce immediate inconveniences, perhaps danger and mischief to other persons. The necessity of such caution and secrecy was one cogent reason for vesting the power of making treaties in the president, with the advice and consent of the senate, the principle on which that body was formed confining it to a small number of members. To admit then a right in the house of representatives to demand, and to have as a matter of course, all the papers respecting a negotiation with a foreign power, would be to establish a dangerous precedent.

"It does not occur that the inspection of the papers asked for, can be relative to any purpose under the cognizance of the house of representatives, except that of an impeachment, which the resolution has not expressed. I repeat that I have no disposition to withhold any information which the duty of my station will permit, or the public good shall require to be disclosed; and in fact, all the papers affecting the negotiation with Great Britain were laid before the senate, when the treaty itself was communicated for their consideration and advice.

"The course which the debate has taken on the resolution of the house, leads to some observations on the mode of making treaties under the constitution of the United States.

"Having been a member of the general convention, and knowing the principles on which the constitution was formed, I have ever entertained but one opinion upon this subject; and from the first establishment of the government to this moment, my conduct has exemplified that opinion. That the power of making treaties, is exclusively vested in the president, by and with the advice and consent of the Senate, provided two thirds of the senators present concur; and that every treaty so made and promulgated, thenceforward becomes the law of the land. It is thus that the treaty-making power has been understood by foreign nations; and in all the treaties made with them, we have declared, and they have believed, that when ratified by the president with the advice and consent of the senate, they become obligatory. In this construction of the constitution, every house of representatives has heretofore acquiesced; and until the present time, not a doubt or suspicion has appeared to my knowledge, that this construction was not the true one. Nay, they have more than acquiesced; for until now, without controverting the obligation of such treaties, they have made all the requisite provisions for carrying them into effect.

"There is also reason to believe that this construction agrees with the opinions entertained by the state conventions when they were deliberating on the constitution; especially by those who objected to it, because there was not required in commercial treaties, the consent of two thirds of the whole number of the members of the senate, instead of two thirds of the senators present; and because in treaties respecting territorial and certain other rights and claims, the concurrence of three fourths of the whole number of the members of both houses respectively, was not made necessary.

"It is a fact declared by the general convention and universally understood, that the constitution of the United States was the result of a spirit of amity and mutual concession. And it is well known, that under this influence, the smaller states were admitted to an equal representation in the senate with the larger states; and that this branch of the government was invested with great powers; for on the equal participation of those powers, the sovereignty and political safety of the smaller states were deemed essentially to depend.

"If other proofs than these and the plain letter of the constitution itself be necessary to ascertain the point under consideration, they may be found in the journals of the general convention which I have deposited in the office of the department of state. In these journals it will appear, that a proposition was made 'that no treaty should be binding on the United States which was not ratified by a law,' and that the proposition was explicitly rejected.

"As therefore it is perfectly clear to my understanding that the assent of the house of representatives is not necessary to the validity of a treaty; as the treaty with Great Britain exhibits in itself all the objects requiring legislative provision; and on these the papers called for can throw no light; and as it is essential to the due administration of the government that the boundaries fixed by the constitution between the different departments should be preserved; a just regard to the constitution, and to the duty of my office, under all the circumstances of this case, forbid a compliance with your request." Richardson's "Messages of the Presidents," Vol. I., pp. 194–6.

Note 5.—"*Resolved* that it being declared by the Second Section of the Second Article of the Constitution that the President shall have power, by and with the advice and consent of the Senate, to make treaties, the House do not claim any agency in making treaties, but that when a treaty stipulates regulations on any of the subjects submitted by the Constitution to the power of Congress, it must be dependent for its execution, as to such stipulations, on a law or laws to be passed by Congress. And it is the Constitutional right and duty of the House in all such cases to deliberate on the expediency or inexpediency of carrying such treaty into effect, or to determine an act thereon as in their judgment may be most conducive to the public good." Annals of Congress, 4th Congress, 1st Sess., p. 771.

Note 6.—To support his proposition that the treaty-making power does not extend to subjects committed to the legislation of Congress, Professor Mikell says:

"One branch of the treaty-making power itself has gone on record denying this power. In 1844, April 12, a treaty was signed at Washington, between the United States and the Republic of Texas, by which Texas transferred to the United States all its rights of separate and independent sovereignty and jurisdiction. Three resolutions were introduced by Mr. Benton, May 13. They declared that the ratification of the treaty would be the adoption by the United States of the Texan War, and that the treaty-making power of the President and Senate did not include the power of making war, either by declaration or adoption. On June 8, the treaty was rejected by the Senate by a vote of 35 to 16.

"Immediately preceding the rejection of the treaty a resolution was introduced by Mr. Henderson declaring that 'such annexation would be properly achieved . . . by an act of Congress admitting the people of Texas, with defined boundaries, as a new State into the Union.'

"This course was followed and on March 1st, 1845, a joint resolution to that effect was approved."

This handling and interpretation of the political events accompanying Texan annexation, is extraordinary. The clearly apparent explanation of the actions of the two Houses of Congress, written large in the debates and in American history, lies in the struggle over slavery, which ended in the Civil War. There are, however, several recorded facts which, with detriment to Professor Mikell's argument but in the interests of accuracy, should be added to his account. These are: that Mr. Benton's resolutions did not pass; that Mr. Henderson's resolution did not pass; that the joint resolution was the work of a new session of Congress held after a new election.

Note 7.—The first eight amendments to the Constitution are as follows:

Article I. Congress shall make no law respecting an establishment of religion, or prohibiting the free exercise thereof; or abridging the freedom of speech, or of the press; or the right of the people peaceably to assemble, and to petition the government for a redress of grievances.

Article II. A well-regulated militia being necessary to the security of a free state, the right of the people to keep and bear arms shall not be infringed.

Article III. No soldier shall, in time of peace, be quartered in any house, without the consent of the owner; nor, in time of war, but in a manner to be prescribed by law.

Article IV. The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searchers and seizures, shall not be violated; and no warrants shall issue, but upon probable cause, supported by oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized.

Article V. No person shall be held to answer for a capital, or otherwise infamous crime, unless on a presentment or indictment of a grand jury except in cases arising in the land or naval forces, or in the militia, when in actual service, in time of war, or public danger; nor shall any person be subject, for the same offense, to be twice put in jeopardy of life or limb; nor shall be compelled, in any criminal case, to be a witness against himself, nor be deprived of life, liberty, or property, without due process of law; nor shall private property be taken for public use, without just compensation.

Article VI. In all criminal prosecutions, the accused shall enjoy the right to a speedy and public trial, by an impartial jury of the state and district wherein the crime shall have been committed, which district shall have been previously ascertained by law; and to be informed of the nature and cause of the accusation; to be confronted with the witnesses against him; to have compulsory process for obtaining witnesses in his favor; and to have the assistance of counsel for his defense.

Article VII. In suits at common law, where the value in controversy shall exceed twenty dollars, the right of trial by jury shall be preserved, and no fact, tried by a jury, shall be otherwise reëxamined in any court of the United States than according to the rules of the common law.

Article VIII. Excessive bail shall not be required, nor excessive fines imposed, nor cruel and unusual punishments inflicted.

Note 8.—The language of the court is as follows: "That it was competent for the two countries by treaty to have superseded a prior Act of Congress on the same subject is not to be doubted; for otherwise the declaration in the Constitution that a treaty, concluded in the mode prescribed by that instrument, shall be the supreme law of the land, would not have due effect. As Congress may by statute abrogate, so far at least as this country is concerned, a treaty previously made by the United States with another nation, so the United States may by treaty supersede a prior Act of Congress on the same subject. In Foster & Elam *vs.* Neilson, 2 Pet. 253, 314, it was said that a treaty 'was to be regarded in Courts of justice as equivalent to an Act of the legislature, whenever it operates of itself without the aid of any legislative provision.' In the case of The Cherokee Tobacco, 11 Wall., 616, 621, this Court said 'a treaty may supersede a prior Act of Congress, and an Act of Congress may supersede a prior treaty.' So in the Head Money Cases, 112 U. S., 580, 599, this Court said: 'So far as a treaty made by the United States with any foreign nation can become the subject of judicial cognizance in the Courts of this country, it is subject to such Acts as Congress may pass for its enforcement, modification or repeal.' Again, in Whitney *vs.* Robertson, 124 U. S., 190, 194: 'By the Constitution a treaty is placed on the same footing, and made of like obligation, with an Act of legislation. Both are declared by that instrument to be the supreme law of the land, and no superior efficacy is given to either over the other. When the two relate to the same subject, the Courts will always endeavor to construe them so as to give effect to both, if that can be done without violating the language of either; but if the two are inconsistent, the one last in date will control the other, provided always that the stipulation of the treaty on the subject is self-executing.' See also Taylor *vs.* Morton, 2 Curtis, 454, 459; Clinton Bridge Case, 1 Woolworth, 155; Ropes *vs.* Church, 8 Blatchf., 304; 2 Story on Const., Sec. 1838. Nevertheless, the purpose by statute to abrogate a treaty or any designated part of a treaty, or the purposes by treaty to supersede the whole or a part of an Act of Congress, must not be lightly assumed, but must appear clearly and distinctly from the words used in the statute or in the treaty."

Note 9.—The language of the court is as follows: "As was said by Chief-Justice Marshall in The Peggy, 1 Cranch, 103, 110: 'Where a treaty is the law of the land, and as such affects the rights of parties litigating in Court, that treaty as much binds those rights, and is as much to be regarded by the Court as an Act of Congress.' And in Foster *vs.* Neilson, 2 Pet. 253, 314, he repeated this in substance: 'Our Constitution declares a treaty to be the law of the land. It is, consequently, to be regarded in Courts of justice as equivalent to an Act of the legislature, whenever it operates of itself without the aid of any legislative provision.' So in Whitney *vs.* Robertson, 124 U. S., 190: 'By the Constitution a treaty is placed on the same footing, and made of like obligation, with an act of legislation. Both are declared by that instrument to be the supreme law of the land, and no superior efficacy is given to either over the other. When the two relate to the same subject, the Courts will always endeavor to construe them so as to give effect to both, if that can be done without violating the language of either; but if the two are inconsistent, the one last in date will control the other, provided always that the stipulation of the treaty on the subject is self-executing.' To the same effect are The Cherokee Tobacco, 11 Wall., 616, and the Head Money Cases, 112 U. S., 580."

Note 10.—Mr. Justice Wilson said: "But even if Virginia had the power to confiscate, the treaty annuls the confiscation. The fourth Article is well expressed to meet the very case: it is not confined to debts existing at the time of making the treaty; but is extended to debts heretofore contracted. It is impossible by any glossary, or argument, to make the words more perspicuous, more conclusive, than by a bare recital. Independent, therefore, of the Constitution of the United States (which authoritatively inculcates the obligation of contracts) the treaty is sufficient to remove every impediment founded on the law of Virginia. The State made the law; the State was a party to the making of the treaty; a law does nothing more than express the will of a nation; and a treaty does the same."

Note 11.—Mr. Justice Iredell said: "The opinion I have long entertained, and still do entertain, in regard to the operation of the fourth article is, that the stipulation in favor of creditors, so as to enable them to bring suits, and recover the full value of other debts, could not at that time be carried into effect in any other manner, than by a repeal of the statutes of the different States, constituting the impediments to their recovery, and the passing of such other acts as might be necessary to give the recovery entire efficacy, in execution of the treaty."

Note 12.—Additional comment upon this case made by Professor Mikell is as follows: "In Ware *vs.* Hylton, it was decided that a law of Virginia, passed in 1777, which provided that any citizen of Virginia, owing money to a subject of Great Britain, might pay the same into the loan office of the State and be discharged of the debt, was abrogated by the treaty of 1783, between the United States and England. This treaty provided that the creditors of either of the contracting parties should meet with no lawful impediment to the recovery of all debts theretofore contracted.

"It is submitted that this case is no authority for the broad proposition that the treaty-making power is not limited by the reserved rights of the States. In the first place the treaty in question was entered into by the Continental Congress before the adoption of the present Constitution. Now the method of entering into a treaty under the confederation differed from that under the Constitution. Under the confederation each state was entitled to only one vote in Congress and Congress could make no treaty without the consent of nine States. As there were thirteen states in the confederation, this meant that the assent of three-fourths of all the States was necessary to the making of a treaty. Under the present Constitution a treaty is not so directly the act of a State, and that assent of three-fourths of the States is not necessary. Each State has two Senators and they may not vote in unison; but, more important is the difference that the Constitution does not require the assent of three-fourths or even of two-thirds of the States to the making of a treaty, but only the assent of two-thirds of the Senators present when the treaty is voted on. It might well be then that greater force should be allowed to a treaty negotiated by the States in the Continental Congress where they acted much as independent States in a league, than under the present Constitution where the vote on treaties is not by States at all. The position of the States in the Confederation seems to be referred to by Wilson, J. where he says (p. 281): 'The State made the law; the State was a party to the making of the treaty; a law does nothing more than express the will of a nation; a treaty does the same.' Again the decision in Ware *vs.* Hylton that a treaty overrides a state law confiscating debts due foreigners is not a decision that the treaty-making power under the Constitution can be used to deprive a State of any of its reserved rights; for while this right of confiscation did exist in Virginia before the present Constitution it was not only not reserved, but is expressly surrendered by the Constitution—in that section providing that no State shall pass any law impairing the obligations of a contract.

"Indeed, the very reason the States were so careful to insist on an expression of their reserved rights, in framing the present Constitution, was because, by the new Constitution, they had in general created a more centralized government than existed under the Confederation.

"What the case really decides is that any treaty made under the Articles of Confederation and which was valid under the Articles of Confederation was valid by adoption after the Constitution was adopted." *American Law Register,* Vol. 57, pp. 540–2.

Note 13.—The language of the Court is as follows: "In 1796, but a few years later, this Court said: 'If doubts could exist before the adoption of the present national government, they must be entirely removed by the sixth article of the Constitution, which provides that "all treaties made or which shall be made under the authority of the United States, shall be the supreme law of the land, and the judges in every State shall be bound thereby, anything in the Constitution or laws of any State to the contrary notwithstanding." There can be no limitation on the power of the people of the United States. By their authority the State Constitutions were made, and by their authority the Constitution of the United States was established; and they had the power to change or abolish the State Constitution or to make them yield to the general government and to treaties made by their authority. A treaty cannot be the supreme law of the land, that is, of all the United States, if any act of a State legislature can stand in its way. If the Constitution of a State (which is the fundamental law of the State and paramount to its legislature) must give way to a treaty and fall before it, can it be questioned whether the less power, an act of the State legislature, must not be prostrate? It is the declared will of the people of the United States that every treaty made by the authority of the United States shall be superior to the Constitution and laws of any individual State, and their will alone is to decide. If a law of a State contrary to a treaty is not void, but voidable only, by a repeal or nullification by a State legislature, this certain consequence follows,—that the will of a small part of the United States may control or defeat the will of the whole.' Ware *vs.* Hylton, 3 Dall., 199. It will be observed that the treaty-making clause is retroactive as well as prospective. The treaty in question, in Ware *vs.* Hylton, was the British treaty of 1783, which terminated the war of the American Revolution. It was made while the Articles of Confederation subsisted. The Constitution, when adopted, applied alike to treaties 'made and to be made.' . . .

"In Chirac *vs.* Chirac (2 Wheat., 259), it was held by this Court that a treaty with France gave to her citizens the right to purchase and hold land in the United States, removed the incapacity of alienage and placed them in precisely the same situation as if they had been citizens of this country. The State law was hardly adverted to, and seems not to have been considered a factor of any importance in this view of the case. The same doctrine was reaffirmed touching this treaty in Carneal *vs.* Banks (10 id., 181), and with respect to the British treaty of 1794, in Hughes *vs.* Edwards (9 id., 489). A treaty stipulation may be effectual to protect the land of an alien from forfeiture by escheat under the laws of a State. Orr *vs.* Hodgson, 4 id., 453. By the British treaty of 1794, 'all impediment of alienage was absolutely levelled with the ground despite the laws of the States. It is the direct constitutional question in its fullest condition. Yet the Supreme Court held that the stipulation was within the constitutional powers of the Union.'"

Note 14.—As is well known, after this decision, Congress, passed the Wilson Act (26 Stat., 713) which was construed by the Supreme Court as constituting an adoption by Congress of a special rule enabling the States to extend their otherwise non-existent authority to liquors shipped from other States before they became commingled with the property in the State by sale in the original package. It was also construed as not applicable to interstate shipments made to a consignee for his own use and not for sale. For the particular application of these principles, see:

In re Rahrer, 140 U. S., 545 (1891).
Crutcher *vs.* Kentucky, 141 U. S., 47 (1891).
Brennan *vs.* Titusville, 153 U. S., 289 (1894).
Vance *vs.* Vandercook, 170 U. S., 438 (1898).
Caldwell *vs.* North Carolina, 187 U. S., 622 (1903).
N. & W. R. R. Co. *vs.* Sims, 191 U. S., 441 (1903).
Am. Ex. Co. *vs.* Iowa, 196 U. S., 133 (1905).
Pabst Brewing Co. *vs.* Crenshaw, 198 U. S., 17 (1905).
Foppiano *vs.* Speed, 199 U. S., 501 (1905).
Heyman *vs.* Southern Ry. Co., 203 U. S., 270 (1906).
Rearick *vs.* Pennsylvania, 203 U. S., 507 (1906).
Delamater *vs.* So. Dakota, 205 U. S., 93 (1907).

In this connection, it may be well to note that in a recent work on "The Treaty Power under the Constitution of the United States," by R. T. Devlin, Esq.—a work valuable for the careful collection of authorities and precedents—one finds in the Index under the caption "State supreme in police power," one case cited, and one only, as controlling this subject. It is the case of Cantini *vs.* Tillman, 54 Fed. Rep., 969 (1893). This is also cited by Professor Mikell as showing that the judge did "not conceive of the cases beginning with Ware *vs.* Hylton, and ending with Hauenstein *vs.* Lynham, as having established the doctrine of the supremacy of the treaty-making power over the reserved powers of the States," p. 553. The suit was one brought to determine the constitutionality of the South Carolina "Dispensary Act." The Federal district judge, Judge Simonton, sat as circuit judge, and held that the Wilson Act was applicable, and that the South Carolina statute was constitutional. After disposing of the case on the authority of the Supreme Court decisions construing the Wilson Act, Judge Simonton added:

"It is urged in behalf of those complainants that they are Italian subjects, and are protected by the treaty stipulations between Italy and the United States. . . .

"Under these articles the complainants have the same rights as citizens of the United States. It would be absurd to say that they had greater rights. We have seen that the right to sell intoxicating liquors is not a right inherent in a citizen, and is not one of the privileges of American citizenship; that it is not within the protection of the fourteenth amendment; that it is within the police power. The police power is a right reserved by the States, and has not been delegated to the general government. In its lawful exercise, the States are absolutely sovereign. Such exercise cannot be affected by any treaty stipulation," p. 976.

No extended comment is necessary. In the first part of his opinion the judge had shown that the Act of Congress had made the State statute constitutional. He cannot be presumed to have intended by his closing words to contradict his own argument, to say that, apart from that act, the statute was constitutional, and Leisy *vs.* Hardin was not law. Moreover, he had just shown that the treaty had by its terms no application whatever; his language therefore must be interpreted with reference to the facts before him and in relation to his whole opinion. In no event, can it properly be cited as establishing the statement of Mr. Devlin, or the contention of Professor Mikell. It is significant that neither, while quoting at length this and the License Cases, make the slightest reference to Leisy *vs.* Hardin and cognate decisions.

Note 15.—The facts necessary to a full comprehension of *all* the questions involved in this dispute are too complex to be inserted in the body of this essay, as they are strictly relevant only to questions other than the one discussed. Inasmuch, however, as they afford an admirable illustration of how, practically, the question of the right of the United States to enforce treaty provisions, may arise, they are here stated in the language of Mr. Root, the then Secretary of State: "The treaty of November 22, 1894, between the United States and Japan provided, in the first article:

"'The citizens or subjects of each of the two high contracting parties shall have full liberty to enter, travel, or reside in any part of the territory of the other contracting party and shall enjoy full and perfect protection for their persons and property. . . . In whatever relates to rights of residence and travel; to the possession of goods and effects of any kind; to the succession to personal estate, by will or otherwise, and the disposal of property of any sort and in any manner whatsoever which they may lawfully acquire, the citizens or subjects of each contracting party shall enjoy in the territories of the other the same privileges, liberties, and rights, and shall be subject to no higher imposts or charges in these respects than native citizens or subjects or citizens or subjects of the most favored nation.'

"The Constitution of the State of California provides, in Article 9:

"'SECTION 1. A general diffusion of knowledge and intelligence being essential to the preservation of the rights and liberties of the people, the legislature shall encourage by all suitable means the promotion of intellectual, scientific, moral and agricultural improvement.

"'SECTION 5. The legislature shall provide for a system of common schools, by which a free school shall be kept up and supported in each district at least six months in every year, after the first year in which a school has been established.

"'SECTION 6. The public school system shall include primary and grammar schools, and such high schools, evening schools, normal schools and technical schools as may be established by the legislature, or by municipal or district authority. The entire revenue derived from the State school fund and from the general State school tax shall be applied exclusively to the support of the primary and grammar schools.'

"The Statutes of California establish the public school system required by the Constitution. They provide that the State comptroller must each year estimate the amount necessary to 'raise the sum of seven dollars for each census child between the ages of five and seventeen years in the said State of California, which shall be the amount necessary to be raised by ad valorem tax for the school purposes during the year.'

"The Statutes further provide that the board of education of San Francisco shall have authority 'to establish and enforce all necessary rules and regulations for the government and efficiency of the schools (in that City) and for the carrying into effect the school system; to remedy truancy; and to compel attendance at school of children between the ages of six and fourteen years, who may be found idle in public places during school hours.'

"The Statutes further provide, in Section 1662 of the School law: 'Every school, unless otherwise provided by law, must be open for the admission of all children between six and twenty-one years of age residing in the district, and the board of school trustees, or city board of education, have power to admit adults and children not residing in the district, whenever good reasons exist therefor. Trustees shall have the power to exclude children of filthy or vicious habits, or children suffering from contagious or infectious diseases, and also to establish separate schools for Indian children and for children of Mongolian or Chinese descent. When such separate schools are established, Indian, Chinese, or Mongolian children must not be admitted into any other school.

"On the 11th of October, 1906, the board of education of San Francisco adopted a resolution in these words:

'*Resolved:* That in accordance with Article X, Section 1662, of the school law of California, principals are hereby directed to send all Chinese, Japanese, or Korean children to the Oriental Public School, situated on the South side of Clay Street, between Powell and Mason Streets, on and after Monday, October 15, 1906.'

"The school system thus provided school privileges for all resident children, whether citizen or alien, all resident children were included in the basis for estimating the amount to be raised by taxation for school purposes; the fund for the support of the school was raised by general taxation upon all property of resident aliens as well as of citizens; and all resident children, whether of aliens or of citizens, were liable to be compelled to attend the schools. So that, under the resolution of the board of education, the children of resident aliens of all other nationalities were freely admitted to the schools of the city in the neighborhood of their homes, while the children of Indians, Chinese and Japanese were excluded from those schools, and were not only deprived of education unless they consented to go to the special oriental school on Clay Street, but were liable to be forcibly compelled to go to that particular school.

"After the passage of this resolution, admission to the ordinary primary schools of San Francisco was denied to Japenese children, and thereupon the government of Japan made representations to the government of the United States that inasmuch as the children of residents who were citizens of all other foreign countries were freely admitted to the schools, the citizens of Japan residing in the United States were, by that exclusion, denied the same privileges, liberties, and rights relating to the right of residence which were accorded to the citizens or subjects of the most favored nation. The question thus raised was promptly presented by the government of the United States to the federal court in California, and also to the state court of California, in appropriate legal proceedings. . . .

"It is obvious that three distinct questions were raised by the claim originating with Japan and presented by our national government to the courts in San Francisco. The first and second were merely questions of construction of the treaty. Was the right to attend the primary schools a right, liberty, or privilege of residence? and, if so, was the limitation of Japanese children to the oriental school and their exclusion from the ordinary schools a deprivation of that right, liberty, or privilege? . . .

"The other question was whether, if the treaty had the meaning which the government of Japan ascribed to it, the government of the United States had the constitutional power to make such a treaty agreement with a foreign nation which should be superior to and controlling upon the laws of the State of California." *American Journal of International Law*, Vol. I., Part I., pp. 274–276–277.

Note 16.—"It would, I believe, be entirely competent for Congress to make offenses against the treaty rights of foreigners domiciled in the United States cognizable in the Federal Courts. This has not, however, been done, and the Federal officers and Courts have no power in such cases to intervene, either for the protection of a foreign citizen or for the punishment of his slayers. It seems to me to follow, in this state of the law, that the officers of the State charged with police and judicial powers in such cases must in the consideration of international questions growing out of such incidents be regarded in such sense as Federal agents as to make this Government answerable for their acts in cases where it would be answerable if the United States had used its constitutional power to define and punish crime against treaty rights." Richardson's "Messages of the Presidents," Vol. 9, p. 183.

Note 17.—"A bill to provide for the punishment of violations of treaty rights of aliens was introduced in the Senate March 1, 1892, and reported favorably March 30th. Having doubtless in view the language of that part of Article III, of the treaty of February 26, 1871, between the United States and Italy, which stipulates that 'the citizens of each of the high contracting parties shall receive, in the States and Territories of the other, most constant protection and security for their persons and property, and shall enjoy in this respect the same rights and privileges as are or shall be granted to the natives, on their submitting themselves to the conditions imposed upon the natives,' the bill so introduced and reported provided that any act committed in any State or Territory of the United States in violation of the rights of a citizen or subject of a foreign country secured to such citizen or subject by treaty between the United States and such foreign country and constituting a crime under the laws of the State or Territory shall constitute a like crime against the United States and be cognizable in the Federal courts. No action was taken by Congress in the matter.

"I earnestly recommend that the subject be taken up anew and acted upon during the present session. The necessity for some such provision abundantly appears. Precedent for constituting a Federal Jurisdiction in criminal cases where aliens are sufferers is rationally deducible from the existing statute, which gives to the district and circuit Courts of the United States jurisdiction of civil suits brought by aliens where the amount involved exceeds a certain sum. If such jealous solicitude be shown for alien rights in cases of merely civil and pecuniary import, how much greater should be the public duty to take cognizance of matters affecting the lives and the rights of aliens under the settled principles of international law no less than under treaty stipulation, in cases of such transcendent wrong doing as mob murder, especially when experience has shown that local justice is too often helpless to punish the offenders." Richardson's "Messages of the Presidents," Supplement, 1899–1902, pp. 69–70.

Note 18.—"I renew the urgent recommendations I made last year that the Congress appropriately confer upon the Federal Courts jurisdiction in this class of international cases where the ultimate responsibility of the Federal Government may be involved, and I invite action upon the bills to accomplish this which were introduced in the Senate and House. It is incumbent upon us to remedy the statutory omission which has led, and may again lead, to such untoward results. I have pointed out the necessity and the precedent for legislation of this character. Its enactment is a simple measure of previsory justice toward the nations with which we as a sovereign equal make treaties requiring reciprocal observance." Ibid., p. 128.

Note 19.—These Sections so amended would read substantially as follows:

Section 5336. If two or more persons in any state or territory conspire . . . by force to prevent, hinder, or delay the execution of any law or treaty of the United States; . . . each of them shall be punished by a fine of not less than five hundred dollars and not more than five thousand dollars; or by imprisonment with or without hard labor, for a period not less than six months nor more than six years, or by both such fines and imprisonment.

Section 5508. If two or more persons conspire to injure, oppress, threaten, or intimidate any person being within any state or territory in the free exercise or enjoyment of any right or privilege secured to him by the constitution or laws of the United States, or under any treaty of the United States, or because of his having so exercised the same; or if two or more persons go in disguise on the highway or on the premises of another, with intent to prevent or hinder his free exercise or enjoyment of any right or privilege so secured, they shall be fined not more than five thousand dollars, and imprisoned not more than ten years; and shall, moreover, be thereafter ineligible to any office, or place of honor, profit, or trust created by the constitution, or laws of the United States.

Section 5509. If in the act of violating any provision in either of the two preceding sections any other felony or misdemeanor be committed, the offender shall be punished for the same with such punishment as is attached to such felony or misdemeanor by the laws of the state in which the offence is committed.

Note 20.—This act as reported was as follows: "Be it enacted by the Senate and House of Representatives of the United States of America, in Congress assembled, that any act committed in any state or territory of the United States in violation of the rights of a citizen or subject of a foreign country secured to such citizen or subject by treaty between the United States and such foreign country, which act constitutes a crime under the laws of such state or territory, shall constitute a like crime against the peace and dignity of the United States, punishable in like manner as in the courts of said state or territories, and within the period limited by the laws of such state or territory, and may be prosecuted in the courts of the United States, and upon conviction, the sentence executed in like manner as sentences upon convictions for crimes under the laws of the United States."

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HELD AT PHILADELPHIA

FOR PROMOTING USEFUL KNOWLEDGE

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THE FORMATION OF COAL BEDS.

III.[1]

By JOHN J. STEVENSON.

(*Read November 1, 1912.*)

The Rocks of the Coal Measures.

Coal beds, Devonian, Carboniferous, Mesozoic and Tertiary, alike, are associated with shales, sandstones and, in many cases, with calcareous beds, the last often containing a marine or a fresh-water fauna. Interior or limnic basins frequently bear close resemblance to paralic or coastal basins, so that distinction between the types becomes arbitrary in some great areas. In the Indiana-Illinois field, wide invasions of the sea appeared again and again throughout practically the whole period of accumulation. On the other hand, the Appalachian basin, almost land-locked during most of its history, experienced few invasions and those, of comparatively small extent, were confined to the earlier periods; in the later stages, the whole region was practically limnic.

Study of reports by observers in the several countries makes certain that conditions needed for formation of coal beds were to

[1] Part I. appeared in these *Proceedings*, Vol. L., pp. 1–116; Part II. in same volume, pp. 519–643.

all intents and purposes the same in all regions and in all periods, from the Devonian coals of Bear Island in the Arctic to the Tertiary coals of Wyoming or Trinidad; but the varying descriptions and explanations presented by students make equally certain that one cannot ascertain what the essential conditions are, if his investigation be confined to areas embracing a score or even several hundreds of square miles. The investigation must cover a great area, in which merely local features do not obscure those which are general and which actually bear upon the problem in hand. Such an area is the Appalachian Basin of the eastern United States, where one finds the Pennsylvanian or Coal Measures divided into

Dunkard	Greene
Wheeling	Washington
	Monongahela
Athens	Conemaugh
	Allegheny
Pottsville	Beaver
	New River
	Pocahontas

The order is descending.[2]

The Appalachian coal field, now embracing approximately 70,000 square miles of almost continuous deposits, occupies only a part of the original area. The deep synclinal basins of anthracite in eastern Pennsylvania are separated by 50 to 100 miles from the great bituminous region at the west, while southwardly one finds insignificant fragments along the eastern side until he comes to Georgia and Alabama. The greatest extent of the area of deposit was probably at the close of the Pottsville, when it reached from southern New York in west southwest direction to beyond central Alabama, more than 800 miles; at the north, it spread from the old Appalachian land, at the east, westward to beyond Newark in

[2] J. J. Stevenson, "Carboniferous of the Appalachian Basin," *Bull. Geol. Soc. Amer.*, Vol. 18, 1907, p. 178. The Pottsville is subdivided in this paper into Beaver and Rockcastle. I. C. White, in West Virginia Geol. Survey, Vol. I*a*, 1908, p. 13, has suggested that Rockcastle be replaced by New River and Pocahontas; this should be accepted, as Stevenson did not assign proper significance to Pocahontas, regarding it as merely a subordinate stage.

Ohio, while at the south it reached the western boundary of Alabama. The area of deposit at that time embraced not less than 200,000 square miles. The present outcrop approaches the western border at a few localities in Ohio and Kentucky as well as in Alabama, but for the most part it is two score or more miles east from the original limit. The eastern border is approached in the southern anthracite field of Pennsylvania and apparently it was not far eastward from the Pocahontas outcrop in Virginia; in Alabama, the eastern outcrop is not more than 25 miles from the original border on that side. But, in most of the space north from Alabama, the present continuous outcrop is from 30 to 100 miles west from that border as it probably existed at the close of the Pottsville. The Appalachian field included a small part of New York, more than two thirds of Pennsylvania, the western third of Maryland. nearly the whole of West Virginia, the eastern third of Ohio and Kentucky, with southwestern Virginia, eastern Tennessee, the northern half of Alabama as well as northwestern Georgia. Here then is an area of sufficient extent to provide ample illustration of purely local features and their relations to the effects of widely acting agents.

The Appalachian Basin.

The Appalachian basin, from its origin to the close of the Palæozoic, was the scene of frequent changes in the relations of land and water. Schuchert and Ulrich[3] have shown that such changes were merely commonplaces in the earlier periods. Those students are not in agreement respecting several matters, which have much interest from a philosophical standpoint, but they are in full agreement respecting all matters which concern the questions at issue here. As Schuchert has shown, the Appalachian basin originally was continuous with the broad Mississippi region and much of it was covered with sea. Toward the close of the Ordovician the Taconic revolution began, which, at the east, widened

[3] C. Schuchert, "Palæography of North America," *Bull. Geol. Soc. Amer.*, Vol. 20, 1910, pp. 427–606; E. O. Ulrich, "Revision of the Palæozoic Systems," ibid., Vol. 22, 1911, pp. 281–680.

Appalachia by additions along the western side from New England through Virginia, thus giving a great area on which erosion could work and did work, as evidenced by clastic sediments in the northern part of the basin. The Cincinnati uplift of authors, occurring at the same time, led to the elevation of Cincinnatia (of Schuchert), the western boundary of the basin. Contemporaneously, as indicated by Schuchert, a less conspicuous land area, Alleghania, appeared within the basin, rudely parallel to Appalachia and extending southwardly across western Pennsylvania and eastern Ohio. It was separated from Cincinnatia by the Ohio basin. During the Silurian, there was occasional communication across Cincinnatia with the Mississippi region beyond and the faunas indicate that the basin opened northwardly to the Atlantic ocean. The same type of evidence shows that the basin was divided by a land area in southern Virginia, so that there was a northern sea extending into New York, as well as a southern sea in Tennessee and Alabama.

Studies by many geologists make clear that the southern portion of Appalachia was unstable. Southward from central Pennsylvania, the early Devonian rocks are wanting along the eastern side, while in southern Virginia and thence southward only the lower beds of the Middle Devonian are found. In Alabama the Devonian, more than 8,000 feet thick in central Pennsylvania, is represented by only dark shale rarely exceeding 100 feet and, near its southern limit, varying from 3 to 30 feet.

The area embraced in Schuchert's Alleghania was of decided instability. It received deposits during the Chemung, for that formation with its characteristic conglomerates crossed the area, though with reduced thickness; but all the principal elements of the section observed in central Pennsylvania are present. The intervals decrease toward this area and there is notable thinning above the upper conglomerate. The Catskill beds, following the Chemung, thin out against Alleghania, showing that once more it was above water. That formation, as defined by Vanuxem, the first to assign a definite meaning to the term, is 3,900 feet thick in Fulton county of Pennsylvania; 3,000, in the eastern portion of Bedford; 1,980 in western Bedford; it is concealed in Somerset, except on the western edge, where it is brought up by a great anticline and is 10 to 15 feet thick, while, at 4 or 5 miles farther west in Fayette county, it has disappeared and the Upper Pocono beds of the Mississippian rest on the Chemung. The rate of decrease under Somerset is very nearly the same as that in Fulton and Bedford. This thinning is shown on the western side of the Catskill deposits from New York to New River in Virginia, beyond which southwardly Chemung and Catskill both disappear.[4]

The Carboniferous was opened by subsidence in the basin. The northern portion still received the greatest deposits along the eastern side in the old valley or "trough of sedimentation," but the area widened westwardly so that the later Pocono rocks of Pennsylvania overlap the Catskill of the Devonian and rest without apparent nonconformity on the Chemung rocks of Alleghania, as they do beyond in the Ohio basin. There was distinct widening eastwardly in Virginia and southward. Campbell[5] showed that phenomena in Virginia, which had puzzled earlier observers, were due to overlap; that the coal-bearing Mississippian deposits rest there on Ordovician rocks, which in all probability had been upraised during the Taconian revolution. Still farther south, the oldest rocks of the Mississippian overlap the Catskill, the Chemung and, at length, even the thin Chattanooga shales, the last Devonian representative toward the south. But during succeeding stages of the Mississippian, there was distinct contraction of the area of deposit on the western side, for the Maxville lies within the Logan and the Shenango within the Maxville;[6] at times, there may have been dry land in the Alleghania region. But at the south there was continued depression,

[4] J. J. Stevenson, "Bedford and Fulton Counties," Second Geol. Surv. of Penn., 1882, pp. 73–75, 81; "The Upper Devonian Rocks of Southwest Pennsylvania," *Amer. Jour. Sci.*, III., Vol. XV., 1878, pp. 423–430; "On the Use of the Name Catskill," ibid., Vol. XLVI., 1893, pp. 330–337.

[5] M. R. Campbell, "Palæozoic Overlaps in Montgomery and Pulaski Counties, Virginia," *Bull. Geol. Soc. Amer.*, Vol. 5, 1894, p. 182.

[6] J. J. Stevenson, "Lower Carboniferous of the Appalachian Basin," *Bull. Geol. Soc. Amer.*, Vol. 14, 1903, p. 85. This paper, on pp. 89–96, contains a discussion of the varying geographical conditions during the Mississippian.

increasing southwardly, so that in that direction the thickness of the deposits increases until eastern Alabama is reached, where one finds progressive overlap and each deposit has its attenuated outcrop beyond that of its predecessor. Toward the close of the Mississippian, Alleghania was becoming better defined; all of the formations are present in most of it but they are very thin, nowhere more than 400 feet thick at the north, less than one fifth as much as in the anthracite region. Whether or not the Shenango shales of western Pennsylvania are synchronous with the upper red beds of the Mauch Chunk region cannot be determined, as a gap of 60 miles exists, from which the beds have been removed. Fossils are rare and insufficient for correlation; they make evident, however, that marine conditions prevailed in Alleghania, for the individuals obtained in southwestern Pennsylvania are large, well developed and thoroughly characteristic. The water was probably too shallow and too variable in distribution to permit abundant life; the sun cracks, ripple marks and other features indicate that these fine muds were spread out on mud flats, with constantly shifting areas of tidal waters. It is certain that withdrawal of the sea was continuous on the western side, so that before the close of Mississippian, the Ohio basin had become dry land and Alleghania had become once more a distinct ridge, dividing the basin longitudinally from New York to central Tennessee. But the withdrawal affected almost the whole of the Appalachian basin; and this withdrawal may have been caused by extensive deformation of the surface. While Alleghania was raised at the west, there was rejuvenation of Appalachia at the east. In the later Mississippian, the streams had reached base level along the borders, for only fine muds were carried into the basin; but the Pottsville opens with coarse deposits from Pennsylvania to Alabama.

The distribution and character of the Pottsville deposits[7] seem to place beyond doubt the assertion that at the beginning of the Pennsylvanian the whole basin, excepting at the southwest corner,

[7] D. White, "Deposition of the Appalachian Pottsville," *Bull. Geol. Soc. Amer.*, Vol. 15, 1905, pp. 267–282; J. J. Stevenson, "Carboniferous of the Appalachian Basin," ibid., Vol. 18, 1907, pp. 142–150.

was a land area. Ancient Appalachia at the east towered above the old trough of sedimentation, now become a broad valley with irregular surface, while at the west rose the flat-topped Alleghania, hundreds of feet high at the north and separated from Cincinnatia by the broad, shallow valley of the Ohio basin, which deepened southwardly. The eastern valley and the slope of Appalachia were drained by a river following the westerly side of the valley and finding its outlet at the south in Tennessee, where there still remained a considerable body of water. A gradually lengthening stream drained the western valley and found its outlet at the south in the body of water, which was continuous around the southern end of Alleghania.

The story of the Appalachian basin for the Silurian, Devonian and early Carboniferous is one of local deformations, of differential elevations and depressions, of alternating water and dry land areas, of sea invasions and expulsions or withdrawals. Similar conditions continued throughout the Pennsylvanian. The subsidence during the earlier stages was evidently differential, increasing toward the south. As one follows the New River formation along the face of the bituminous area, he finds not merely lower and lower beds but, in Alabama, also a vastly increased thickness in each member of the section, so that the mass, belonging apparently in greatest part to the New River, is greater than the whole column in the anthracite area, though that includes the Pottsville and at least two thirds of the Athens. The condition throughout the Pottsville was that of subsidence and the area of deposit constantly increased toward the west. Along the sides of Alleghania and in the Ohio basin, the New River overlaps the Pocahontas and the Beaver overlaps the New River. The character of deposits in the anthracite region and in Alabama affords ground for belief that, while subsidence prevailed within the basin to the end of the Pottsville, there was interrupted elevation in much of Appalachia, causing frequent rejuvenation of the streams and preventing eastward expansion of the area of deposition. During the Athens and later periods, that area seems to have been contracting steadily, first at the south and eventually on all sides until, at the close of the Dunkard, completion of the Appalachian revolution brought deposition to an end in the comparatively small area which remained.

Before presenting in detail the evidence on which these statements are based, it is well to call attention to a matter respecting which some misapprehension seems to exist. Time breaks in deposition, due to existence of a land surface, do not leave in every case a record in the way of non-conformity, which can be recognized in even a considerable area. Schuchert[8] has emphasized in this connection the conditions observed in the neighborhood of Louisville, Kentucky, where the limestone deposit is conformable throughout and appears to be continuous. The Devonian portion can be distinguished from the Silurian only by the fossils, although the portions are separated by a long land-interval. He offers many other instances to which the writer may add one, already referred to. In Westmoreland and Fayette counties of Pennsylvania, the Upper Pocono or Logan is shown resting conformably upon the Chemung, while at 60 miles east those formations are separated by not less than 4,000 feet of Catskill and Lower Pocono. Nor is it in any sense necessary that there be extensive erosion during a somewhat prolonged period of sub-aerial exposure, if the land be level or low-lying, even though the period be long enough to admit of the cutting of considerable valleys. Schuchert has shown that, though exposed during the whole period since the Taconian revolution, the Cincinnatian region has lost certainly little more than 400 feet by erosion and that in all probability the greater part of this loss has occurred since the Pleistocene elevation. Ulrich[9] says that a limestone in the St. Louis area, 5 feet thick, was exposed during the Silurian and the Devonian, yet it was not removed. Illustrations of the slowness of erosion, where land is level, are abundant in portions of Vermont, where one finds broad, terraced valleys in the Quaternary sands and gravels. The region has always been one with heavy rains, yet in some extended spaces the broad upper terrace is only slightly scarred, though, since it was aban-

[8] C. Schuchert, "Palæography of North America," pp. 441, 442.

[9] E. O. Ulrich, "Revision of the Palæozoic Systems," p. 306.

doned, the streams have cut their valleys, hundreds of feet deep, and have lined them with terraces.

The existence of a land area in Alleghania and the Ohio basin is made clear by the distribution of Pottsville deposits. The Pocahontas formation is present in the southern anthracite field and in the western part of the Western Middle, but it is wanting in the Eastern Middle and the Northern as well as in the bituminous region of Pennsylvania and Ohio. Along the eastern outcrop, it is present in the southern part of West Virginia and the adjacent part of Virginia, but it thins away quickly toward the west and northwest. It has not been recognized southwardly beyond Virginia. The New River is very thick in the southern and in the western part of the Western Middle, but is wanting in the northern anthracite field. It is very thick in eastern Alabama within the outlying areas, but it loses thickness quickly toward the west. This part of Alabama is a region of non-conformability throughout. Butts[10] has shown that that unconformity is found at close of Cambrian, Ordovician, Silurian and Devonian. There is notable non-conformity of erosion between Mississippian and Pennsylvanian. The sandstone and shale mass, closing the former in eastern Alabama, was removed from a great space prior to deposit of the Pottsville. In the continuous bituminous region, one finds the upper beds of the New River at about 70 miles south from the Pennsylvania line; the lower beds appear in succession until in the southern part of the state one finds, in all probability, the whole formation. The formation is wholly wanting in the northern part of the state and in by far the greater part of Pennsylvania. Indeed, there seems to be good reason for doubting the accuracy of identifications along the eastern outcrop in the latter state. In southern West Virginia it is possible to trace the formation across the state by means of exposures and the many records of oil-borings preserved by I. C. White. The lower members disappear in succession westwardly against the face of Alleghania and only the uppermost members

[10] C. Butts, "Iron Ores, Fuels, and Fluxes of the Birmingham District, Alabama," U. S. Geol. Surv. Bull., 400, 1910, pp. 14–16.

reach Kentucky. The formation can be followed easily along the eastern outcrop beyond central Tennessee, where the lower portion first crosses Alleghania, and becomes continuous with the deposit in the Ohio basin. There one finds the Bonair sandstone, midway in New River, passing across Alleghania, where it rests on Mississippian beds. On the western side in the Ohio basin, the higher New River beds disappear northwardly, each overlapped by its successor, so that beyond the Ohio River one finds only the topmost member occupying a long narrow space, extending almost to the present Lake Erie. At the close of the New River, most of the bituminous region within Pennsylvania and northern West Virginia was above the area of deposit. During the Beaver that area seems to have increased constantly so that, at the close of the Pottsville, Alleghania had disappeared and the Homewood sandstone or its equivalent covered the whole basin. The last portion of Alleghania to become buried was in Jefferson, Clearfield, Indiana, Westmoreland and Fayette counties of Pennsylvania. Differential subsidence continued throughout the Pottsville; even in the Beaver the condition is notable. That formation is 250 to 300 feet thick in western Pennsylvania, but on the Kanawha River in central West Virginia it is fully 1,000 feet, while in southwest Virginia the thickness seems to be even greater.

The Allegheny shows curious irregularities of thickness within the bituminous area, which are due clearly to local disturbances; but, leaving that feature out of view, one finds in a general way very little variation, except along the western border, where the section is shortened. The thickness may be taken as approximately 250 feet. In the anthracite area, the old trough of sedimentation continued and the great influx of materials from Appalachia gave a thickness several times as great. There, too, one finds anomalous deposition, with abrupt changes in structure of coal beds and remarkable variations in the intervals between them, evidence that there were many and serious local disturbances.

In the Conemaugh, there is less evidence of local disturbance. The variations are, as it were, regular. Measurements across the bituminous region show rapid thickening eastward to the Ohio

River but comparative uniformity thence to the eastern outcrop. In Muskingum and Guernsey counties of Ohio, the thickness increases from 315 to 340 feet but, 40 miles farther, at the Ohio it is 500 feet. In Pennsylvania and western Maryland the average is very nearly 600 feet. How thick the formation was in the northern anthracite field cannot be determined, as the top of the section has been removed, but the beds there are not less than 1,000 feet thick. The conditions were the same throughout the whole period of deposit, for variations in the upper half are similar to those in the lower half. Apparently there was slower subsidence along the western border than elsewhere, but no proof of overlapping or of regression can be found, as the outcrop is usually at a considerable distance from the border of deposit. There was a singular uniformity of conditions from north to south along the middle line of the bituminous area, a distance of more than 200 miles. At the most northerly outcrop in Pennsylvania, the thickness is approximately 600 feet and thence southward along the whole line it varies from 575 to 600 feet. Beyond Doddridge county of West Virginia, definite measurements cannot be made as coal beds and limestones alike have disappeared; but at Huntingdon, 100 miles beyond, and just west from the middle line the thickness is said to be 660 feet. At the extreme southeastern outcrop in West Virginia, the interval has been reported as 800 feet but some doubt remains as to the upper limit. Conditions during the Athens resembled those during the Pottsville, in that the trough of sedimentation with greater subsidence still existed at the east. But there was no longer differential subsidence toward the south and there is much reason for believing that there was notable contraction of the area of deposition in that direction, so that the Conemaugh may have extended, at most, only a short distance into Tennessee.[11]

But when one reaches the Wheeling he finds a notable change. Going eastward from the western outcrop in Ohio, the thickness

[11] The measurements of the Conemaugh have been taken from J. J. Stevenson, Ohio Geol. Survey, Vol. III., 1879; Second Geol. Serv. of Pennsylvania, Reports K, 1876, KK, 1877, T2, 1882; I. C. White, U. S. Survey, Bull. 65, 1891; West Virginia Geol. Surv., Vol. I., 1899.

of the Monongahela is 206, 250 and at the Ohio River 261 feet. Beyond that river, 275, 300, 340 and 380 in Pennsylvania to just beyond the Monogahela River; 316 at a few miles farther and 212 in the Frostburg basin of Maryland. Adding the coal beds and their partings one has 213 at the western outcrop, 270 at the Ohio River, 285 at western line of Pennsylvania, 400 near the Monongahela, 370 beyond the Monongahela and 252 in the Frostburg basin of Maryland.[12] It is evident that the topographical conditions have been changed and the area of deposit has become a trough with its deepest line midway in the bituminous region. The ancient trough of sedimentation at the east has disappeared. For in another direction the contrast with the Athens conditions is equally striking. No shortening of the section northward was observed in the Athens, but in the Monongahela, the shortening in that direction is distinct. Many measurements are available in southwest Pennsylvania and West Virginia.[13] These show that the thickness increases from 156 feet at the most northerly exposure in Washington county of Pennsylvania to about 400 feet at the West Virginia line, the increase being gradual. The extreme thickness is maintained in West Virginia for more than 50 miles. Thence the section can be followed only with difficulty as all horizons become indefinite, but evidently it becomes shorter, for, where the horizons again become definite, along the southern border, the thickness is 250 to 281 feet. The conditions were similar during deposition of the Washington. Throughout the Wheeling, the area of deposition was basin shaped, with the rate of subsidence increasing toward central West Virginia. It was contracting on all sides and there is little or no reason to suppose that any important deposits were made in the anthracite region or south from West Virginia.

[12] Ohio Geol. Surv., Vol. III., p. 262; Second Geol. Surv. Penn., Report K, pp. 211, 216, 240, 340; "Carboniferous of the Appalachian Basin," *Bull. Geol. Soc. Amer.*, Vol. 18, 1907, p. 47; G. P. Grimsley, "Ohio, Brooke and Hancock Counties," West Virginia Geol. Surv., 1907, p. 39.

[13] J. J. Stevenson, Second Geol. Surv. Penn., Rep. KKK, 1878, p. 292; a considerable number of measurements cited here from Rep. K were made by I. C. White; I. C. White, U. S. Survey, Bull. 65, pp. 54, 55; Well records in W. Va., Vol. I.

The area of Dunkard deposits seems to have been much less than that of the Wheeling, but erosion has stripped the borders and one can make few positive statements respecting the conditions. The full section, as it now exists, is found only at rare places in the long narrow strip within western Pennsylvania and West Virginia. There appears to be the same tendency to northward shortening of the section; there is evidence in Pennsylvania that there were local foldings, that, as in the earlier periods, there were not merely general movements leading to decrease of the area of deposition but also others due to strains varying in direction at different times.

Evidence of elevation and subsidence is found in buried valleys, marking the courses of subaerial streams. These are so numerous that one need select only a few instances.

That Alleghania and the Ohio basin were dry land at the close of the Mississippian, is clear from the evidence of erosion as well as of corrosion. Hyde[14] has summarized the observations of his predecessors and has added the results of his own studies. The base of the Coal Measures along the outcrop belt in southern Ohio rests directly on the Logan formations, which for the most part are Lower Mississippian. These were subjected to great erosion, which left a relief of 200 to 300 feet. Hyde followed this surface of unconformity across Ohio from the central line of the state southward to the Ohio River, finding frequent variations of 100 feet in the elevation. The Coal Measures sandstones are often let down into the Logan, but ordinarily the non-conformity is gentle. Here and there one sees old valleys which can be traced for considerable distances. The erosion was mostly post-Maxville.

Soon after the elevation of Alleghania and the Ohio basin, a stream began to cut for itself a valley, which, before the end of the New River stage, extended from the Canadian highlands southwardly across Ohio, Kentucky and Tennessee to an outlet at the

[14] J. E. Hyde, "Notes on the Absence of a Soil Bed at the Base of the Pennsylvanian of Southern Ohio," *Amer. Journ. Sci.*, Vol. XXXI., 1911, pp. 557–560.

southwest. This stream must have been determined very quickly after the region became dry land, for, before the end of the New River, it had made a terraced valley, at least 30 miles wide in some parts of its course and showing irregularities of surface which indicate existence of many minor tributaries. The main stream had its source in the Canadian highlands; an important tributary drained part of the Mississippian ridge of Michigan and its course lay within the area of Lake Erie; a second important tributary came from the east, draining a part of southwestern New York and northern Pennsylvania. In Ohio, this valley area is for the most part west from the present outcrop of Pennsylvania beds; but its eastern side is traced readily from 10 miles south of Lake Erie to the southern border of Summit and Portage counties, about 80 miles, for it is filled with coarse sandstone and conglomerate, which thin out abruptly at the east, permitting the overlying beds to rest on Mississippian rocks. The western edge is approached in Wayne and Medina counties, where the coarse beds become very thin. Fragmentary exposures of the eastern side are found in counties farther south until, in Vinton, Jackson and Pike, the Pennsylvanian outcrop swings westward and the exposures extend to apparently midway in the valley. Thence into Kentucky the outcrop again trends southwardly and only the extreme eastern border is seen. In northern Kentucky, another valley, now filled with New River beds, begins in Carter county at 20 miles south from the Ohio River and deepened rapidly southward in Mississippian rocks. Its direction, west of south, is such that, within a few miles from the last recorded exposure, it should unite with the main valley. In southern Kentucky on the western side of the Main Valley area, M. R. Campbell discovered a valley in Mississippian rocks, deepening toward the east and now filled with New River beds. Farther south, in Tennessee, the relations soon become indefinite, but observations on the eastern side by Hayes make sufficiently clear that the valley was distinct at half way to the Alabama line until midway in the New River.

Some features of this valley should be emphasized. Its existence is distinct for not less than 400 miles and, beyond central Ohio, it deepened rapidly toward the south. It was dug in soft rocks of the Mississippian, shale, limestone or comparatively fine grained sandstone; but it headed eventually in the Archæan rocks of Canada, while an important branch rose in the Mississippian area of Michigan, covered with a cherty limestone. A gradual though probably not continuous subsidence is shown by the distribution of New River beds, which terminate one after another in progressive overlap northward until beyond the Ohio River one finds only the newest members of the formation. In like manner, overlap is distinct on the eastern or Alleghania side of the valley; at the north, the Beaver rests on Mississippian beyond termination of the New River; Hayes and others saw that, in White, Bledsoe and Cumberland counties of Tennessee, the lower members of the New River thin away in succession on the west slope of Alleghania until at last the Bonair sandstone, midway in the formation, crosses the ridge where it rests on Mississippian. A similar condition exists on the eastern side of the ridge, facing the old trough of sedimentation.

The valley was filled eventually by New River deposits. In Ohio, only the latest members appear; coarse sandstone, of which the lower portion is dense, hard and white, containing quartz pebbles from the Canadian Archæan and pebbles of fossiliferous chert from Michigan. At many places in northern Ohio, this is a mass of pebbles with hardly enough sand to bind them, while mingled with them at times are irregular pieces of shale—the whole giving unmistakable proof of river action. The chert pebbles continue almost to the Ohio River at the south, more than 400 miles from the source, the measurement being made in direct line. The upper portion contains no chert but abundance of quartz pebbles, and in Jackson and Pike of Ohio, more than 300 miles from the only possible source, those pebbles, occurring throughout the deposit, are often as large as a hen's egg. In most of Kentucky, the equivalents of these later deposits are merely coarse sandstones with layers of small pebbles.—it must be remembered that there one sees only the border, not the deeper part of the valley. In the southern part of the state the beds consist largely of "hailstone grit," for there the exposures reach beyond those at the north. Soon after passing into Tennessee, the rocks lose coarseness and within 40 miles, according to M. R. Campbell, are no longer hard enough to affect the topography; but in that interval a new sandstone, the Bonair, belonging lower in the column, is reached: fine-grained at first, it soon becomes coarse and within a few miles it is a pebbly rock, massive, 60 to 90 feet thick and containing very little clay. The rate of fall in the original stream cannot be determined as there was differential subsidence, but some conception may be gained from the thickness of deposits. The extreme along deepest part of the valley in northern Ohio is 175 feet; in southern Ohio, 310 feet remain and the original thickness was not far from 400 feet; in southern Kentucky, it was more than 1,000 and in central Tennessee not less than 1,500. The deposits are all of river origin; there is no trace of marine conditions, except at the extreme south, nor is there any evidence of shore action; the pebbles are round, not flat: proof of selective action by running water abounds along the whole course. One has here merely a subaerial valley, filled with river deposits. The main western drainage line followed the same course until late in the Athens.[15]

Roy[16] has published some notes respecting the Sharon coal bed, the first member of the Beaver formation, which show that the closing deposits of the New River had become dry land, exposed to subaerial conditions. In the Mahoning valley that coal bed occupies serpentine, usually narrow troughs, which sometimes unite, but ordinarily are separated by long intervals of barren ground. The troughs were eroded in the old plain and the separating ridges are merely planed down knolls. In some cases, the troughs were eroded in Waverly rocks, which there are largely Devonian. The lowest coal bed in Jackson county, in the southern part of the state, is

[15] This summary is based on observations by J. S. Newberry, M. C. Read, A. W. Wheat, E. B. Andrews, A. A. Wright for Ohio; A. R. Crandall, J. Lesley, G. M. Sullivan, W. M. Linney, M. R. Campbell for Kentucky; J. M. Safford, W. Hayes, M. R. Campbell for Tennessee. These are given in "Carboniferous of the Appalachian Basin," *Bull. Geol. Soc Amer.*, Vol. 15, 1904, pp. 37–210.

[16] A. Roy, "Third Annual Report of the State Mine Inspector," Columbus, 1876, pp. 129–131.

midway in the great sandstone mass filling the valley just described. It occupies a trough in that sandstone, showing that, during migrations of the stream in its valley, portions of the flood plain remained exposed long enough to permit accumulation of an important coal bed.

A valley of notable extent existed in western Pennsylvania during the early Allegheny. There is good reason for believing that it reached as far east as the border of Cambria county, but connected observations begin only in Jefferson county, somewhat more than 40 miles farther northwest; thence the course can be followed across southern Clarion, northern Armstrong, northern and western Butler into northern Beaver,—almost to the Ohio River, a distance of about 90 miles in direct line. The interval from the Vanport limestone down to the Homewood sandstone—the last member of the Beaver—is filled with coarse to pebbly sandstone in a strip, 8 to 10 miles wide, on each side of which the normal section is exposed. To trace this valley southward along the Ohio valley is not possible, as the horizon passes quickly under cover, but there are good reasons for supposing a southward extension. Borings at Wheeling, West Virginia, on the Ohio, report the interval filled with sandstone; at Moundsville, 10 miles south, a line of borings begins, which is continuous across Wetzel county of West Virginia into Greene county of Pennsylvania, in all of which sandstone fills the interval, thus indicating the existence of a long tributary from the east. It may be that the stream's course lay well west from the Ohio, nearer that of the pre-Beaver valley and that even the top member of the Beaver was invaded. Hodge reports that in Coshocton county of Ohio, a sandstone begins at 25 feet below the Vanport limestone and continues downward 280 feet to a thin coal bed resting on the New River conglomerate, thus passing through the whole of the Beaver.[17]

The portion of the column, beginning with the Vanport lime-

[17] The observations by W. G. Platt, I. C. White, H. M. Chance, J. F. Carll and J. J. Stevenson, on which this summary is based, are recorded in "Carboniferous of the Appalachian Basin," *Bull. Geol. Soc. Amer.*, Vol. 17, 1906, pp. 65–228; J. T. Hodge, Ohio Geol. Survey, Vol. III., 1878, p. 572.

stone and extending upward for 75 feet or more, tells of stream erosions in a great area. That limestone is replaced with sandstone at many places in Pennsylvania is shown by I. C. White. Grimsley[18] has described a "washout," which he observed at New Cumberland, on the Ohio River in West Virginia. It involves the Middle Kittanning coal bed and the associated rocks. The course of the "roll" is S. 30° E. The replacing sandstone is exposed along a stream near the town, where it is 1,200 feet wide. Approaching from the west, the coal is cut off, its thick underlying clay becomes sandy and the sandstone mass becomes continuous with that below the clay. This valley was filled during deposition of the sandstone which elsewhere forms the roof of the coal bed. Within the "roll," nodular and lenticular masses of coal occur along with numerous long strings, one and a half to 3 inches thick. This cut out was traced for about 2 miles.

The same horizon is marked by stream cutting in a considerable part of the Hocking Valley coal field of Ohio. The phenomena were described first by E. B. Andrews and at a later date by Orton.[19] The latter is not inclined to believe that the work was done by streams, thinking rather that it was done by the ocean.

Illustrations of similar conditions are found abundantly in coal fields elsewhere. Ashley[20] has described the "Coxville Carboniferous river" in Parke county, Indiana, a Coal Measures valley filled with sandstone. It is 600 feet broad and the sandstone is exposed to a depth of 40 feet. On each side the sandstone spreads above the exposure and is seen resting on a coal bed. At another locality, the sandstone is 180 to 190 feet thick. At Silver Island in Fountain county and elsewhere the same features are shown at this horizon. It had been suggested that these, with some others, are parts of a drainage system, but Ashley hesitated to accept this, believing that if it were true there should be evidence of greater unconformity than has been observed. He remarks, however, that

[18] G. P. Grimsley, "Clays, Limestones and Cements," West Virginia Geol. Survey, Vol. III., 1905, pp. 215, 216.

[19] E. Orton, Ohio Geol. Survey, Vol. V., 1884, pp. 936, 937.

[20] G. H. Ashley, "The Coal Deposits of Indiana," Twenty-third Ann. Rep. Indiana Geol. Survey, 1899, pp. 272, 377, 385, 386, 552, 821, 956, 1261.

an extensive uplift in the northern part of the field would be sufficient. Channels are numerous at several horizons in Indiana and some of them seem to belong to a drainage system flowing southwest, as the smaller channels enter the larger in that direction and the larger ones increase in size. Non-conformity has been observed at many horizons in Indiana.

"Washouts" receive much attention in the British coal reports. Some are of slight extent vertically, of a type which will be considered in connection with the roof of coal beds; but there are others of serious importance, resembling those already described. Strahan[21] states that in the Ebbw valley of South Wales, the Rock Yard and Three-Quarter veins have been washed out for 1,200 yards on one property, a vertical cut of not less than 110 yards. In another valley, the Rock has been removed for about a mile. Scott[22] has described an old valley or estuary due to denudation and removal of Coal Measures beds. The earlier Coal Measures were removed and others deposited in their stead. Subsequently, some of the newer beds were removed and were replaced with others, also of Coal Measures age. Prestwich,[23] who long before Scott had discussed this "Symon Fault," recognized that it differs notably from the ordinary washouts of coal and that the Lower Coal Measures had been removed from an area of great length and breadth. The work, in his opinion, may have been done by subaerial denudation or by wasting currents. Fragments of coal and associated rocks are not uncommon in the newer deposits. Geikie[24] has given among others an illustration of contemporaneous erosion observed in the Coal Measures at Sanquhar, Scotland. Respecting all, he is compelled to the conclusion, "it is evident that the erosion took place, in a general sense, during the same period with the accumulation of the strata." De la Beche, in his "Geological

[21] A. Strahan, "Geology of the South Wales Coal Field," Part II., 1900, pp. 65, 68.

[22] M. W. T. Scott, "On the Symon Fault in the Colebrook Dale Coalfield," *Quart. Journ. Geol. Soc.*, Vol. XVII., 1861, pp. 457 et seq.

[23] J. Prestwich, "Geology of Colebrook Dale," *Trans. Geol. Soc.*, II., Vol. V., Part III.; "Geology," Vol. II., 1888, pp. 98, 99.

[24] A. Geikie, "Text Book of Geology," 3d ed., 1893, p. 506.

Observer," has discussed such occurrences in detail. Green[25] described several instances seen in the Yorkshire area. The Handsworth Rock, 40 feet of sandstone, disappearing towards north and south, fills a trough eroded in shale. The great deposit, known as the Rotherham and Harthill red rock, was deposited in a valley eroded in upturned Middle Coal Measures; and the deposition was earlier than the Permian, since the red rock underlies the magnesian limestone. The little coal basin of Commentry in France shows a striking example of contemporaneous erosion, which has been exposed in cross section by two of the great quarries. Toward the close of the period of deposit, a valley was eroded in the Coal Measures. Afterwards, this was filled by successive deposition with light-colored sands and gravels. At a somewhat later date, an eruption of igneous rock in the immediate vicinity pushed these horizontal beds into a compressed, somewhat complex synclinal and folded the older beds beyond into overturned folds, while faulting the Grande Couche, to whose roof the erosion had reached.[26] The same process of erosion was repeated in later times and a newer filled-valley has been exposed during deepening of the eastern tranchée.

Contemporaneous erosion provides evidence that the rocks underwent folding during deposition of the Coal Measures. A few notes from southwestern Pennsylvania will suffice for illustration and, no doubt, they will recall to the reader instances in other localities.[27] The Washington-Brady Bend anticline is crossed by the Monongahela River at Pittsburgh and the Claysville anticline is crossed by the Ohio River at a short distance farther west, near Woods run. These folds existed in the later part of the Cone-

[25] A. H. Green, "The Geology of the Yorkshire Coalfield," London, 1878, pp. 397, 456, 481–484.

[26] J. J. Stevenson, "The Coal Basin of Commentry in Central France," *Ann. N. Y. Acad. Sci.,* Vol. XIX., 1910, pp. 198, 199. H. Fayol has presented a very different explanation of the phenomena in "Reunion extraordinaire dans l'Allier," *Bull. Soc. Geol. France,* III., Vol. XVI., separate, pp. 35–37.

[27] Second Geol. Survey Pennsylvania, Rep. K, 1876, pp. 310, 311, 324–326; Rep. KK, 1877, p. 303.

maugh and had lifted much of the region above the area of deposition. On the latter fold, a deep railway cutting shows sandstone, 25 feet thick, resting on shales with limestone. At a few rods west, the sandstone suddenly becomes 75 feet thick, replacing the underlying beds; but, within two miles, the lower part of the sandstone disappears almost abruptly and the normal section reappears. The same sandstone was seen in another section farther north, but, in that direction, the horizon soon passes into the air while southwardly it passes almost at once under cover. The rocks on each side of this valley have a dip of 80 feet per mile, whereas that of the sandstone within is but 40 feet. The crest of the Washington axis is shown well in a railway cutting. There, the shales overlying the Ames limestone, midway in the Conemaugh, come down and replace that limestone and underlying beds to an unknown distance below the roadway; but at barely half a mile the normal section is reached. This is clearly on the crest of the fold, for the Ames limestone dips in opposite directions on the sides of the shale-filled space. On the west slope of the Salzburg anticline in Westmoreland county, near Penn station, one may see an illustration of alternating erosion and deposition, in type resembling the "Symon Fault." This is in the Monongahela formation, somewhat more than 100 feet from the bottom. At the entrance to a long railway cutting, a sandstone, 60 feet thick, rests on 6 feet of irregular sandstone, containing streaks of coal. Within a few yards, 8 feet of limestone is shown under the upper sandstone but it continues for less than 20 yards and is cut off abruptly by the sandstone. In a branch cutting, the sandstone is well exposed for a short distance but is soon replaced with yellow shale, which is very local.

Aside from the continued contraction of the area of deposition, there is little evidence of great movements within the Appalachian basin. For considerable periods of time, areas of many hundreds of square miles received no deposits; the anticlines evidently were developed slowly. The Appalachian revolution apparently spent its force during Coal Measures time mostly at the east. But in Europe the Upper Carboniferous disturbances have left more noteworthy records. Barrois,[28] long ago, showed that the great movement in the Cantabrian area occurred between the Middle and the Upper Coal Measures. Douville had found evidence of similar conditions in the Rhine country and had concluded that the movement was general between Saxony and the Vosges. Barrois recognized the time as one of great denudation and reworking of materials, for the conglomerate of Tineo came partly from Carboniferous rocks. More recently, he has shown by stratigraphical and palæontological evidence that in the Nord basin there exist two anticlinals within rocks of the lower coal terrain.

Angular and rounded fragments of coal have been found in sandstone, shale, limestone and even in the coal itself; that such occurrences have an important bearing on hypotheses respecting the formation of coal beds has been patent to students everywhere but no systematic studies have been made by any except within very recent years. The conditions deserve careful consideration.

The earliest recorded observation, found by the writer, is that by Logan,[29] who referred to pebbles of coal and coal shale in the Pennant as though they were familiar objects. De la Beche speaks of them in the same way in his "Geological Observer." Some of the pebbles are 2 to 3 inches in diameter and exhibit the definite cleavage. Rounded pebbles of coal belonging to the lower series have been found in the upper—and it is certain that the coal, in some cases, was hard when removed, for at quarries in Swansea, *Sigillaria* stems show impressions of the pebbles. Jukes,[30] in discussing the evidence of unconformity between the Carboniferous and the Permian of South Staffordshire, finds additional proof in the pres-

[28] C. Barrois, "Recherches sur les terrains anciens des Asturies et de la Galice," *Mem. Soc. Geol. du Nord.*, Vol. 2, No. 1, pp. 599, 600; "Exposé de l'état des connaissances sur la structure géologique du bassin houiller dans le Département du Nord," Lille, 1909, p. 20.

[29] W. E. Logan, "On the Character of the Beds of Clay lying immediately below Coal Seams of South Wales," *Proc. Geol. Soc.*, Vol. III., 1840, p. 276.

[30] J. B. Jukes, "The South Staffordshire Coal-Field," 2d ed., 1859, p. 136.

ence of angular and rounded fragments of Coal Measures rocks with pebbles of coal in the lower part of the Permian.

Andrews[31] found in the lower part of a sandstone overlying the Nelsonville coal bed a rounded fragment of coal, measuring 4 by 2 inches. It bears so close resemblance to coal from Straitsville, only a few miles away, that he believed it derived from that place—the coal bed being the same at both localities. This great coal deposit is only 200 feet above the bottom of the Ohio Coal Measures. Andrews is convinced that the coal had been completely formed by the time that 12 feet of shale and one foot of sandstone had accumulated at Straitsville. He observed irregular fragments of coal, some angular, others rounded, in a sandstone within Wayne county of West Virginia.

Jordan[32] states that the Welsh Coal Measures are divisable into the Pennant Grit above, with few coal seams, and a lower division, mostly shale, with numerous coal seams. He found no coal pebbles in the lower division, but in the lower part of the Pennant they are present, associated with pebbles of granite. Logan's pebble of cannel was found in slate overlying a bed of ordinary coal and was supposed by him to have been derived from a bed, 2,000 feet lower in the series. Jordan objects that there is no evidence that the lower beds were upraised and denuded before deposition of the upper beds. He thinks that the pebbles were derived "either from the seam of coal above which they are found or from the destruction by erosion of a seam of coal, which once existed approximately in the position in which they are found, the erosion in either case being effected by the strong water courses which distributed the grains of sand and other material upon the coal seam." He refers to the "Rock Fawr" seam near Bridgend, where the sandstone roof contains a notable quantity of slightly rounded pebbles of coal, similar to those of the underlying seam. Logan's pebble, he thinks, came from a superficial layer of cannel in the Penslawdd seam. The

[31] E. B. Andrews, Ohio Geological Survey, Vol. I., Part I., 1873, pp. 355–357.

[32] H. K. Jordan, "On Coal Pebbles and their Derivation," *Quart. Journ. Geol. Soc.*, Vol. XXXIII., 1877, pp. 932, 933.

effects of a water current are seen in the Forest of Dean, where a coal seam, 5 to 6 feet thick, was washed out in one portion of the colliery and redeposited in another, where it is 8 to 12 feet thick. The character of the pebbles led him to the conclusion that the coal, prior to deposition of roof materials, "was to great extent consolidated though perhaps only partially indurated."

In discussing this paper, Moggridge stated his belief that the pebbles were derived from broken up coal beds, the debris being distributed in the newer deposits. There is a bed of good cannel only 4 miles from Penslawdd, so that one need not look far for the source, the more so since the cannel is at greater altitude. Morris thought the pebbles derived from one of three sources; they might be fragments of floating wood encased in sandstone and carbonized, they might come from the breaking up of submerged forests, whose fragments became embedded in sands and clays, or from the breaking up of coal beds. Jordan could not accept Moggridge's suggestion, because the present greater altitude of the cannel bed is due to late movements, or those of Morris because the pebbles are confined to sandstone roofs and are not distributed throughout the series.

It is well to introduce here, in advance, notes having some bearing on the matter in hand, though more upon another, which will be considered in connection with coal beds themselves. Stevenson[33] found coal fragments in a sandstone overlying the Pittsburgh coal bed. At one locality, the lower layers "contain lumps of coal, coarse pebbles and fragments of vegetable stems, the whole looking as though its deposition was accompanied by enough disturbance to tear off part of the old swamp. It is clear, however, that not all of the fragments found in the stratum belong to the same bed. Some of them are crushed and fractured in such manner as to show that they were consolidated before removal, while others are saucer-shaped." He thinks that the latter came from the Pittsburgh coal bed and that the others were derived from an older bed, outcropping at some distance eastward. At another locality, the derivation is

[33] Sec. Geol. Surv. Penn., Report K, 1876, pp. 90, 137, 285; Report KKK, 1878, pp. 79, 81, 87, 118.

local, for the upper division of the Pittsburgh has been removed and its fragments distributed in the overlying sandstone. The condition is in no wise unusual. In a later report, he says that the Homewood sandstone, the closing deposit of the Beaver, contains in its lower portion disks and pots of coal of shape such as one might expect where a soft mass has been entangled in sandstone and subjected to heavy pressure. At another locality, the sandstone contains coal fragments, some quite large, which he thinks represent a coal bed removed from the area during deposition of the coarse more or less pebbly rock. As that rock in this locality fills an old valley, it is possible that the larger fragments represent boggy material accumulated on undermined banks. In some places mentioned by this observer, the fragment-bearing sandstone rests on the uneroded Pittsburgh coal. In all probability, a sand-laden stream, sweeping across the area, removed part of the unconsolidated coal and carried it away to be deposited on an overflow surface along with living plants, as well as with the sand and hardened coal brought from a distance. The same observer mentions a locality, where the coal had been cut out and replaced with a confused mass of coal, slate and sandstone. I. C. White[34] has recorded several instances similar to the last, in widely separated localities, where the coal has been replaced with a conglomerate of worn and rounded pieces of limestone, coal, slate, and sandstone.

"Washouts" similarly filled have been reported by other observers in Pennsylvania and elsewhere. The conditions are precisely such as one can see in the streams now flowing across the bituminous field and the conclusion is the same in both cases—that the stream flows across the outcrops of rocks whose fragments are in its bed or in the "bottom" deposit of its banks. The Banc des Chavais in the Grande Couche of Commentry belongs to this type.

Renault[35] studied very carefully the coal pebbles found in the sandstones of the Commentry coal basin. Some resemble freshly

[34] I. C. White, Second Geol. Surv. Penn., Report Q, 1878, pp. 114, 268; Report Q2, 1879, pp. 270, 274–276; Report Q3, 1880, p. 176.

[35] B. Renault, "Quatrième note pour servir a l'histoire de la formation de la houille," *Comptes Rendus*, Vol. 99, 1884, p. 201.

broken coal, but others are pebbles with the angles rounded. Their coal differs from that of the beds in that it is less compact, absorbs water, has less brilliant fracture and can be cut more readily. It has the alternate bright and dull laminæ of ordinary coal. Apparently, the conversion was not complete when the fragments were torn away and the interrupted process was not renewed. He concludes that, during formation of the Commentry coal terrain, there were frequent erosions of the earlier beds of coal, clay and limestone; that those beds do not belong, as might be imagined, to a much older coal period; that the coal, found as pebbles, is, so to speak, less advanced, offering some properties differing from those of plant materials fully converted in place; that the time required for conversion of vegetable matter into coal, though very long, appears not to be excessive, since a coal basin of moderate size already possessed some coal, while the deposits were increasing. There can be no doubt respecting Renault's conclusion as to the source. No rocks older than Middle Coal Measures are known to exist in this basin of barely 12 square miles, which is divided by the broad dejection cone of Montassiégé, which contains no coal.

Fayol's[36] observations, recorded in his original work as well as in the résumé published in 1890, are of no slight importance in this connection. Pebbles of coal, angular or rounded, in all shapes and varying in size from mere grains to 4 decimeters, occur in all parts of the terrain within the Commentry basin. They are rare in the conglomerates but abound in the medium-grained sandstones of both les Pegauds and les Ferrieres, the coal-yielding divisions separated by the barren Montassiégé area. They are associated frequently with grains and pebbles of carbonaceous shale. The character of coal in the pebbles varies. Those in the older part of the formation are anthracite, like the adjacent coals; those in les Ferrieres are meager, as is the coal of that area; while those of les Pegauds are of flaming coal like that from the Grande Couche. So that the coals of the pebbles are like those of the immediate area. At the same time, it is all-important to note that, according to Fayol,

[36] H. Fayol, "Études sur le terrain houiller de Commentry," livre premier, *Bull. Soc. Ind. Min.*, 2me Ser., Vol. XV., 1887, pp. 140, 141.

pebbles of anthracite have been obtained near the Grande Couche and that in some pebbles the coal has the appearance as well as the composition of lignite. But these last are exceptional—they, evidently, are of the type studied by Renault. The distribution of the pebbles is absolute proof that, before the Gres Noirs coal bed was formed in its present area, not only the older rocks with anthracite, but also the Grande Couche itself and its associated beds were exposed to subaerial streams, by which the pebbles of coal and carbonaceous shale were rounded. The writer collected many of these pebbles from a sandstone at less than 60 feet above the Grande Couche.

Barrois[37] says that pebbles of coal are less numerous in the paralic basins of north France than in the limnic basins of the plateau, but he had opportunity to study some which had been discovered recently. Geologists, in the majority of cases, have believed that coal pebbles had travelled for only short distances and that they prove the process of conversion far advanced when the fragments were detached; but some, objecting to such rapidity of conversion, have preferred to believe that the fragments, when entombed, were merely rolled vegetable matter. He notes the statement respecting the Commentry pebbles, that some, at least, show contraction, evidence that the conversion was not complete. The marshes of the Pas-de-Calais, attacked by tides, give off blocks of peat, which become rounded and at length ellipsoidal. E. Geinitz has made a similar observation on the Baltic shore near Rostock. The Bruay pebbles occur in hard coarse sandstone, are from mere grains to 14 by 5 by 3 centimeters. They are chiefly cannel, at times have laminæ of brilliant coal and, under the microscope, they show vegetable structure—they recall the peat pebbles of the Pas-de-Calais. They have suffered contraction, for they are surrounded by a film of calcite which penetrates the pebbles in veinules.

As the result of his studies, Barrois has found that coal pebbles usually occur in coarse sandstones above coal beds; that they have

[37] C. Barrois, "Observations sur les galets de Cannel-coal du terrain houiller de Bruay," *Ann. Soc. Géol. du Nord.*, Vol. 37, 1908, pp. 3 et seq.

the coal of the area, not differing materially in volatile content; that they belong to some coal bed not far away, for one never finds maigre pebbles in a gras area, or the reverse; that pebbles of cannel occur more frequently than those of ordinary coal. These conditions hardly justify the supposition that the pebbles were brought by streams flowing over beds, which, already coal, alternated with shale and sandstone. The Bruay pebbles are all from one coal bed and that must have been near by. The presence of laminæ of brilliant coal in the sandstone, identical with the laminæ in the cannel, leads to the same conclusion, because in the Nord basin, as in South Wales, cannel is in the roof of the beds. When a coal bed is eroded, the cannel is the first portion to be removed, which explains the frequent occurrence of cannel pebbles in areas where that type of coal is rare. Barrois concludes that the Bruay pebbles came from one bed, in which the material was not wholly converted. The erosion occurred simultaneously over an extensive area and was due to changes in course of a stream, loaded with sediment, which inundated the bog abruptly. It must have come from a distance, for the deposit contains elements of crystalline rocks, larger and more abundant than in any other clastic deposit within the basin.

Petrascheck[38] investigated the mode of occurrence of coal pebbles in a sandstone within the Galician area. The deposit is thick, usually only moderately coarse, but in the portion carrying the pebbles it becomes irregular and conglomerate. Some fragments of coal are distinctly rolled, some have merely rounded angles, while others have the edges sharp. The minutely pitted surface of some fragments led him, at first, to imagine that they had been peat when entombed, the pitting being due to pressure by sand grains. But the conditions throughout compelled him to abandon this conception. The form and substance of the pebbles favored belief that at the time of burial the material was already hard. Glance coal breaks into angular pieces and can endure little chafing, while cannel and

[38] W. Petrascheck, "Das Vorkommen von Steinkohlengerollen in einem Karbonsandstein Galiziens," *Verhandl. k. k. Geol. Reichsant.*, 1909, Wien, 1910, pp. 380 et seq.

carbonaceous shale are rounded easily. The contrasts are shown well by fragments in this sandstone, for the glance coal is angular and the cannel rounded. Fragments of slaty coal also are rounded, but the shale portion resisted better than the coal portion and the fragments are flatter than those of cannel. The bond between coal and shale must have been, at entombment, such as is seen in slaty coal now. It might be supposed that the pebbles are buried fragments of wood; but such complete penetration of wood by shale is inconceivable; there would be, moreover, so great change in volume that the fragments could not retain their form. He is convinced that the consistency of glance on the one hand and of cannel on the other is so different as to make certain that the materials had acquired their characteristics before burial. The source of the pebbles cannot be ascertained, but they do not appear to have come from any contiguous bed, and the only suggestion possible seems to be that they have been derived from much older deposits. The features of the rock carrying the coal pebbles, especially its coarseness, in which it differs from the sandstone on each side, seem to suggest that it may occupy a valley eroded in the sandstone.

Coal pebbles are not confined to the Coal Measures. Haast[39] found them in Cretaceous sandstone of northern New Zealand and Hutton found them abundant in a conglomerate of the same age in Otago, where the rock rests on the eroded surface of a coal bed. Fragments of coal have been reported by the writer from upper Cretaceous sandstones of New Mexico and a large block of oolite coal was obtained in the chalk of Kent, England. A more curious phenomenon is the existence of apparently rolled pebbles in the coal itself. Gothan[40] states that in the Lias area of Fünfkirchen, Hungary, there is, near Vasas, abundance of "Mugelkohlen," round to ellipsoidal fragments of pure coal, embedded in almost all of the coal beds. In size they vary from nut to two fifths of a meter;

[39] J. Haast, "Report on the Geology of the Malvern Hills, Canterbury," Geol. Surv. New Zealand, 1872, pp. 50, 52, F. Hutton, "Report on the Geology and Gold Fields of Otago," Dunedin, 1875, p. 106.

[40] W. Gothan, "Untersuchungen über die Entstehung der Lias-Steinkohlenflöze bei Fünfkirchen (Pecs, Ungarn)," *Sitzungber. d. k. preus. Akad.*, Vol. VIII., 1910, pp. 136–143.

the surface is smooth, metallic and lustrous, often with a scale-like coating such as one sees on concretions. They are separated easily from the surrounding coal, to which they are not related, and they do not occur in the associated rocks. Gothan considers the various suggestions offered to explain the occurrence of these nodules, but finds them either insufficient or not in accord with the conditions. He seems to be convinced that they are pebbles, owing their rounded form to attrition. The Geological Survey collection at Berlin contains similar forms from a mine in the upper Silesian Carboniferous, where the pebbles of coal are associated with others of quartzite, granulite, etc. There and at other localities the association is evidence of transport, but, at Vasas, rock pebbles are unknown. Gothan sees no reason to suppose that they came from a distance. He conceives that they may have been formed even while the Jurassic Waldmoor existed and that wind-moved water may have detached pieces of the harder peat. The more resistant portions of those pieces would be rubbed against each other until rounded and eventually they would sink into the peaty mud. These "balls" occur elsewhere. Hughes found[41] balls of very pure coal enclosed in coal beds in India and Stainier reports that at Turon in Asturia there is a bed formed wholly of rolled pebbles of coal; he mentions two localities in Australia, where coal pebbles are embedded in coal of notably different composition and states that such pebbles occur in the coal basins of Mons and Charleroi, Belgium.

These citations suffice to illustrate the varying conditions in which coal pebbles or fragments occur in clastic rocks or even in coal beds themselves. Gothan's explanation for existence of balls in coal may account for origin of the material. A broad stream meandering through a deep bog might easily tear off small fragments, as supposed by him, but even then the necessity for transport remains, since there could be no sufficient chafing in quiet or gently moving water. In all other cases, the transportation is clear.

[41] T. Hughes, "The Jherria Coalfield," Mem. Geol. Surv. India, Vol. V., pp. 254–256; X. Stainier, "Des rapports entre la composition des charbons et leurs conditions de gisement," *Ann. des Mines de Belgique,* Vol. V., 1900, pp. 95–97.

In some instances, the distance was small or the detached pieces were enveloped in sands and swept along as part of the mass to the place of deposition. This was evidently the condition where one finds irregular chunks and petty lentils of coal as in the sandstones of western Pennsylvania and at many places in other coal fields. These masses, torn off by a sand-laden stream, were transported without material attrition and were deposited where the speed slackened on an overflow surface. It must be noted that one rarely finds such masses in localities where the underlying coal bed shows evidence of erosion; very often the sandstone with coal fragments rests on an uneroded coal bed; while in very many cases the sandstone resting on a bed with channeled top is wholly without noteworthy fragments. The channel was dug in the vegetable material and was filled with sand of later arrival. It is difficult to conceive how material torn from a bed could be deposited over or very near the place of origin, unless one imagine a whirlpool of modest area; but it is easy to understand how a sand-laden stream flowing irregularly across a plain, covered with a thin marsh, could remove the cover and deposit it elsewhere. That condition is approached in considerable areas by streams like those of the Paraguayan region, where the channels are aggraded quickly in flood time and the turbid waters are driven to seek new courses.

But if the coal fragments be rounded, they point to conditions wholly different from those just considered. In the summary of observations given above, there are references to the process of conversion and to the time required for its completion. Those topics lie, for the most part, outside of the question in hand and are related to it only incidentally; but the structure and composition of coal in the pebbles make certain that it was already well advanced in conversion when removed from the bed. The Commentry pebbles in some cases were already anthracite while others, those from the Grande Couche, were still flaming coal; for both types are found in the same sandstone—that above the Grande Couche—and, along with them, are thoroughly rounded pebbles of carbonaceous shale.

In not a few localities the pebbles are cannel and they have been regarded as derived from the cannel bench of an underlying bed. That cannel pebbles should retain their shape and size better than those of glance coal is normal, because cannel is tough and glance is brittle; but there is no reason to suppose that sapropelic muds became hard and resistant with great speed while the underlying felted peaty materials became compacted slowly. It would seem more probable that cannel pebbles are more numerous because cannel survived the shocks of transport and the glance coal was reduced to minute grains. The evidence that the pebbles have undergone much change since entombment seems to be slight and of hardly material importance. The writer, during a second visit to Commentry in 1910, examined very closely more than 100 coal pebbles scattered through the sandstone up to 60 feet above the Grande Couche. In only two, possibly three, was there appearance of contraction. Almost without exception, the pebbles were coated by a thin film of clay, such as commonly covers, in whole or in part, coal fragments on beds of actual streams in the Appalachian basin. This mud-coat, by drying, might leave a space in which a film of calcite could be deposited; but, aided by strong pocket-glass, the writer could find no evidence of contraction in the pebbles. There had certainly been no change after the sandstone was compacted. Fracture planes are rarely seen but, in very many pebbles, the typical cleavage is distinct. The pebbles of shale are not clay balls; they are fragments of laminated shale. In any event, the form of the pebbles, shale and coal alike, is that due to stream transport. Some indeed are flattened like coast shingle, but that is due merely to the original form, a block with laminated structure. Every feature of these pebbles appears abundantly on the beds of streams flowing across the Pittsburgh coal area of southwestern Pennsylvania. They leave no possible room for doubt that the coal fragments, like those of sandstone and shale, were deposited by streams flowing over outcrops of coal, shale and sandstone.

In the larger areas, pebbles are not distributed indiscriminately throughout the mass of sandstone or shale; they are localized. Petrascheck's descriptions as well as those of the Silesian area by Gothan recall the conditions observed in western Pennsylvania but they seem to be in channels within sandstone, whereas those of Pennsylvania are channels within coal beds. The coal pebbles in the latter localities could not have come from the enclosing coal; all of them, coal, sandstone, shale, limestone, are rounded as by stream transport and the rounding is such that they must have been brought from a considerable distance. Everything about these pebbles of coal indicates that, during much of Coal Measures time, a considerable part of the area of deposition was land, showing outcrops of the various types of Carboniferous deposits, whence flowing streams gathered their loads of detritus. With varying conditions, streams shifted their courses or washed down the materials accumulated on their beds to fill the lower reaches of their channelways.

The phenomena of non-conformity and of contemporaneous erosion compose a body of evidence that throughout the Pennsylvanian the progress of events was like that in previous and in succeeding periods of the world's history; there were foldings of the crust, there were differential elevations and subsidences and at all times much of the region was exposed to subaerial erosion.

The Distribution of Sedimentary Rocks.

The Coal Measures rocks are sandstones, shales, limestones and coals, the terms being employed in the broad sense. All occur in each of the great eras and limestone seems to be wanting in only the Pocahontas or earliest stage of the Pottsville. An understanding of the geographical distribution and structural variations of these rocks should give some insight into the conditions prevailing at the time of their deposition; but determination cannot be complete, as erosion has removed the beds from a broad strip on the eastern border between the anthracite fields of Pennsylvania at the north and the Alabama line at the south. Beyond the latter, one finds on the eastern side only Pottsville beds; later formations are unrepresented; it is more than possible that they never were represented.

Pocahontas deposits occupied an area on the eastern side, very narrow at first but widening gradually toward the west until the close of the stage, attaining the greatest width near the Tennessee-Virginia line. Whether or not they extended across Tennessee into Alabama cannot be determined by the stratigrapher, the palæobotanist must answer the question; but one can hardly resist the *a priori* conclusion, whatever that may be worth, that the Pocahontas did extend across Alabama and around to the southwestern outlet, as no outlet westward for the waters of the eastern valley appears in Virginia and Tennessee, and there seems to be not the slightest reason for supposing an eastern outlet anywhere to the Atlantic. The New River area is much greater, embracing the southern and middle anthracite fields at the north, where the western limit is well defined. In the bituminous region, the eastern outcrop is continuous from the northern limit in West Virginia into Alabama, where the formation is recognizable throughout the whole field; northward, on the westerly side of Alleghania, it occupies a broad area to the northern border of Kentucky whence it extends in a narrow strip almost to Lake Erie. The Beaver, at its close, evidently covered the whole basin from the northern border southward to central Tennessee; beyond that line it has been removed by erosion for about 75 miles and it is not reached again until one is well south from the northern line of Alabama. The stratigrapher cannot make correlation of horizons there, but the presence of Beaver seems established beyond doubt.

The formations of the Athens are recognizable in the anthracite fields as well as throughout the bituminous region southward into Kentucky and West Virginia; how extensively they were represented in Tennessee is undetermined. The Wheeling and Dunkard deposits, of less original extent and confined to the northern part of the bituminous region, can be studied not only by means of the many recorded exposed sections, but also by means of many hundreds of oil-well records, which make clear the conditions as they existed in the deeper portions of the region.

The Sandstones.—Stratigraphers have asserted many times that sandstones are of very little worth as horizons. It is true that those deposits exhibit abrupt changes in structure and composition, both laterally and vertically; and it is equally true that, in not a few cases, sandstones, due to filling of valleys and occupying restricted areas, may be misleading. Yet examination of broad areas proves that many sandstones are of great geographical extent, though often interrupted and sometimes assuming the form of immense lentils embedded in shale. In a general way, one may consider the variations as alike in all; at one locality, the mass may be fine, coarse or even pebbly to conglomerate in its different layers; at another, it may be wholly fine, coarse or pebbly; while at a third, it may be represented by more or less argillaceous shale. It may be massive, irregularly bedded or shaly and the change in structure or composition may be abrupt or almost imperceptible. There would appear to be no system in these variations; yet it may prove worth the pains to seek some explanation of the conditions, for though the quest may fail of complete success, one is likely to gather suggestions by the way, which may prove of service in other directions. Four sandstones have been selected for study: Bonair of the New River, Homewood of the Beaver, Pittsburgh of the Monongahela and Waynesburg of the Washington. But in considering these, one must make comparison with others.

The Bonair sandstone of M. R. Campbell, midway in the New River formation, can be followed from its northern termination in West Virginia, along the eastern outcrop, and from northern Tennessee, on the western, almost continuously into the southeastern basins of Alabama. The eastern and western prongs on the sides of Alleghania unite across that old ridge in central Tennessee, whence the rock spreads as a sheet throughout the coal area of southern Tennessee and of Alabama. The northern limit on the western side, in the Ohio basin of Schuchert, is very near the northern line of Tennessee where it is without pebbles; but within less than 20 miles southward it becomes notably a pebble rock; at 12 miles east from the latter place it is described as 55 feet of "conglomerate and sand stone" and a similar description is given for a section at 25 miles south from the last; but at 25 miles south-southwest, the Bonair is a mass of conglomerate with shale, and the rock is still coarser at a few miles southeast, on the eastern outcrop near the Alabama line. At a few places, the western outcrop swings several miles toward the west, approaching the border of deposit, and shows another type of change. In Putnam county, the sandstone is very thin, with an unusual thickness of shale above and below it, the greater part of the mass having been replaced with shale; in Warren county, pebbles seem to be wanting and the rock is merely a cross-bedded sandstone. Where the mass passes under cover on the east side of this area, it is much less coarse than along the outcrop line.[42]

On the eastern side of the coal area in Tennessee, the Bonair is largely pebble rock near the Alabama line, but at 20 miles north, it is sandstone, 65 to 75 feet thick, and this is its character for several miles. But, at 32 miles from the Alabama line, it is a mass of "conglomerate and massive sandstone," a condition prevailing northward at all exposures for about 30 miles; but, thence until near the Virginia line, the sections show only sandstone with some shale, there being apparently no pebble rock. The outcrop on this side trends considerably east of north, so that, near the Virginia line, one is 75 miles away from the western outcrop; yet the rock is without pebbles, whereas on the western side, in the Ohio basin, it is coarse and pebbly. The probable equivalent in southwest Virginia is for the most part loosely cemented sandstone with shale, changing to shaly sandstone toward the west but becoming a great sandstone with some pebbles at a few miles farther along the extreme easterly outcrop. Beyond New River in West Virginia, the Bonair horizon has been recognized for about 40 miles; ordinarily the rock is merely a sandstone, but, toward the northern termination, the outcrop is carried eastward and, at the extreme exposure, one finds the rock very coarse with quartz pebbles abundant and at times with diameter of 2 inches. Westwardly it decreases rapidly and within a few miles thins out against the slope of Alleghania.[43]

Returning to the south and going southeastwardly in Alabama, one finds striking changes in the Bonair. In that state are several troughs, separated by narrow intervals and lying southeast from the continuous area, followed thus far, while that area extends unbroken

[42] This summary is based on observations by J. M. Safford, C. W. Hayes, M. R. Campbell, recorded in "Carboniferous of the Appalachian Basin," *Bull. Geol. Soc. Amer.*, Vol. 15, 1904, pp. 114–126, 136–146.

[43] For the observations of Campbell, Hayes, F. H. Bradley, Safford, I. C. White and Stevenson, see *Bull. Geol. Soc. Amer.*, as above, pp. 136–190.

into the Warrior coal field. Raccoon mountain, a prong from the continuous area, shows on its westerly side the Bonair sandstone, 30 to 50 feet thick and in great part pebbly; but on the easterly side the thickness is 75 to 80 feet and the rock is almost wholly pebbles. On Blount mountain, the southern prolongation of the east side of Raccoon, the mass thickens southwardly along the strike to 100 and finally, as estimated, to 500 feet. It is not pebbly throughout, but in portions where conglomerate prevails, the pebbles are not cemented firmly. In the small Lookout area, the Bonair is 50 to 60 feet thick and very coarse near the Georgia line, but at 10 miles southwardly it is a moderately coarse sandstone. The Cahaba basin is only a short distance southeast from the strike-line of the Lookout, but the interval sufficed for great change and the Bonair horizon is marked by more than 600 feet of conglomerate, sandstone and gritty shales; while in the Coosa field, only a few miles farther southeast, the rock is coarse conglomerate about 500 feet thick. The Lookout area, at the Tennessee line, is barely 30 miles from the present border of Archæan and the Coosa area is several miles nearer. The latter is not more than 30 miles from Raccoon mountain in direction of dip. The rock is coarsest in Coosa, less so in Cahaba, less in Blount and still less in Raccoon; in the Warrior basin beyond, one finds the Bonair persistent almost to the western boundary of Alabama, but losing its coarseness and at length replaced more or less with shale.[44]

Certain features of the Bonair should be emphasized. Where the western border of its area is approached in Alabama and at a few localities in central and northern Tennessee, the rock is less thick, with few pebbles, a more or less cross-bedded sandstone, at times replaced in part with shale. Along the western outcrop in Tennessee, aside from the extreme western localities, the rock consists, in considerable spaces, very largely of pebbles, while in other and intervening considerable spaces, it is merely a sandstone with layers of pebbly rock varying in number and thickness in different localities. And this condition exists where the Bonair passes under cover toward the east, as also where the equivalent area is cut by

[44] For the observations by H. McCalley, A. M. Gibson, Safford, Hayes and J. Squire, see as above, pp. 126–136.

the outcrop farther south. But where the horizon is exposed on the eastern outcrop near the Alabama line, and thence northward for miles the rock is pebbly with layers of conglomerate: while farther north, for an equally long distance, the rock is sandstone, rarely containing conglomerate layers but not unfrequently layers of shale. It must be noted that spaces in which conglomerate features prevail throughout the mass appear, from the descriptions, to be narrow and that bands of conglomerate pass out from them into the sandstone on both sides. At times the conglomerate is as a lentil in the sandstone. The features are the same in the southeastern basins of Alabama, for there the conglomerate shows vertical as well as horizontal passage into finer material.

The other great sandstones of the New River show similar variations, but conditions in successive beds are rarely the same in any locality. The Etna sandstone, below the Bonair, can be recognized in an almost equally great area; it varies in texture as does the upper sandstone; but it is often comparatively fine-grained and without pebbles where the Bonair is very coarse, and very coarse where the Bonair is not coarse. The sandstones were formed after the same manner, though the local conditions varied.

The Homewood sandstone of I. C. White is the closing deposit of the Pottsville, apparently the first bed to cover the whole extent of Alleghania. It was recognized in the anthracite fields by its lithological character and the identification was made complete by D. White's study of the plants, which proves that it underlies the first beds carrying an Allegheny flora. It can be followed in the bituminous region from northwestern Pennsylvania into northern Tennessee, beyond which to central Alabama it has been removed by erosion. Its equivalent in Alabama has not been determined.

The Homewood is, for the most part, a coarse conglomerate in the southern and middle anthracite fields, becoming less coarse in the latter, but even there containing pebbles up to the size of a hen's egg. The coarseness decreases in the northern field and at the easterly end the deposit is a sandstone with layers of "pea conglomerate." The small Broad Top area, which may be regarded as on the line of strike with the northern field, shows only a moderately coarse sandstone with occasional pebbles, rarely one half inch in diameter.

Some insignificant fragments, containing a score or two of square miles, remain, at the northwest, between the northern field and the bituminous region. In those, the rock is for the most part a massive conglomerate, with occasional fragments as large as a walnut, but there is little of fine material, showing marked selection by the depositing agent. Along the Allegheny front, the Homewood is by no means a coarse rock at the north in Clinton but in Center, the next county south, it has one part exceedingly coarse, with mostly quartz pebbles, at times as large as a hen's egg. In Blair, no pebbles are reported but in Bedford there are some pebbly layers; thence southward to the Potomac, it seems to be merely a massive sandstone. The only unexpected feature here is the presence of large pebbles in Center county.

This sandstone is exposed frequently in a strip, 75 miles wide, west from the Allegheny crest. On the northern border in Bradford county, it contains occasional layers of pea conglomerate, but those disappear quickly toward the west so that pebbles are few in the adjoining county. Southward to the Conemaugh River, half way to the southern boundary of the state, there is at most localities only sandstone, sometimes broken by shales; but in Clearfield county, midway in this strip, and just west from the Center county area, very coarse rock is reported at this horizon, there being layers of conglomerate with quartz pebbles often as large as a hen's egg. The deposit is in an irregular narrow space, extending half way across the county and the coarse material is wanting on the western border. This marks the eroded crest of Alleghania and the Homewood rests on what seems to be the Logan or lowest deposit of the Mississippian. South from the Conemaugh, the Homewood is variable: at one locality it has 70 feet of sandstone while at 4 miles away the interval is filled almost wholly by shale. But for the most part, from the Conemaugh to the Baltimore and Ohio railroad in West Virginia, the rock is a moderately coarse sandstone with occasional pebbles, seldom larger than a pea.

Farther west in Pennsylvania, the Homewood is sandstone at all localities along the northern border, varying in thickness from 15 to 70 feet at expense of underlying beds. Pebbly layers occur at times but the pebbles are small; southward, in Clarion and

Venango, it is coarse to somewhat pebbly sandstone at some localities but shaly at others; there, as in northern Butler, it varies from 15 to 80 feet, always at expense of underlying beds. In Mercer it is from 70 to 30 feet, being thickest at the north where it varies from good building stone to pebbly rock, while farther south in Lawrence the horizon is marked by shale to coarse pebbly rock, but in most of the county it seems to be represented by fine material. This is within the drift covered area and the exposures are not sufficient for determining the relations of the pebbly areas.[45]

The change beginning in western Pennsylvania becomes very marked in Ohio. Along the northern and western outcrop the deposit is wholly indefinite, being mostly shale, sandy to argillaceous, with occasionally some shaly sandstone. So great is the contrast between these and the eastern conditions, that for a generation the relations between the Ohio and the Pennsylvania Measures were ground for very serious dispute. The Homewood is nowhere in Ohio an important member of the section. In Kentucky the interval is filled with characterless shale and sandstone. In northern Tennessee, the section extends to and above the Homewood horizon and without doubt one of the important sandstones is equivalent to the Homewood. On the eastern side in Virginia and West Virginia, the horizon is distinct, though at some localities, north from New River in the latter state, one cannot differentiate the Homewood from underlying beds. But the rock underlying the Allegheny flora is usually a well-marked sandstone for at least 40 miles north from that river; there, however, the outcrop turns toward the east and the rock becomes pebbly. In Tucker county, the last eastward exposure shows 55 feet of rock, the lower portion for 40 feet being massive conglomerate. Westwardly from the outcrop, the rock rapidly becomes less coarse and, within a score of miles, it is shaly sandstone or shale.

The Homewood is buried deeply in the greater part of West Virginia, north from the Kanawha River, as well as in eastern Ohio

[45] The observations by F. Platt, W. G. Platt, I. C. White, H. M. Chance, E. V. d'Invilliers and Stevenson are recorded in "Carboniferous of the Appalachian Basin," as above, pp. 42–70. The reader will find an admirable summary of earlier observations by H. D. Rogers, J. D. Whelpley, R. M. S. Jackson, P. W. Shaeffer and J. P. Lesley in H. D. Rogers's "The Geology of Pennsylvania," 1858, Vol. II., pp. 21–26.

and southwestern Pennsylvania. For that area one can depend only on the series of oil-well records, chiefly those collected and collated by I. C. White. Where exposed along the eastern and southern border in West Virginia, the horizon is marked usually by a sandstone, seldom very coarse and sometimes shaly. In the interior or deep part of the basin, where the coal beds are indefinite, it is not always easy to carry the section, though the drillers find no difficulty in identifying the horizon. At the north, in the "Panhandle," the Homewood seems to be represented in most cases by shale, sandstone occurring, for the most part, as filling valleys. So also in Washington of Pennsylvania and Wetzel of West Virginia the interval is frequently filled with shale. The horizon is indefinite throughout; in many records it is marked by sandstone, in many others by shale. There is no room for doubt that, in considerable spaces, sandy shale was consolidated into sandstone: but careful tabulation has convinced the writer that, in not a few of the long lines of records reporting sandstone, one has merely the records of subaerial valleys eroded not long before or after the close of the Beaver.

The Homewood material came from all sides of the basin. On the eastern side, the quartz pebbles from the old Appalachian land decrease rapidly in size westward; the strip of coarse rock in Center and Clearfield counties of Pennsylvania with possibly related patches in Jefferson and Elk counties as well as a similar strip near the northern outcrop may be records of valleys heading east from the present Allegheny front. The materials at the west came clearly from the low slopes of Cincinnatia and from the north. The very marked variations in thickness, always at the expense of underlying beds, leads one to suppose that the irregular crustal movements, so characteristic of the Allegheny, had already begun.

The Allegheny was a time of great irregularity of deposition, there being abundant evidence of subaerial erosion at many places and at different horizons; and the old valleys have been filled, in most instances, with more or less pebbly sandstone. At the southeast the formation is marked by coarse massive sandstones extending into the Conemaugh, which cross West Virginia in southwest direction; but they lose their coarseness quickly toward the northwest. The sandstones of this formation as well as those of the Conemaugh become less important in Ohio, where occasionally they contain some small pebbles.

The Pittsburgh sandstone of H. D. Rogers, the first great inorganic deposit of the Monongahela, is separated from the underlying Pittsburgh coal bed by a shale varying much in thickness—often wanting. The distribution and characteristics of this sandstone show that great changes had taken place since the close of the Beaver, even since the close of the Allegheny. The area as it now exists is restricted to the southwest corner of Pennsylvania, a narrow strip of eastern Ohio and north central West Virginia. Outliers in synclinals at the east as far as the Potomac area of Maryland and West Virginia may be regarded as evidence that the eastern border of the deposit was not more than 75 miles west from the Archæan of Appalachia.

The horizon is marked by shaly sandstone and sandy shale in the outliers, but when one, going westward, reaches the continuous area in Westmoreland and Fayette of Pennsylvania, he finds commonly a hard massive sandstone, occasionally changing into shaly sandstone. I. C. White has followed this in West Virginia to the Kanawha River and thence along the southern outcrop into Ohio. There, as in Pennsylvania, the rock is often coarse, at times forms cliffs, is feldspathic, seldom pebbly, except at the southwest, and the pebbles are always small. Within little more than a score of miles from the eastern outcrop this rock disappears, permitting, in southern Pennsylvania and adjacent part of West Virginia, the Redstone limestone to rest on the shale overlying the Pittsburgh coal. The change is very abrupt. At Morgantown, West Virginia, this sandstone, 40 feet thick on the east side of the Monongahela River, is absent on the west side and its interval has disappeared from the section. In Pennsylvania, this sandstone extends southwardly from the northern outcrop 60 or 70 miles but it thins westwardly so that in the West Virginia "Panhandle" it is absent. Its continuity along the northern outcrop is broken and a gap of perhaps 25 miles is in the panhandle and Jefferson county of Ohio, but the rock reappears in Harrison county of the latter state, where it is 40 to 70 feet thick. Thence it has been followed to southern Ohio, where it is continuous with the southern border as determined by I. C. White in West Virginia.

Whether or not the sandstone existed in the northern area, where no trace remains, cannot be determined. Erosion has removed the whole section in the space where the sandstone should be present; but it seems probable that the sandstone was not wholly continuous, as an outlying exposure in Jefferson county of Ohio shows only shale. Aside from this gap at the northwest, the sandstone is practically continuous around the whole Monongahela area; it is often coarse, sometimes shaly, at others massive, is seldom pebbly, except at the southwest, where it has conglomerate layers with pebbles up to an inch in diameter; occasionally it is replaced with sandy, even argillaceous shale. It thins away rapidly toward the center of the area; well records in the deeper part of West Virginia frequently note sandy shale or sandstone, just above the Pittsburgh coal bed, but, in view of the disappearance of the deposit at the border of the area, these occurrences cannot be taken as its equivalent.

The material came from all sides of the basin, as is clear from the distribution, but on the western and southwestern outcrop the rock is coarse, at times even conglomerate, whereas the earlier sandstones are fine grained. If the conglomeratic sandstones at top of the New River were exposed to erosion at this time, one would have no difficulty in determining the source of the material. That those sandstones were exposed appears the more probable when one considers that the area of deposition had become greatly restricted. The coarse rocks of the Logan in southern Ohio, long exposed, may have yielded some of the material, but Hyde's description of those deposits makes clear that they were not the source of the larger pebbles. The character of the material along the eastern outcrop suggests that it had come from a distance and had been rehandled many times.

The higher sandstones of the Monongahela in Pennsylvania are mostly of small areal extent and are present for the most part on the borders of the Monongahela area; but in West Virginia they are thicker and more extended. Yet there as in Pennsylvania they decrease toward the center of the area and are replaced with finer deposits.

The Waynesburg sandstone, separated by a thin deposit of shale from the underlying Waynesburg coal bed, is the first important member of the Washington formation.

This sandstone was not seen in the Broad Top basin of Pennsylvania but it is present and 45 feet thick in the Potomac region of western Maryland. The horizon is not reached in other outlying patches of the higher coals and only occasional fragments remain on the extreme east side of the continuous Washington area. These, separated by intervals of several miles, consist of coarse sandstone containing pebbles of small size, scattered irregularly throughout the mass. At six or eight miles farther west, the rock is continuous. At the northern outcrop it is from 25 to 50 feet thick, consisting of sandy shale to laminated sometimes massive sandstone; thence to the West Virginia line the same character persists, though the lower part tends to become massive and the thickness increases at times to 75 feet, but not at expense of underlying deposits. Oil well records show that in the extreme southwest corner of Pennsylvania this "Bluff Sand" of the drillers persists with thickness of 55 to 65 feet. Westwardly into the West Virginia panhandle the deposit is somewhat thinner, less well consolidated, while the lower portion occasionally contains pebbly layers. Southwardly in West Virginia, I. C. White has followed the Waynesburg sandstone along the eastern and southern outcrop into Ohio. It is 50 to 75 feet thick and for long distances forms rugged cliffs. At the southeast, on the Pocatalico River, he found it massive, very coarse and pebbly. In the interior of West Virginia, this sandstone is persistent in all well records southward to some distance beyond the Baltimore and Ohio main line and westward to the middle line of Doddridge and Wetzel counties. Farther west, it is seldom enough consolidated to be called "sandstone" in the drillers' record. Farther south, the records can hardly be compared; typical horizons are lacking in a considerable area and the region is marked by notable irregularity in intervals.

Following the northern border, one finds this sandstone 50 feet thick in Jefferson, Harrison and Belmont counties of Ohio and it is persistent thence along the western outcrop. In Morgan county it contains layers of pebble rock; in western Washington it is 50 feet of sandstone with no pebbles reported, while in the southeastern part of that county a massive pebble rock extends at times to almost 100 feet above the Waynesburg coal bed. Within the oil region of the same county the Waynesburg is represented by 28 feet of pebble-rock. In Athens and Meigs it is a coarse sandstone, at times a pebble-rock in the latter county, where it becomes continuous with the southern outcrop in West Virginia.

The Waynesburg sandstone can be traced almost uninterruptedly around the Washington area; it extends many miles farther south and west into the interior than does the Pittsburgh sandstone; on the western outcrop it is coarser than that deposit and shows the pebbly layers much farther northward, while it extends many miles farther eastward. The north-south area, in which it is not recognizable distinctly by comparison of drillers' records, is not more than 50 miles wide and 100 miles long. The rock varies in structure, often abruptly, so that within a very short distance the topography may change from rude to gentle outlines; but the variations are like those of other sandstones. The conglomerate bands and occasional areas of conglomerate rock on the western outcrop indicate that the source of the Pittsburgh pebbles had become more available. The presence of conglomerate and very coarse sandstone at Pocatalico on the southeast outcrop certainly indicates a source of pebbles not far away, but the occurrence may indicate also a buried valley.

The higher sandstones of the Washington are very indefinite at the north, where the changes are so frequent that the beds must be taken as lentils of no great extent; but the Marietta sandstones of I. C. White are in the southwestern part of the area, where, in earlier times, only irregular deposits existed. This group was named because quarried near Marietta on the Ohio River in Washington county of Ohio; but it is recognizable for scores of miles in each direction within the Central area, where red shales are the striking feature, where the earlier sandstones have disappeared to be replaced with the red shale containing lentils of sandstone. They indicate extensive exposures of coarse rock at the southwest and west.

Sandstones of the Greene or closing formation of the Pennsylvanian tell even more clearly of the changing conditions. The great Fish Creek and Gilmore sandstones near the top of the formation occupy the middle line of the area from their northern outcrop to their last exposure in West Virginia. They are coarse, loosely cemented and weather into caverns. The area in which they remain is too narrow to afford information respecting the local conditions of deposit. Their presence along the middle line of the area, where the lower formations have little aside from fine materials, marks the approaching close of deposition in the Appalachian basin.

It is evident that the materials for these sandstones had not a common source. The Bonair, east from Alleghania, received its sand and pebbles from the east, from Appalachia; it becomes less coarse as it approaches Alleghania but beyond that ridge it is again coarse, even pebbly. The sands and pebbles of this western prong must have come from the north as did those of the still newer beds of the New River. The Homewood like the Bonair is very coarse in eastern parts of the basin but the pebbles decrease in size as well as number toward the northwest. But in much of western Pennsylvania, the rock is coarse and more or less pebbly. Here again one must look to the north for the source of coarse material; none could come even from the line of the present Allegheny mountains, for there the rock is without coarse elements except along narrow easterly-westerly lines, marking filled valleys, cut probably in the sandstone itself. The fine sands and argillaceous shales, so commonly marking the horizon in Ohio, point unmistakably to the low Cincinnatia at the west as their place of origin. The sandstones of the higher formations extend successively farther toward the interior of the area of deposit, and for the most part become coarser and less firmly cemented as one ascends in the series. The area of deposit was contracting throughout and elevation along the borders permitted the streams to cut down to the coarse beds of earlier formation.

The abrupt variations in structure and composition, laterally and vertically, seem to find explanation in the phenomena of actual river deposits. River phenomena are distinct in the Bonair west from Alleghania. Along the middle line of the old channel way the rock is coarse, usually with abundant pebbles of considerable size, but on each side the coarseness diminishes so that, at the east, one finds sandstone with pebbly layers and, at the west, merely cross-bedded sandstone with shale. Where the sandstones extend over broad areas, the conditions are less quickly apparent; but the channel-ways of streams across the often flooded plains are marked by the lines of coarse materials, while the migrations of those streams are recorded in pebbly bands at various levels, now on one, now on the other side of the more or less persistent channel-way. The form of the pebbles and of the sand grains is that due to the action of running water; the remarkable freedom from argillaceous matter characterizing so many sandstones and conglomerates could be brought about only by running water supplemented, perhaps, by the winds.

Other features of the sandstones deserve consideration.

Tree-trunks have been observed in sandstones of all ages since the Devonian. Long ago J. Hall found fragmentary stems in the Devonian of New York; Dawson reported them from rocks of the same age in Canada; Sherwood saw them in northern Pennsylvania and Newberry described forms from the Lower Devonian of Ohio. Such stems are not rare in the Upper Pocono (Logan) of Pennsylvania; they have been reported from the New River beds of Ohio, the Beaver beds of Pennsylvania, Ohio and West Virginia; the Millstone Grit of New Brunswick; the Allegheny beds of Pennsylvania and West Virginia and occasionally from sandstones of higher formations. They are characteristic of Carboniferous sandstones in other areas as well as of those of other times.[46]

In fine grained sandstones one usually finds only small pieces and comminuted fragments of wood but occasionally a large almost uninjured stem has been found, resembling those sometimes dropped on overflow plains by receding floods. Large trunks are not reported from many localities but they have been seen most frequently in coarse sandstones. Hildreth saw some more than 30 feet long in a Beaver sandstone on the Kanawha River; another stem, in

[46] S. P. Hildreth, *Amer. Jour. Sci.*, Vol. XXIX., pp. 22, 37, 73, 76, 107; L. Lesquereux, Geology of Pennsylvania, 1858, Vol. II., p. 840; F. Platt, Sec. Geol. Surv. Penn., Rep. H, 1874, p. 23; A. Sherwood, ibid., Rep. G, 1878, pp. 21, 38–40; I. C. White, ibid., Rep. Q, 1878, p. 203; Rep. Q2, 1879, p. 137; U. S. Geog. Surv. W. of 100th Mer., Vol. III., Supp. 1881, p. 196.

probably an Allegheny sandstone on the same river, was not less than 50 feet long. As a rule, the fragments mentioned by observers are much smaller, rarely exceeding 7 or 8 feet; they are broken at the ends, without trace of root or branch; some appear to have retained their bark when entombed, but, in a great proportion of the instances, the rock contains indeterminate casts of the stem with scattered impressions of the bark. The battered fragments are unquestionably those of floating wood which had long endured exposure, while those which show no injury, aside from loss of roots and branches, were probably prostrate stems carried from a flooded plain. There seems to be no general distribution of stems in any sandstone; in each case the occurrence is noted by the observer as an interesting local phenomenon. If the materials had been carried out to a great basin, where the plant remains could float until water-logged, there would have been a general distribution over a wide area, such as that described by A. Agassiz as existing off the coast of Lower California and in the Caribbean; but the condition is wholly different in the Coal Measures sandstones and bears close resemblance to that observed in the rivers of this day, where logs and undermined trees are stranded on the banks or on gravelly islands to be attacked by successive floods and, after removal of the fragile portions, to be buried in the accumulating deposits.

The less injured fragments, retaining the bark, differ much from those found in coal beds in that commonly they are but slightly deformed by pressure—and this in spite of the fact that ordinarily they are merely casts surrounded by brilliant coal from the bark. Prostrate trunks in coal beds are flattened, while stumps in the coal retain the wood, converted into mineral charcoal and surrounded by the brilliant coal. It may be that the uncompressed stems were those thrown upon sandy bars to decay slowly and to have the interior replaced with sand, while the battered fragments may have remained long above reach of ordinary floods, to be swept away only after loss of the interior. But in any event, one must recognize that the small quantity of the wood found in sandstones is a very important matter; the sandstones and conglomerates mark times when activity of denuding agencies was greatly increased, when the destructive effect of floods upon vegetation ought to be most marked.

Surface features of sandstones received little attention from earlier observers in the Appalachian basin. Ripple marks, sun cracks and rain prints seem to have been regarded as mere commonplaces and the recorded observations are merely incidental. Observers in recent years have recognized the importance of these surface markings.

The ripple or wave marks on some Silurian sandstones attracted attention long ago, as they are exposed in broad spaces and, for the same reason, occasional references are to be found to similar markings on some Devonian beds. The earliest note respecting their occurrence in Carboniferous rocks in that by Rogers,[47] who says of the sandstones of Formation X that "beautiful ripple markings are often met with on the surface of the large slabs of the finer of these sandstones." This formation is equivalent to the Upper Pocono of Pennsylvania; and the observation is important because it was made in the area where the earliest coal beds were formed. The rocks are in the lowest division of the Mississippian or Lower Carboniferous.

H. D. Rogers, J. P. Lesley, B. Halberstadt and G. P. Grimsley have recorded observations of wave marks and mud cracks in the Mauch Chunk of Pennsylvania and West Virginia; and J. Barrell has discussed their importance in a memoir to which reference will be made on another page.

Scattered observations show that such surface markings are of common occurrence in Pottsville rocks.[48] Smith obtained a fine slab of sun-cracked sandstone of New River age near Huntsville, Alabama; Ashley reports sun cracks in New River sandstones of

[47] W. B. Rogers, "Report of the Geological Survey of the State of Virginia for 1837," reprint, Boston, 1884, p. 183.

[48] E. A. Smith, letter of December 23, 1911; G. H. Ashley, letter of October 24, 1911; J. W. Foster, cited by J. P. Lesley in "Manual of Coal and its Topography," Philadelphia, 1856, p. 105; I. C. White, Sec. Geol. Surv. Penn., Rep. Q3, 1880, pp. 194, 195.

Cumberland and Rhea counties, Tennessee, the former being on the western, the latter on the eastern outcrop; Foster described a coarse sandstone on Licking River, Ohio, with ripple marks and indistinct fucoids, the latter being most probably casts of sun cracks. White reports the flags at a quarry in Mercer county of Pennsylvania as showing both ripple marks and rain prints.

The writer finds no record of ripple marks or sun cracks on sandstones of the Allegheny. Several correspondents assert that they have seen them frequently but cannot remember the localities as no entries were made in the note books. Condit[49] observed excellent examples in the Conemaugh of Ohio at 15 feet below the Pittsburgh coal bed and at 60 feet below the Ames limestone. Stevenson saw in Fayette county of Pennsylvania a Conemaugh sandstone of which the layers, exposed in a quarry, are covered with irregular ripple marks, closely resembling those made by winds on dunes or sand plains. A laminated sandstone at 57 feet below the Pittsburgh coal, in Allegheny county, is ripple marked on many of the surfaces. In Fayette county, the shales overlying the Pittsburgh coal frequently contain thin layers of ripple marked sandstone and in Greene county the Pittsburgh sandstone shows the irregular trails known as *Spirophyton*. In Fayette and Westmoreland counties, ripple-marked surfaces characterize the Waynesburg sandstone at the base of the Washington formation. The uniform testimony of those who have studied the Appalachian basin is that ripple marks and sun cracks are familiar phenomena in the Coal Measures sandstones or in the clayey films separating the layers.

Footprints in sandstone have been reported from but one locality. King long ago announced the discovery and the occurrence was confirmed sometime later when he and Lyell[50] studied the rock together. The quarry in a Conemaugh sandstone was about 5 miles southeast from Greensburg, Westmoreland county, Pennsylvania.

[49] D. D. Condit, letter of February 14, 1912; J. J. Stevenson, Sec. Geol. Surv. Penn., Rep. K, 1876, pp. 99, 200, 208, 309; Rep. KK, 1877, pp. 31, 208.

[50] C. Lyell, "On Footmarks Discovered in the Coal Measures of Pennsylvania," *Quart. Journ. Geol. Soc.*, Vol. II., 1846, pp. 417–420; Vol. VII., 1851, p. 244.

The sandstone, in thin flags used for paving, is divided by laminæ of unctuous clay, which received and retained the impressions. Twenty-three footprints were obtained, all of them on the under surface of slabs, casts in relief of impressions made upon the clay. There were also casts of shrinkage cracks in the clay, made after the footprints were formed. Rain prints were observed on the slabs which Lyell took to England.

The sandstones in other coal fields have similar markings; Ashley has described ripple-marked sandstones in Indiana and J. A. Udden has found them in Illinois. Dawson,[51] who recognized the importance of recording all observations, has noted the occurrence of ripple and rain marks as well as of footprints at many localities within the Acadian areas. A sandstone in South Joggins shows distinct rain and footprints; on the shore of Northumberland strait, where the strike coincides with direction of the shore, great surfaces are exposed with ripple marks and worm trails. In 1842, he found, near Tatamagouche, footprints on a rippled surface and in 1843 he discovered two other series of prints, one of which was somewhat defaced by rain marks. Many beds within this region have ripples, rain marks, worm trails and sun cracks in clay laminæ within the sandstones. Lyell summarized the information respecting them. Hull has recorded similar conditions in Lancashire of England and Miller has described the footprints at Dalkeith in Scotland.[52] Similar markings are reported from almost all the large coal areas, and they are characteristic of sandstones containing laminæ of clay on which the markings were impressed.

Many authors have noted the "Vegetable soils" or "Ancient soils" observed in sandstone. These may be marked by local deposits of coal or by erect trees *in situ*, with or without traces of coal around the roots.

[51] J. W. Dawson, "Acadian Geology," 2d ed., 1868, pp. 167, 215, 217, 325, 328, 355, 357, 410; Supplement, 1878, pp. 62, 64.

[52] C. Lyell, "On Fossil Rainmarks of the Recent, Triassic and Carboniferous Periods," *Quart. Journ. Geol. Soc.*, Vol. VII., p. 244; E. Hull, "Geology of the Country around Wigan," 2d ed., Mem. Geol. Surv. Great Britain, 1862, pp. 9, 10.

The official reports note the not infrequent occurrence of coal patches in sandstone, some of them only a yard but others several rods long and wide. Without doubt, not a few of these are merely blocks of vegetable matter removed by sand-laden streams during change of channel-way; but others, such as that described by I. C. White,[53] are unquestionably *in situ*. In this case, the deposit is of impure cannel, 5 feet thick where opened, but disappearing in all directions within a few rods. It evidently marks the site of a shallow pond on the sandy surface, which was filled with sapropel material. It is probable that a similar explanation applies in many other cases, as impure cannel is the usual material.

Not many references to erect trees in sandstone are to be found in reports on the Appalachian basin; such trees, for the most part, are rooted in shales. Lesquereux[54] has mentioned the occurrence of a forest of *Sigillaria* and *Calamites* in sandstone over the great coal bed at Carbondale in the Northern Anthracite field. This seems to be the only recorded instance where the relations are clear; but Dawson[55] observed several ancient soils in sandstone. His Division II., 650 feet thick, has two old soils with erect trees; Division III., 2,134 feet thick, has many with erect trees, the old soils being in most cases very thin shale enclosed in sandstone. At one locality this thin shale bears erect *Calamites* and shows rain prints as well as footprints of batrachians; another, somewhat lower, with erect stems, has yielded several species of batrachians as well as remains of insects and land mollusks; at another, the sandstone cliff shows trees as pillars of sandstone and with them are associated *Calamites*, all vertical to the bed, which is inclined at 19 degrees. Here the sandy flat, supporting the trees, was inundated and covered with sand; in time, the trunks rotted and were broken off to be covered by the increasing deposit, which filled the interior of the decaying stem. At another horizon, one stem rises 4 feet and is surrounded by sandstone and the succeeding shale, but another reaches only to the top of the sandstone. On this sandstone there

[53] I. C. White, Sec. Geol. Surv. Penn., Rep. Q, 1878, p. 202.

[54] L. Lesquereux, "Geology of Pennsylvania," 1858, Vol. II., p. 840.

[55] J. W. Dawson, "Acadian Geology," pp. 156–178.

grew a forest of *Calamites*, which, in their turn, were surrounded by the mud, which reaches to the top of the larger *Sigillaria*. This growth of *Calamites* on sand, which had buried the *Sigillaria*, recalls the conditions at Topeka, Kansas, already described, where during a great flood the young trees of a large nursery were buried by sand, on which a dense growth of cottonwoods developed within a few weeks. The conditions recall also those described by Russell on the Yahtse River in Alaska. The trees were killed, not broken by the mass of gravels; the trunks decayed, some were broken off by the wind and the stumps were buried under new material brought down by the river, but others remained, at the time of Russell's examination, projecting many feet above the surface.

The evidence all points in one direction. The buried channelways, the cross-bedding reported at many localities and the rounded pebbles indicate river not shore deposit. Plants buried *in situ* by inundation, the ripple-marked and sun-cracked surfaces, the rain prints, the footprints of batrachians, the pool-like accumulations of vegetable matter, the absence of marine fossils and the distribution of the coarser materials make up, altogether, a mass of evidence which it is difficult if not impossible to controvert. The sandstones were great flats, subject to inundation by the rivers to which they owed their origin. There appears to be no evidence to support the supposition that they are either shore or deepwater deposits.

The Shales.—Coal Measures shales vary in structure from merely compacted muds to finely or coarsely laminated beds; in composition from fine clay to sand or impure limestone; in color from almost white to black, the latter often passing to cannel or even to ordinary coal. Thick deposits of shale frequently hold lenses of sandstone and similar lenses of shale occur in sandstone. Some shales are rich in remains of a marine, a brackish water or of a freshwater fauna; others are crowded with impressions of land plants, retaining the most delicate markings of all parts; others have only indistinct plant remains, with which a marine fauna sometimes occurs; others still, of notable thickness and area, have rare and mostly obscure traces of either vegetable or animal life.

Sandstone predominates in the Pottsville but in later formations shale is a characteristic feature. This is true of the anthracite area almost equally with the bituminous region, as appears from the sections and drill-hole records published by the Pennsylvania survey.[56]

The anthracite region, including the broad eroded spaces between the coal fields, is about 70 by 100 miles, but the coal area, which has escaped erosion, is considerably less than 500 square miles. The Pottsville deposits are almost wholly sandstones or conglomerates except locally in the Eastern Middle, where the Beaver shows here and there thick beds of shale, 22 to 42 feet thick. Conditions changed gradually after the beginning of the Athens, so that above the Mammoth coal bed, identifiable with comparative certainty throughout much of the area, one finds abundance of shale. At the northeast in the Southern field, one section has 194 feet of shale in a total of 218; another has one bed, 64 feet, and three thinner beds in 257 feet; midway in the field, some sections show nearly one half shale in 900 feet above the Mammoth. There is much variation in thickness and in position of the shale beds and none is persistent in all the sections. In the Western Middle, the thickest bed at the easterly end is but 40 feet, but farther west are beds of 45 to 107 feet with others of less thickness, while at the western end shale and sandstone are often in equal thickness. The proportion of fine shale above the Mammoth is as large as in most of the bituminous region and some of the beds are thicker than any there outside of the central space in West Virginia. Farther south along the eastern border in Alabama, where only the Pottsville remains and the conglomerates are thick and coarse, one finds great beds of finer materials, though argillaceous shale seems to be comparatively unimportant.

Sandy shales are closely related in distribution to the sandstones; black or carbonaceous shales will be considerd in connection

[56] The survey of the anthracite fields was planned by C. A. Ashburner and was executed under his direction. His death occurred after completion of the work but before preparation of the report. Discussion of the results was assigned to A. D. W. Smith and it is given in Vol. III. of the Final Report.

with coal beds; it is necessary here to study in detail only the red shales and to note a few matters concerning shale deposits generally.

The Red Shales.—The red and green muds and laminated sandstones of the Catskill pass gradually into the early Carboniferous in a great area within Pennsylvania and Virginia. In like manner, the red shales of the Upper Mississippian pass into the Pottsville through a transition series of sandstones, conglomerates and red to green shale beds, this feature being especially characteristic in the southern anthracite field, where the column is complete. The reds and greens of the Catskill mark a condition, which originated in southeastern New York during the Middle Devonian and spread slowly west and southwest, reaching southwestern Pennsylvania late in the Chemung, the last great division of the Devonian. The condition, whatever its cause may have been, appears to have been without relation to the character of the water; the fauna in the northern portion of the area is freshwater, but in southwestern Virginia,[57] very near the termination of the red deposits, *Spirifer disjunctus* and some other forms were obtained at the top of the formation, showing that marine conditions reached as far northward as New River and that they were not inconsistent with the deposition of red beds. The Mauch Chunk or Upper Mississippian red beds seem to have yielded no marine forms in eastern Pennsylvania, but in southern Pennsylvania and southward, the middle and lower portions are gradually replaced with the Maxville limestone, which is marine, while in western Pennsylvania the upper portion or Shenango shale has yielded marine forms in Crawford, Mercer and Fayette counties.[58] The fossils are large and they did not live amid unfavorable conditions. The shales are red in Fayette county, so that again it is evident that influx of salt water did not prevent formation of red beds. The Pennsylvanian red shales have neither the constancy nor the extent of those in the Catskill and Mauch Chunk, but they resemble the former in that the conditions favoring their formation existed at first in a small area, whence they gradually spread; they differ

[57] J. J. Stevenson, "The Chemung and Catskill on the Eastern Side of the Appalachian Basin," *Proc. A. A. A. S.*, Vol. XL., 1891, separate, p. 7.

[58] I. C. White, Sec. Geol. Surv. Penn., Rep. Q4, 1881, p. 77; J. J. Stevenson, ibid., Rep. KKK, 1878, p. 308.

in that after a maximum area was reached, the conditions ceased to be general, became more or less localized and the deposits were isolated, at times widely separated.

The earliest appearance of the Pennsylvanian reds is in the New River of northwestern Georgia, where two beds, 11 and 35 feet, were found, with 103 feet of variegated shale intervening.[59] No reds are reported from the Pottsville of the anthracite region and they are rare in the Allegheny, occurring only in the lower part of that formation. A bed, 32 feet thick, was found near Drifton in the Eastern Middle at 30 feet below the Buck Mountain coal bed and, near Harleigh, a thin bed underlies that coal. In the northern part of the field, a soft red sandstone is at a few feet below the Mammoth and near Harleigh a thin bed of red sandstone overlies the Buck Mountain; at a few miles west, in the Western Middle, some thin streaks of red shale exist between the Buck Mountain and the Mammoth. These are all within a narrow north and south space and must have been brought down from the Alleghania slope.

Red shale first appears in the bituminous region during the latter part of the Allegheny. The most southerly locality is in Boyd county of Kentucky, where 18 feet of green and red shale were seen near the top of the formation. The deposit is altogether local, for measured sections and well records in adjoining counties of Ohio and West Virginia show no trace of red at this horizon. The nearest notable deposit is more than 80 miles distant toward the northeast in Washington county of Ohio, where 64 feet of red shale begins at 503 feet below the assumed place of the Pittsburgh coal bed and so extends downward to the middle of the Allegheny. There, one has reached what may be termed the Central area, in which red shales are a striking feature from the middle of the Allegheny to the close of the Pennsylvanian. This area embraces contiguous portions of Washington county of Ohio, Wood, Ritchie, Wirt, Calhoun, Roane, Jackson, Gilmer and Clay counties of West Virginia, in all not far from 3,500 square miles. Red shale in the Allegheny is reported here and there from other counties but in each case the deposit is insignificant.

[59] J. W. Spencer, "The Palæozoic Group," Geol. Surv. Georgia, 1893, p. 139.

At the beginning of the Conemaugh, one finds on the eastern and northern parts of the bituminous region an important sandstone, which becomes unimportant on the western outcrop in Ohio. In several counties within the Central area, its place is occupied by red shale. The same material occurs in occasional borings farther north near the Pennsylvania line and thin streaks are reported in a few wells north from that line; but these occurrences seem to be isolated. As one rises in the Conemaugh, he finds the areas increasing, for widely extended deposits appear below the Cambridge, the first persistent limestone of the Conemaugh. At this horizon the reds, though variable, are thick in some portions of the Central area and very irregular in others; but conditions favoring deposition of reds existed at many localities, somewhat widely separated; such deposits are reported from the Central area; from Ohio at 100 miles toward the west; from the northern counties of West Virginia; from several counties in southwestern Pennsylvania as well as from Webster county of West Virginia on the eastern outcrop. Away from the Central area, most of the deposits are thin, apparently of small area; their interrelations cannot be ascertained but there is no doubt that many of them were wholly isolated. They suffice to show that, prior to the formation of the marine Cambridge limestone, conditions favorable to deposition of red shales existed at very many localities within an area of not less than 10,000 square miles.

The Pittsburgh reds of I. C. White underlie the Ames limestone, which carries a marine fauna and is midway in the Conemaugh. This interval between the two marine limestones is marked by the greatest expansion of reds within the Appalachian basin. No trace of the deposit is seen on the eastern side of the bituminous region except in a small space within western Maryland and the adjacent part of Pennsylvania. Aside from that locality it seems to be absent along the eastern outcrop in Pennsylvania and West Virginia as well as along the western outcrop in Ohio. But in the interior portion of the bituminous region the Pittsburgh reds are present from Boyd county of Kentucky to the northern outcrop, a distance of 275 miles, and the width at times is 80 miles, giving an area of certainly not less than 17,000 square miles. The thickness varies; it becomes almost 250 feet in some localities, when the mass is continuous below with that under the Cambridge limestone and at others where it is continuous with that above the Ames; but it is notable throughout its whole extent; even at the northern border, where no other reds are found in the Conemaugh, the Pittsburgh reds are from 30 to 50 feet thick. At the same time, it must be noted that this, like those which precede and those which follow, is in no sense a uniform deposit; the variations in thickness and character are greater than those of the sandstones and are marked by extreme irregularity. Making all allowance for defective methods of keeping the records of borings, one must recognize that a mass of red shale, 50 feet thick in one well, may be replaced, even in the Central area, with sandstone in another well only 200 feet away; that red shales alternate vertically with light gray, blue or almost white shales as well as with gray white or bluish sandstones; comparison of well records, preserved and collated by I. C. White in the West Virginia reports, leaves no room for doubt that red shales are often continuous laterally with light colored shales and sandstones, and that the transition may take place within a few rods. But in the upper portion, the Pittsburgh reds are as nearly continuous throughout the whole area as is any other deposit in the series.

The Washington reds, the "Big reds" of the drillers, follow the Ames limestone and, where that rock is absent, are often continuous with the lower deposit. This mass spreads with considerable thickness into counties adjoining the Central area but it underlies not much more than 4,000 square miles and is absent at many places even within the main red area. It seems to be wanting in most of Ohio, but a thickness of 60 feet is reported in Muskingum county at 50 miles from a locality on the Ohio River, where it is said to be 100 feet thick, no reds having been observed in the intervening space. It occurs as red shale occasionally in northern West Virginia but seems to be wanting in Pennsylvania, though its place is marked by the fine-grained Birmingham shale of that state. Its variations laterally and vertically are wholly like those of the Pittsburgh. The area of red shows more notable contraction in the upper part of the Conemaugh, but, locally, the reds were deposited in an area almost as great as that of the Pittsburgh. Thick deposits are reported from some counties within the Central area and none whatever from others; isolated deposits are reported from 9 counties of Pennsylvania and from 6 in Ohio but there seems to be very little in the greater part of West Virginia. The total area of the reds during the later Conemaugh at any one time was less than 1,000 square miles and the deposits are widely separated. At the same time, one must note carefully that, while the deposits are usually of small superficial extent, yet the thickness of some is important.

The conditions during the Monongahela were much like those at the end of the Conemaugh but the area in which deposits were made is much less. No red is reported from Pennsylvania except a thin streak at one locality, nor is there any in the West Virginia panhandle. There is none in Ohio except near the Ohio River toward the Central area. But, as one approaches that area, the red increases and some of the beds are important. In West Virginia, there seems to be very little along the eastern side north from the Kanawha River and in the interior the occurrences are few and irregular until one comes to the Central area, where beds are many but more irregular than at any time during the Conemaugh. In Ritchie county, every foot of the section for 300 feet above the Pittsburgh coal bed is marked by red shale in some well or another; but that statement tells little respecting the conditions. The beds vary from 7 to 110 feet as measured in different records; in some borings, one finds 220 feet of red in a vertical distance of 300 feet, while in others near by the total is less than 100 feet. Similar variations are found in other counties but the maximum thickness is less. Aside from the insignificant and distant patches in Pennsylvania and Ohio, the area in which reds were deposited at various times during the Monongahela is less than 4,000 square miles and no deposit has great superficial extent.

During the Washington, local conditions favoring deposition of reds existed here and there in a much greater area; but the conditions were local. Reds are reported from three localities in Washington and two in Greene county of Pennsylvania; from six in Ohio; from a number of places in northern West Virginia; but these are all far apart and the most of them are insignificant. Only when one reaches the Central area does he find the deposits assuming importance. Even there the occurrence is indefinite; a boring in Wood county, West Virginia, passed through two beds, 100 and 60 feet thick, but in another well, only a short distance away, the same intervals show 60 and 20 feet of red. Greater contrasts appear elsewhere, for thick deposits of red in one well are replaced with sandstone in another, less than one eighth of a mile distant.

The story is the same for the Greene. In southwestern Pennsylvania deposits, 50 to 90 feet thick, were seen, but they are local, being absent in sections four or five miles away. There are certainly some reds in the formation within the West Virginia panhandle, but the exposures do not admit of measurement. Some important deposits are reported farther south along the Ohio River but for the most part little information exists respecting them. The Greene formation in West Virginia contains nothing of economic worth and, with the exception of one persistent limestone, there are no definite horizons. There seems to be only a monotonous succession of shales and soft sandstones, all ill-exposed. But, in riding across the Central area, one recognizes at once that red shale forms no insignificant portion of the mass, though the imperfect exposures suggest that the deposits must be lenticular like those in the earlier formations.

Red shales are found in other coal basins and in later formations. Dawson[60] found them abundant in all divisions of the Coal Measures from the Millstone grit to the top and with the same features as in the Pennsylvanian of the Appalachian basin; gray and red shales alternate vertically and at times are continuous laterally. Conditions are the same in later times; lenticular deposits of red clays occur in the glacial till of Canada and of Scotland. The great Pampean formation as originally described by Darwin[61] would seem to be a continuous deposit of reds covering an area almost equal to that of France; but it varies in composition as reds do elsewhere, for records of borings near Buenos Ayres show that the section consists of sand, clay and green shale. Church, to whose studies reference will be made on a later page, found that a vast area of the Plata region is covered with reddish-yellow, semiplastic argillaceous earth, contain-

[60] J. W. Dawson, "Acadian Geology," pp. 156–176.

[61] C. Darwin, "Journal of Researches," New York, 1846, Vol. I., pp. 161, 164, 165; "Thickness of the Pampean Formation near Buenos Ayres," *Quart. Journ. Geol. Soc.*, Vol. XIX., 1863, pp. 68–70.

ing at times, calcareous nodules. The deposit is without pebbles and becomes increasingly sandy toward the west. The Pampean formation resembles the Pittsburgh reds. Gruner[62] has observed that in the Loire basin, red beds are not uncommon in the sterile stage of Saint-Chamond. The deposits are found at all horizons in this formation which is from 650 to 2,600 feet thick and is the middle division of the Loire Coal Measures. In the Lancashire field of England the reds appear to be confined to the upper Coal Measures.

Dawson found abundance of ripple marks, rain and footprints in the Acadian red shales but no record of such markings on the Pennsylvanian reds has come to the writer's notice. Fossil remains, vegetable or animal, are rare, but Raymond[63] discovered reptilian bones in a small basin eroded in the sandstone on which the Pittsburgh red shales rest. Not infrequently the red muds contain nodules of ferruginous limestone in which are marine fossils; these abound in the Pittsburgh reds and cause much annoyance to drillers of oil wells. At one locality in West Virginia on the east side, the Pittsburgh reds are replaced with a succession of variegated shales which are exceedingly rich in marine forms, several of which pass upward into the Ames limestone; and the shales are similar at 25 miles southwest. The Pittsburgh reds, at least in part, were deposited where salt water had access. There is much to suggest similar origin for some other reds. Those below the Cambridge pass upward to that limestone as the Pittsburgh reds pass to the Ames. In considerable areas they replace the limestones and the two deposits are continuous with each other or even with the Washington reds above. The limestones are wedges in the shale as the Maxville becomes a wedge in the Mauch Chunk shales within southern Pennsylvania. The Washington reds are equivalent in position to the Birmingham shales at Pittsburgh, which Raymond, in the publication cited above, has shown to be marine. It is certain that marine conditions are in no wise antagonistic to deposition of red shale. At the same time, one must not forget that the conditions must have been very different

[62] L. Gruner, "Bassin houiller de la Loire," Paris, 1882, p. 217.

[63] P. E. Raymond, "A Preliminary List of the Fauna of the Allegheny and Conemaugh Series in Western Pennsylvania," Topog. and Geol. Surv. (of Penn), 1911, p. 89.

for isolated deposits, which are numerous and often thick. These, in many cases, were far away from any marine invasion, in regions of coal beds and freshwater limestones. Within the Central area, there is almost total absence of limestone, the coal beds are indefinite and most of those which are recognized on the borders are wholly wanting.

The origin of the red color in shales and sandstones has been sought by many students. Crosby[64] has shown that in the northern United States and Canada the soils are rarely red except when derived from a red rock; but southward from latitude 39° redness increases until, in the West Indies and South America, it becomes intense. The color is not due to the rocks, for the red deposit at the south rests on primary rocks not differing from those at the north where no red is found. He thought that the contrast is due, very probably, to climate, the dehydration of ferric hydrate and consequent change of color being caused by solar heat. In a later paper, he says that six years of additional study had led him to assign less importance to solar heat as the converting agent, but he still recognizes it as one of the important agents. Many illustrations are given, which certainly appear to go far toward fortifying his position.

Russell[65] took up the subject at a somewhat later date and reached conclusions differing from those of Crosby. The depth to which decay of rocks extends in the Appalachian region increases southwardly, becoming 100 feet in large areas, and he cites Belt as reporting that, in Nicaragua, the depth at times is 200 feet. In the great limestone valley, south from James River in Virginia, the clay remaining after solution of the limestone is red and sometimes 50 feet thick. He objects to the conclusion that climate or solar heat caused the red color, because in summer the soil is heated as strongly in the northern as in the southern states. The red beds of the Rocky

[64] W. O. Crosby, "Colors of Soils," *Proc. Bost. Soc. Nat. Hist.*, Vol. XXIII., 1885, pp. 219–222; "On the Contrast in Color of Soils of High and Low Latitudes," *Amer. Geol.*, Vol. VIII., 1891, pp. 78–82.

[65] I. C. Russell, "Sub-aerial Decay of Rocks," U. S. Geol. Surv. Bull. No. 52, 1889.

Mountains could not have become red by exposure during deposition, for the playa beds in Nevada and similar regions are creamy white, though the summer temperature reaches 110° to 120° in the shade. The red color was acquired during decomposition of the rock and consequent incrustation of the grains. Richtofen has explained the red of the Rothliegende by supposing that during the Carboniferous there was deep decay of the rock and that this material became that of the Rothliegende. Russell applies the same explanation to the great red deposits of America, which he regards as formed of debris from rocks long exposed to a warm moist atmosphere.

Beede's[66] studies are in place here. It had been ascertained that the light-colored sediments of Lower Permian in Kansas become red in Oklahoma and the same condition was observed in going northward into that state from Texas; in one instance a limestone was traced into a sandstone. Beede, following the Kansas deposits into Oklahoma, found that limestones became sandy in patches, which increased until the limestone disappeared. Farther south the sandstone becomes deep red or brown with patches of white. The limestone fauna reaches southward only a little way beyond the limit of that rock. Shales become red much farther north than do the sandstones and often have deeper color; even the limestone, at times, becomes reddened before disappearance. The sandstones vary much in thickness at expense of the shales, but the thickening is irregular, the rock is cross-bedded and often shows ripple marks. At their southern limit, the shales and sandstones dovetail into Permian conglomerate on the Arbuckle and Wichita mountains, which is formed largely of the limestone, at one time covering those mountains and even now 8,000 to 10,000 feet thick on their flanks. These limestones yield a residual red clay, while the disintegrating conglomerate yields a red sandy clay resembling that of the red beds. It would appear that the lower red beds of Oklahoma were derived from the Arbuckle-Wichita land mass and that the coloring matter is due chiefly to solution of limestones known to have been removed from the area. Beede concludes that the deposits, which are void of fossils

[66] J. W. Beede, "Origin of the Sediments and Coloring Matter of the Red Beds of Oklahoma," *Science*, N. S., Vol. XXXV., 1912, pp. 348–350.

and even of carbonaceous matter, were made in very shallow turbulent water or on vast tidal beaches.

Dannenberg,[67] discussing the importance of red beds, refers to activities of changing climatic conditions as perhaps a notable agent in bringing about the contrast between the productive and the barren measures. In the productive measures, one finds constantly dark gray to black as predominating colors, due to impregnation of the whole mass with coaly substance, while the succeeding barren measures are recognizable by the red color. The Rothliegende, succeeding the Carboniferous, owes the first half of its name to this condition. But the change in color begins before the close of the Carboniferous, for the red appears as soon as conditions for coal-making end—with the entrance of red, the formation of coal beds ceases. In the Saarbruck region, reds occur in the Upper Carboniferous over the productive division. That a luxurious vegetation existed during deposition of this unproductive red shale is proved by the presence of great masses of vegetation in the Rothliegende, such as the petrified forest at Radowenz in Bohemia. Evidently not failure of vegetation but changing climatic conditions, which were unfavorable to the accumulation of plant remains, brought about the new features. The formation of red rocks and weathered products is at present a peculiarity of the torrid zone, where one finds laterite, terra rossa, etc., in which humus is unimportant. Dannenberg is inclined to think that in the Carboniferous, there were moderate, perhaps ocean climates contrasting with the succeeding hot climate of the continental Rothliegende.

Barrell,[68] who regards the Mauch Chunk (Upper Mississippian) red shales as, for by far the most part, of flood-plain origin, has published two important memoirs bearing upon the origin of the red color. In the earlier memoir he shows that the Mauch Chunk contains some impressions of plants but no trace of the carbon remains. The loss of carbon has not decolorized the shale, so that evidently

[67] A. Dannenberg, "Geologie der Steinkohlenlager," Berlin, 1910, pp. 30, 31.

[68] J. Barrell, "Origin and Significance of the Mauch Chunk Shale," *Bull. Geol. Soc. Amer.*, Vol. 18, 1907, pp. 449–476; "Relations between Climate and Terrestrial Deposits," *Journ. of Geol.*, Vol. XVI., 1908, pp. 159–190, 255–295, 363–384.

the oxidation was by free oxygen and not by that derived from ferric oxide. The discussion in the later paper covers the whole question and the author fortifies his position with the wealth of illustration that seems to leave little room for disputing his conclusions; but the discussion is so elaborate that only the final statement can be given here and the reader must be referred to the memoir itself for the detailed argument. The red color of ferruginous rocks as contrasted with the predominating yellows of alluvium is due to three coöperating causes: Spontaneous dehydration, operating to some extent at the surface in warmer regions; dehydration under great pressure and moderate temperature, nearly universal in sediments which become buried and consolidated; diffusion, operating under conditions of warmth and moisture, whether these be at the surface as in warm and humid regions or beneath the surface as may occur in any portion of the earth. By these three means, the light-colored yellow or brown muds and sands may become red shales and sandstones. The chief condition for formation of red shales and sandstones is merely the alternations of seasons of warmth and dryness with seasons of floods.

Gruner and Dannenberg lay stress upon the fact that reds occur in the sterile measures. Certainly the reds seem to have been deposited under conditions which were unfavorable to the accumulation of coal, for that is almost wanting in the central area of West Virginia; great coal beds, traceable for hundreds or even thousands of square miles, thin out to disappearance as they approach that area. At the same time one must not forget that the reds mark local, not general conditions; that they abound in the productive as well as in the less productive portions of the column. Within the Central area they are as important in the upper Allegheny and in the Monongahela as in the Conemaugh and Washington. Even in the limited Loire basin the same is true, for the reds there are practically confined to that portion of the Saint-Chamond area, which is micaceous. Whether or not a similar relation exists in the Saarbruck area, the writer has not been able to ascertain.

The distribution of Pennsylvanian red shales forbids the supposition that they owe their red color to any widely-acting cause. The especial localization of the deposits in the central part of the area, the lateral passage into fine shales and sandstones of wholly different color and the many isolated occurrences of small deposits seem to exclude explanations based on supposed aridity or any other general condition of climate. The shale, at times, contains small areas of coal in distinct beds, and occasionally one finds coal at the horizon of beds which are persistent around the borders. Where the mass is interrupted by other deposits, which continue to within the limits of the reds, a coal bed also at times continues from the border, though at the east only a few miles away it is wanting as the red is continuous vertically. It is certain that occasionally the conditions, favoring accumulation of coal, existed for considerable periods within the Central area of reds. No matter which hypothesis respecting the formation of coal beds be accepted, the condition of general aridity becomes inadmissible, because the existence of coal beds, great or small, is proof of humid atmosphere and dense vegetation not far away. One finds a great mass of reds at the Pittsburgh coal horizon at less than a score of miles from localities where that bed is of workable thickness; and the same statement is true respecting the Harlem and Anderson coal beds. There is every reason to suppose that in a general way the climate, in respect of rainfall, was very much as now; the direction of the winds was the same and there is no reason to suppose that, at any time during the Pennsylvanian, a mountain chain existed on the west side of the Appalachian basin. Yet alternation of wet and dry conditions, as suggested by Barrell, may have been prevalent, though due only indirectly to atmospheric influence.

Topographic changes would seem to be the preferable explanation for conditions in the Central area. The subsidence, converting that area into vast tidal flats, continued until, just prior to the Ames limestone, the region subject to river and tidal overflow may have embraced more than 20,000 square miles. It must be remembered that in the vertical space occupied by the great reds of the Conemaugh one finds the Cambridge and Ames limestones, both marine. The rivers during long periods of little change had acquired low gradients and they carried little coarse material, which was dropped on the border of the low area, while the streams, flowing sluggishly across the flats distributed the abundant fine materials and, as they shifted their courses, sorted the stuff, giving the lenses of clay and sand. The source of the red material is to be sought at the west, for the reds are present mostly on the west side of the bituminous region—even the great Pittsburgh reds extend only a little way east from the middle line of that region. During contraction of the area of deposition, the Mississippian beds became exposed to erosion while the calcareous deposits of the low-lying Cincinnatia had been converted by solution in their exposed portions into red clays such as one sees in so much of the Great Valley within Virginia and Pennsylvania. During deposition of the Pittsburgh reds, residual soils of the northern land must have been an additional source of supply. It seems wholly preferable to regard the Pennsylvania reds as derived from reworking of deposits already red. At the same time, one cannot suppose that the local and widely separated patches in the Monongahela, Washington and Greene were derived from a distant source. Probably they mark the sites of ponds into which the sluggish streams carried muds due to decay of limestones and mingled with those from the fine shale of the red region.

Surface Markings on Shales.—There are no recorded observations of surface markings on Pennsylvanian red shales within the Appalachian basin, though such markings are sufficiently abundant in the Acadian region. But sun cracks and ripple marks are common enough on shale beds of other types. Footprints were found by Mason[69] on slabs of slate from the roof of the Mammoth coal bed. The surfaces show occasional ripple marks along with the tracks of a four-footed animal arranged in regular sequence. This appears to be the only case recorded within the Appalachian. There is little reason to expect such discovery in the bituminous

[69] W. D. H. Mason, "On the Batrachian Foot-tracks from the Ellangowan Shaft in Schuylkill Co., Penn.," *Proc. Amer. Phil. Soc.*, Vol. 17, 1878, pp. 716–719.

region, where one has only natural exposures for study and the shales are so easily disintegrated that only the basset is exposed. Woodworth[70] studying the more or less indurated shales of the Massachusetts region was led by discovery of rain prints to look for batrachian footprints. The search was rewarded almost at once by discovery of impressions belonging to two individuals. Study of the prints convinced him that they were made under slight cover of water. Many scratches were found on the shale surface, resembling those made by the sharp toes of newts in very shallow water.

In situ forests occur frequently in shale beds. Gresley[71] reported that 7 erect trees were found in the roof of the Buck Mountain coal bed at Haven River colliery. He says that tree-stumps with *Stigmaria* roots are of common occurrence in the roofs of several anthracite beds. That of the Baltimore at Wilkesbarre yielded one, 36 inches in diameter at a few feet above the roots. Comparatively few instances of trees *in situ* have been recorded in the coal fields of the United States and most of the notes, which the writer has found, seem to have been made incidentally and are without detail, as are most of those with reference to similar occurrences in sandstones.[72] Long ago Owen[73] described a forest discovered at 12 miles from New Harmony, Indiana. More than 20 fossil stumps had been found in excavating the site for a mill and dam. He disinterred three with 5 to 7 main roots, which ramified in the surrounding material. As these trees, trunks and roots were in normal position, he believed that they had grown there and had

[70] J. B. Woodworth, "Vertebrate Footprints on Carboniferous Shales of Plainville, Massachusetts," *Bull. Geol. Soc. Amer.*, Vol. 11, 1900, pp. 449–454.

[71] W. S. Gresley, "Seven fossil Tree Trunks, probably *in situ,* found in Roof of a 12-feet seam of Anthracite in Schuylkill Co., Penn.," *Trans. Manch. Geol. Soc.*, Vol. XXI., 1890, p. 70.

[72] There is ample reason to expect that when D. White publishes the results of his investigations, all grounds for this complaint will disappear.

[73] D. D. Owen, "On Fossil Palm Trees," *Amer. Journ. Sci.*, Vol. XLV., 1843, pp. 336, 337.

become submerged quietly. Lyell[74] visited this locality at a later date when a quarry had been opened in the overlying sandstone. He saw the trees in a clay shale underlying sandstone and 18 feet above a coal bed. He, with Owen, dug the clay from about one of the trees, which was 4 feet 8 inches high and with roots spreading out as in the normal position. This and two other *Sigillaria,* close by, were casts, the bark converted into coal but the interior filled with mud. The roots were interlaced. A great number of such trees had been removed in working the quarry. Udden[75] notes that a vertical stump resting on a coal bed was seen by him near Peoria, Illinois, but he gives no details aside from the statement that the stump is filled with sandy clay.

There is, however, no lack of information respecting other lands. Dawson and R. Brown have recorded many instances in the Acadian region; in one case there are *Sigillaria* stumps with *Stigmaria* rootlets descending among them from an overlying bed. Occasionally an embryo coal bed existed in the old soil but in some cases there is no trace of coal. The absence of vegetable matter around the base of the stems is in no sense evidence that they are not in place, for Tuomey, as cited on an earlier page, has shown that peat beds raised above the level of water-supply, waste away by drying, the removal being aided by the winds, which carry off the dust-like material. The trees remain, rooted in the underlying soil. Many other students of peat deposits have made the same observation in later years. Gruner says that the lower forest of Treuil has the roots spread out in the roof of the coal and that it is present except where the roof has been washed away and replaced with sandstone. Hawkshaw[76] described the trees found at Dixon Fold near Manchester. Five of them, at nearly right angles to the stratification, were embedded in a soft blue clay, and a thin coal bed on same

[74] C. Lyell, "A Second Visit to the United States of North America," 2d ed., 1850, Vol. II., pp. 272, 273.

[75] J. A. Udden, "Geology and Mineral Resources of the Peoria Quadrangle," U. S. Geol. Surv., Bull. No. 506, 1912, p. 37.

[76] J. Hawkshaw, "Descriptions of the Fossil Trees found in the Excavations for the Manchester and Bolton Railway," *Trans. Geol. Soc.,* II., Vol. VI., 1842, pp. 173–175.

plane as the roots continues as far as the excavation extends. *Lepidostrobus variabilis* occurs abundantly about the level of the roots, more than a bushel of specimens having been obtained around the trees. A coating of coal, one fourth to three fourths of an inch thick, surrounded the trees, so tender that it flaked off and left the stems decorticated; but some harder coal near the roots of one tree showed the bark fluted longitudinally. The largest tree was 11 feet high, 15 feet in circumference at the base and 7 feet and a half at the top. The next in size was 6 feet high, seven and a half feet in circumference and less tapering; the others were shorter. The roots could be followed only a short distance owing to the character of the excavation. They are covered with a thin stratum of coal, 8 to 10 inches thick, which Hawkshaw thinks probably represents the vegetable covering of the place on which the trees stood.

Binney[77] says that when erect trees were first found, an attempt was made to refer them to accidents as snags; but discoveries by Hawkshaw and Bowman, near Manchester, aided toward recognition of their growth *in situ*. During a recent examination of excavations for the Bury and Liverpool railway near Wigan, he had discovered not merely a forest of erect *Sigillaria,* with roots just as they had grown, but also many *Calamites* in similar state of preservation. The excavation is about 25 feet deep and in a light gray, silty clay very like that at St. Helens and Dukenfield, where the earlier discoveries were made, and the deposit is between two coal beds. In a distance of 50 yards, he found 30 upright trees and some prostrate stems of *Sigillaria.* They were 2 to 3 feet in diameter, 2 to 12 feet high and filled with silty clay, the bark having been converted into brilliant coal, one fourth of an inch thick. Many *Calamites* were seen among the trees, 4 to 5 feet high, one to 5 inches in diameter, with a thin coaly crust and filled with the silty clay. Each type occurred in all parts of the deposit from top of the lower seam to bottom of the upper. During a second

[77] E. W. Binney. "On Fossil Calamites found standing in an erect Position in the Carboniferous Strata near Wigan, Lancashire," *Lond., Edinb. and Dubl. Phil. Mag.,* Vol. XXXI., 1847, pp. 259–266.

visit with Hooker, he discovered *Calamites* with rootlets from joints along the stem. These he describes in detail.

Sorby[78] relates that 8 large well preserved stumps had been found at Wadsley, rooted in a clay-like shale; all of them *Sigillaria* with *Stigmaria* roots. The tops are flat as though sawed off. The largest stump is 5 feet 2 inches in diameter and a huge trunk is prostrate alongside. In all, 10 stems were seen in a space of 40 or 50 yards and all are cut off at the overlying sandstone, with which they are filled. Sorby was much interested by the discovery that the roots are arranged as are those of trees in Great Britain of to-day—they are almost horizontal on the west side but pressed down on the east, showing that the prevailing winds were the same as now. Platt[79] described a tree rooted in an inferior fireclay with the roots so arranged as to confirm Sorby's conclusions respecting the direction of the winds. W. B. Dawkins, in commenting upon the paper, stated that he had made examination of the tree and that his conclusion was the same with that of Sorby and Platt.

Adamson[80] described a gigantic *Sigillaria* with 8 forked *Stigmaria* roots attached. The area embraced in the ramification of the roots is 826 square feet; it is difficult to conceive of removing this mass by a landslide or on a level area so as to set it down with the stem vertical and the roots outspread in normal position; and the difficulty is increased by the presence of other trees near by. This tree was figured in 1887 by Williamson[81] who says that a larger example was found near that described by Adamson, and that one of the root divisions was traced 37 feet 4 inches to a sharp tip.

[78] H. C. Sorby, "On the Remains of a Fossil Forest in the Coal Measures of Wadsley, near Sheffield," *Quart. Journ. Geol. Soc.*, Vol. XXXI., 1875, pp. 458–460.

[79] S. S. Platt, "Notes on a large Fossil Tree recently found in Shales of the Coal Measures at Sparth Bottoms, Rochdale," *Trans. Manch. Geol. Soc.*, Vol. XXIII., 1895, pp. 65–69.

[80] S. B. Adamson, *Rep. Brit. Assoc. Adv. Sci.* for 1886, p. 628.

[81] W. C. Williamson, "A Monograph on the Morphology and Histology of *Stigmaria ficoides*," *Palæontograph. Soc.*, vol. for 1886, pp. 45, 46, 48, 51, Pl. XV.

He states that 7 smaller but similar examples were found in excavations for a street in Bradford.

Grand'Eury and Goeppert have described many occurrences of *in situ* trees; and the former, in his memoir before the Geological Congress at Paris, gave figures and descriptions of *Calamites* with roots from the joints similar to those found by Sorby. Barrois[82] has reviewed the conditions in a keenly analytical memoir, referring especially to conditions in the Nord basin. His discussion will find place in another connection; it suffices here to note that he has found erect trees only in deposits which have been laid down in shallow water; they are wholly absent from deposits laid down in water deep enough to float the trees.

Not a few writers insist that occurrences of this sort can be explained readily by supposing them to be due to landslides or deluge-like floods. It might suffice to say with Goeppert that the explanation might answer if the instances were few, but that it does not answer because the number of erect trees is so great. But the proposed explanation is wholly unacceptable because the conditions observed do not suggest either landslides or terrific floods.

The White Mountains of New Hampshire have long been celebrated for the extent of landslides. One is typical of all. Perkins[83] described that which took place in the southern part of those mountains after a prolonged heavy rain in October, 1869. The light-colored streak marking its path was visible at a distance of 50 miles. The whole mountain had been covered with a dense growth of spruce. The slide began at 40 rods below the summit, 4,200 feet above tide. It was barely one rod wide at the top and increased little in the first 50 rods, where the slope is between 50 and 60 degrees; but, in the next 100 rods, the width increased rapidly to 25 and 30 rods at 130 rods from the beginning; thence it decreased to 17 at 166 rods. The whole length is nearly 240 rods and the outline is fusiform. Three miles below the termination of the

[82] C. Barrois, "La répartition des arbres debout dans le terrain houiller de Lens et de Lievan," *Ann. Soc. Geol. du Nord.*, Vol. XL., pp. 187–196.

[83] G. H. Perkins, "Notice of a Recent Landslide on Mount Passaconoway," *Amer. Journ. Sci.*, II., Vol. XLIX., 1870, pp. 158–161.

slide, a level clearing through which Mad River flows, was covered with great heaps of logs brought down by the slide and swept away by the freshet attending it. They were broken and shattered, though some were 60 feet long. They were piled up confusedly to a height of 15 or 20 feet, stripped of foliage and most of the smaller branches. Farther up the stream, no trees were visible; they had been buried in the coarse debris of the slide.

The terrific discharge of Lake Mauvoisin has been cited as evidence that blocks of the surface could be transported with standing trees and be deposited in the normal position. Knowledge respecting this great debâcle is derived from the description by Escher von Linth, of which a synopsis was published in English.[84] The Val de Bagnes is drained by the river Dranse, whose progress had been impeded for several years prior to 1818 by blocks of ice and by snow avalanches from the glacier of Getroz. At length the river was dammed and a lake was formed, which became 10,000 to 12,000 feet long, 700 feet wide at top, 100 feet wide at bottom, with an average depth of 200 feet. The content equalled at least 800,000,000 cubic feet. A gallery, 600 feet long, was cut to drain the lake, but this enlarged quickly in the ice, so that before one half of the water had passed off, the dam gave way and the mass of ice, water and débris was precipitated into the valley below. The whole lake was emptied in less than half an hour and the author well says that one cannot describe the violence of the flood. The passage of the water was checked by a narrow gorge, where it tore away a bridge, 90 feet above the preëxisting stream; beyond that, it entered a wider part of the valley, only to be banked by another gorge beyond. Thus passing from one basin to another, it acquired new violence and carried along forests, rocks, houses, barns and the cultivated surface. The flood seemed to contain more débris than water and it moved at the rate of 18 feet per second. The acquisition of these materials made the current more effective and, when it entered the narrow valley leading from Saint Branchier to Martigny, it con-

[84] "Account of the Formation of Lake Mauvoisin by the Descent of a Glacier and of the Inundations of the Val de Bagnes in 1595 and 1818," *Edin. Phil. Journ.*, Vol. I., 1819, pp. 187–191.

tinued its work of destruction until weakened by spreading over the great plain of the Rhone valley. After ravaging Le Bourg and the village of Martigny, it fell with comparative tranquillity into the Rhone, "leaving behind it on the plain of Martigny the wreck of houses and furniture, thousands of trees torn up by the roots and the bodies of men and animals, which it had swept away."

Neither landslide nor vast flood can be invoked for explanation of phenomena such as those described by Adamson, Potonié and Binney. It is incredible that the work of such destructive agents would leave no record except a group of trees resting normally with the roots of one interlaced with the roots of the others. There is no trace of disturbance at any locality mentioned by the observers named or by any others; yet the discoveries by Binney, Hawkshaw, Bowman and Platt are in the same small area, each covers a considerable space and everywhere there is evidence of wholly undisturbed deposition. The evidence that the trees are *in situ* is as strong as it is for Russell's gravel buried forest in Alaska or for the sea-covered forests on the shores of the Baltic and Britain.

The trees *in situ,* the ripple marks, rain and footprints, the evidence of selective action by streams, all go to show that shales were deposited in, at most, shallow water and that great areas of the Appalachian basin, like other regions in which shales occur, were above the area of deposition for prolonged periods.

The Limestones and the Marine Deposits.—Four limestones, with marine fauna, have been discovered in the Warrior coal field of Alabama, all, except possibly the highest, in the New River; Safford discovered a "local bed" of hard crinoidal limestone in his Upper Conglomerate within Grundy county of Tennessee, also New River; M. R. Campbell found a marine fauna in southern West Virginia within the New River and D. White[85] obtained *Spirorbis* and *Naiadites* in the southern anthracite field. The last is possibly brackish water; the others, distinctly marine, show that during the New River salt water occasionally had access, at least locally,

[85] D. White, "Deposition of the Appalachian Pottsville," *Bull. Geol. Soc. Amer.,* Vol. 15, 1904, p. 277.

as far north as New River of West Virginia on the eastern side of the bituminous region.

Evidence of marine conditions here and there in the northern half of the basin becomes distinct early in the Beaver. On the southeast outcrop along New River, West Virginia, one finds a silicious limestone, non-fossiliferous, of which traces appear at localities farther west almost to the Kentucky line. Somewhat higher is the Eagle limestone of I. C. White, black, blocky and, as are also the associated shales, richly fossiliferous. These deposits seem to be unrepresented farther north and to be confined to a narrow area in West Virginia. No trace of limestone or of any marine deposit within the Beaver is known east from the Allegheny mountains; none has been observed within the first three bituminous basins of Maryland, Pennsylvania or West Virginia, unless the Black Flint of the last state belong to the Beaver and not to the Allegheny,—and it is confined to a small area near the Kanawha River; nor is there any along the northern outcrop in Pennsylvania and Ohio. In northern Mercer county of Pennsylvania, 60 miles south from Lake Erie, one is on the northern limit of the Upper and Lower Mercer limestones of I. C. White, which are in the shale mass underlying the Homewood sandstone and are associated frequently with iron ore.

These deposits are persistent southward along the Ohio-Pennsylvania boundary for about 40 miles but they rarely extend eastward from that line to more than 25 miles. The limits of their area are well marked, north, east and south, within Pennsylvania and no trace is found beyond. The upper limestone is of irregular occurrence in Ohio but the lower bed is persistent with, in several counties, its boundaries at east and west thoroughly well defined. It crosses Mahoning, Portage and Summit, but it is wanting in Medina at the west. It is wanting in the panhandle counties of West Virginia and in eastern Ohio to about 40 miles west from the Ohio River. The Lower Mercer is present southward from Portage and Summit in an irregular strip, 30 to 50 miles wide, to Vinton county and it enters the northwest corner of Scioto at about 20 miles north from the Ohio River. The western boundary is reached at several localities in the northern part of the state, but, for the most part, the present outcrop is east from it as the limestone area seems to follow irregularly the direction of the pre-Beaver valley in which the Sharon sandstone, or latest deposit of the New River, was laid down. For this reason the limestone is found nowhere in Kentucky. The thickness at the north rarely exceeds 5 feet, but it increases southwardly to 10 feet. The Upper Mercer is less persistent than the Lower, but its unexpected appearance at some localities suggests that its area lay farther west. Both limestones are richly fossiliferous, each being at times a mass of shells. They indicate ingress of the sea in a narrow area, probably nowhere exceeding 50 miles in width and reaching northward to within 60 miles of Lake Erie along the Pennsylvania-Ohio line.[86]

The sea again invaded the basin soon after the beginning of the Allegheny, for the Putnam Hill limestone of E. B. Andrews rests on the first coal bed of that formation. It did not reach into Pennsylvania but it is followed easily in Ohio from Mahoning county near the Pennsylvania line to Perry county, where its character so changes that the bed is no longer available as a stratigraphic guide. In much of its extent, this limestone is associated with flint and iron ore and it shows great variation in thickness as well as in composition. Beyond Perry county, its area of deposit lay west from the outcrop and only the iron ore remains to mark its horizon. It carries an abundant marine fauna at most localities. At not far from the Putnam Hill horizon one finds the Kanawha Black Flint which occupies a small area on both sides of the Kanawha River in West Virginia toward the southeastern outcrop. The probabilities are, according to the plant remains, that it belongs lower in the column. This black calcareous rock is embedded in black shale and the mass is rich in marine forms. The area is more than 100 miles east from the eastern limit of the Putnam Hill and Mercer limestones, so that, like the Eagle limestone, it is evidence that the sea had ingress on the eastern side of the bituminous region.

[86] The observations by I. C. White, Newberry, Andrews, M. C. Read, Stevenson, Orton and A. A. Wright are recorded in "Carboniferous of the Appalachian Basin," *Bull. Geol. Soc. Amer.*, Vol. 15, pp. 66–70, 80–86, 89–91.

Not long after deposition of the Putnam Hill, but long enough for deposition of 40 to 80 feet of inorganic materials, the formation of two coal beds and the erosion of broad valleys, another sea invasion is recorded in the Vanport limestone of I. C. White. This underlies in most of its extent an ore deposit, which in the earlier days was so important that the rock below was termed the Ferriferous limestone. Like its predecessors, it is confined to the west side of the basin. A fossiliferous limestone is present in the Lower Allegheny at some places in western Maryland, but one cannot determine whether or not it is contemporaneous with the Vanport, as no fossiliferous limestone has been found at the horizon within 80 miles toward the west or northwest. The Vanport appears to be wanting in the whole of West Virginia as well as in Pennsylvania south from the line of the Ohio River. The deposit is recognized first at about 70 miles north from the West Virginia line and at an equal distance west from the crest of the Allegheny Mountains.

The most easterly locality in Pennsylvania, from which this limestone has been reported, is in Indiana county at 75 miles east from the Ohio line—apparently the tip of a prong; it appears at many places in the next county north, but its distribution indicates that the area is broken into prongs; and this is the mode of occurrence along the northern border where its limits are very well defined. From western Jefferson, the area is continuous to the Ohio line where the bed is 15 to 20 feet thick. The deposit is less regular in Ohio, being represented in many places by fossiliferous shale, calcareous sandstone and occasionally by limestone. These conditions prevail in Mahoning, Columbiana, Stark and western Tuscarawas, the limestone being of frequent occurrence in the last. Thence southward into Elliott county, Kentucky, the limestone with its ore seems to be continuous; beyond that the ore bed is traceable for many miles. The western boundary of the deposit is reached at a few localities in northern Ohio but, for the most part, it is beyond the present outcrop. While the extent of the Vanport in Ohio may have been less than that of the Mercer, its extent in Pennsylvania was far greater. The sea-invasion reached 60 miles farther east into Indiana county and 70 miles farther north into

McKean county on the New York border. The area in Pennsylvania was not less than 3,000 square miles, while that of the Mercer was little more than 500. At the same time, one must keep in mind that the Vanport was not continuous throughout its area; that on the borders it extends in long diverging prongs, terminating in chert or calcareous sandstone. The Vanport was formed at the close of a somewhat rapid submergence, during which many stream valleys were filled with sandstone. Apparently the peculiar mode of occurrence, the variations in structure and composition along the borders were due to the topography; while the conditions in northern Ohio suggest that in that region the water of the estuary was very shallow. In Pennsylvania and in a great part of the Ohio area, this limestone has a rich marine fauna.[87]

The roof shale of the Middle Kittanning coal bed, midway in the Allegheny, contains *Lingula* and *Discina* as far north as Wayne and Stark counties of Ohio. Aside from this, there appears to have been no serious invasion during the Allegheny after the Vanport. There are, it is true, several limestones, but there is no reason to suppose that, excepting the newest of them, they are in any part of marine origin. The Upper Freeport, almost the last Allegheny bed, is the First Fossiliferous limestone of Kentucky, where it has a marine fauna, but, north from the Ohio River, it resembles the others in that the only fossils are minute forms, allied to those usually regarded as freshwater types.

The Uffington shale of I. C. White, the roof of the Upper Freeport coal bed, often yields abundance of plant remains, but at some widely separated localities on the eastern side, in Monongalia and Upshur counties of West Virginia, as well as in Wirt county of the same state, far within the Central area, it has a marine fauna accompanied by fragmentary remains of plants. Whether or not the fauna exists elsewhere in the Central area is unknown, as the horizon is below the surface and the well records are of no service. The distribution of this deposit is without explanation in the present

[87] The observations by I. C. White, W. G. Platt, Chance, Newberry, Orton, Hodge and E. B. Andrews are recorded in "Carboniferous," etc., as above, Vol. 17, 1906, pp. 98–103, 113, 109–113, 116–121, 128.

state of knowledge. Where plant-bearing, this shale resembles the ordinary roof shale, but where carrying remains of animals it is black, somewhat sandy and occasionally somewhat fetid. It recalls conditions described by A. Agassiz as existing in the Pacific ocean between Mexico and the Galapagos islands.

The Uffington shale was followed by the often coarse and massive Mahoning sandstone, containing one or more coal beds of considerable extent, and that in turn was succeeded by a coal bed underlying the Brush Creek limestone of I. C. White, the Black Fossiliferous limestone of the early Pennsylvania reports. This dark, almost black rock, enclosed in black shales, is the first limestone which crossed the bituminous region and reached the line of the Allegheny Mountains—it is recognized without doubt in western Maryland. The deposit is wanting along practically the whole eastern outcrop in West Virginia and most probably throughout the interior of that state, for it has not been found under the great anticline in Wirt county and black shale, at this horizon, is not recorded by the drillers of oil wells. It is persistent in western Pennsylvania, which it enters from Preston county of Virginia and Garrett of Maryland. The area, narrow at first, widens to 15 or 20 miles farther north and retains that width to the Ohio line. Thence it is present for 40 or 50 miles southwestward into Jefferson county of Ohio, beyond which it seems to be wanting for about 30 miles. But it reappears and is followed easily into Muskingum county, beyond which no trace exists, the horizon being exposed at very many places. The gap beyond Jefferson county is evidently due to erosion, but there is no reason to suppose that the limestone ever existed south from Muskingum county. The limestone and shales are crowded with a marine fauna and the conditions indicate that it was deposited in an estuary opening at the east.[88]

The Cambridge limestone of E. B. Andrews is at a little distance higher in the Conemaugh column. A marine limestone, very near this horizon, is in western Maryland, but that locality is more than 75 miles east from the nearest outcrop of the Cambridge; its rela-

[88] For the observations by Martin, I. C. White, Newberry, Stevenson, and Orton, see "Carboniferous," etc., as above, pp. 167–189.

tions are with the eastern side. The most easterly point in Pennsylvania, at which the Cambridge can be recognized with certainty, is almost 60 miles east from the Ohio line and about 70 miles north from that of West Virginia. Thence it is persistent into Ohio. The direction of the area is almost westward in Pennsylvania but in Ohio it becomes west of south, and the bed is easily followed across that state and Kentucky to the last exposure of its horizon. In southern Ohio and in Kentucky it extends eastward beyond any predecessor and at the south it reaches into West Virginia; but it is absent under the Wirt anticline in both Ohio and West Virginia. In Pennsylvania, its area is far less than that of the Vanport and the thickness rarely attains 8 feet. The distribution of the deposit indicates a return to the earlier condition, as this is confined to the west side. The abundant fauna is marine.[89]

Midway in the Conemaugh is the remarkable deposit, the Ames limestone of E. B. Andrews, the Green Fossiliferous limestone of the early Pennsylvania reports. It overlies the Pittsburgh reds, from which it is separated in extensive areas by the Harlem coal bed and the associated shales. It has not been discovered anywhere east from the Allegheny Mountains unless one accept as its equivalent the Mill Creek limestone of the Northern Anthracite field, which certainly is in the Conemaugh, possibly not far from the Ames horizon. The Ames is thin, seldom more than 4 feet, and is more or less argillaceous, especially on the eastern side. The color is bluish green, thoroughly characteristic in most of the area, so that the bed is a most important stratigraphic guide. Along the eastern border it has been recognized positively to 75 miles south from the Pennsylvania line; it is present in western Maryland and southwestern Pennsylvania, wherever its horizon is exposed; it is equally persistent in Ohio and Kentucky, being the Fourth Fossiliferous limestone in the latter state. It extends on the west side to the middle line of the basin, being exposed under the Wirt anticline in both Ohio and West Virginia. It was deposited in an area

[89] For observations by Martin, I. C. White, W. G. Platt, Stevenson, Orton, Andrews, Lovejoy and Bownocker, see "Carboniferous," etc., as above, pp. 168, 175–180, 183–194, 197–201.

of not less than 16,000 miles, possibly much more, since no information can be derived from the ordinary well records. This widely extended deposit was certainly not continuous with the Mill Creek limestone of the Northern field; the nearest outcrops of the two rocks are separated by 150 miles, including a part of the bituminous region in which the Ames never existed. The fauna is marine throughout, even on the extreme western border in Meigs county of Ohio where Condit[90] found the limestone impure, sandy, ferruginous, conglomeratic with pebbles of sandstone and with sun cracks on its upper surface. This marine invasion, affecting the greater part of the Conemaugh area, followed the deposition of the fine muds known as the Pittsburgh reds and was succeeded by the Washington reds. Even where the reds are absent, the limestone is usually between deposits of fine grain. Marine conditions preceded it and continued after it; shales equivalent to the Pittsburgh reds carry a marine fauna at some localities and, in Pennsylvania, marine forms persisted up to 50 feet above the limestone.[91]

The only limestones in the anthracite region are in the northern field, where they were seen by Ashburner. Three of them are without fossils but the fourth, the Mill Creek at 688 feet above the Baltimore coal bed and one foot thick, has a marine fauna. A black shale at Dundee, in the same field and 250 feet above the limestone, has the same assemblage of fossils. A peculiar feature of this fauna is that it includes some forms unknown elsewhere in the Appalachian basin, though abundant in the coal area beyond Cincinnatia—which seems to indicate communication by some other way than that at the southwest.

Marine invasions practically ceased with the Ames episode: there are other beds of limestone in the upper part of the Conemaugh but they appear to be at least non-marine.

Five limestones have been recognized in the Monongahela, but they are confined to a small space in southwestern Pennsylvania and

[90] D. D. Condit, letter of April 24, 1912. The locality is Sec. 10, Salem township, Meigs county.

[91] The observations by I. C. White, Stevenson, W. G. Platt, Martin, Newberry, Hodge and Andrews are recorded in "Carboniferous," etc., as above, pp. 167–202, 208, 211, 215.

immediately adjacent parts of Ohio and West Virginia, in all less than one fifth of the present area of the formation. The deposits are especially important in Pennsylvania between the Monongahela and Ohio Rivers, perhaps 2,000 square miles, but they disappear rapidly in all directions. The extreme development is near Wheeling on the Ohio, where one finds 154 feet of limestone in 190 feet of measures; but nearly the same thickness is shown near the Monongahela, where, however, the section is longer, as it has sandstones and shales which are wanting at Wheeling. These deposits vary from almost pure limestone to calcareous shale, and in much of the area they are in layers one to 4 feet thick, separated by much thinner layers of calcareous shale. Their appearance is so characteristic that one familiar with them in any locality could hardly mistake Monongahela limestones elsewhere for those of any earlier formation. Animal remains are confined to a few types. Minute forms, resembling the ostracoids found in the upper limestones of the Conemaugh, are abundant at many places. Teeth of *Helodus* and a spine of *Ctenacanthus marshii* have been collected from midway in the formation within Washington county of Pennsylvania; the fourth limestone is rich in *Naiadites* near Uniontown, Pennsylvania, and a blue shale near Morgantown, West Virginia, contains abundance of *Solenomya.* The fish remains are the same with those which abound in the marine limestones of Illinois, but these marine forms are evidence of sea invasions so brief as to have no significance, for they are unaccompanied by marine molluscs. All the features indicate that the Monongahela limestones are, in greatest part, of freshwater origin.

The Washington formation has six limestones, confined practically to Greene and Washington counties of Pennsylvania, all, except one, disappearing quickly in each direction. They resemble those of the Monongahela, some being covered with similar forms, thought to be of freshwater types. Larger fossils are very rare. I. C. White obtained from a black shale in the upper portion scales of *Rhizodus* and other fishes, which are most probably freshwater in their relations, as the same genera occur in a cannel layer at Linton, Ohio. The Greene formation has many limestones within southwestern Pennsylvania, but apparently most of them are mere lenses and few of them can be regarded as definite members of the section, though they are the striking feature in the lower half of the formation. The Nineveh limestone, however, is persistent, having been recognized along a line of more than 100 miles, and is 22 feet thick at its last outcrop in West Virginia—strangely persistent in an area where every other bed in the column is changeable. Although the beds have small extent, the quantity of limestone in the Greene is very great. Fossils are rare; minute forms, mostly ostracoids, occur in many beds and occasionally one finds in the shales a form resembling *Naiadites*. Some of the more argillaceous limestones contain much finely comminuted vegetable matter.

The composition and structure as well as the fossils in many limestones above the Ames horizon have led to the belief that they were deposited in freshwater basins; and evidence of like character is not wanting in some of the Allegheny limestones.

I. C. White[92] found that the Upper and Lower Freeport limestones are very often brecciated in some of the layers and concluded that they had been deposited as muds in inland lakes—conclusion very like that of E. B. Andrews presented in 1873. Ostracoids are abundant in the Upper Freeport. Farther south in Pennsylvania, the brecciated limestones appear toward the end of the Conemaugh and the fossils are ostracoids along with forms resembling *Spirorbis*. The limestones of the Monongahela, Washington and Greene are brecciated at very many localities and some of them rarely show normal structure. Ostracoids and *Spirorbis*-like forms are extremely abundant in some.[93] Hyde's[94] observations in Ohio prove that conditions are the same in that state. A limestone in Noble county, below the Ames, about 10 feet thick, has an irregular top owing to erosion prior to deposition of the overlying sandstone. The upper surface is mud-cracked and the cracks are filled with

[92] I. C. White, Sec. Geol. Surv. Penn., Rep. Q, 1878, contains numerous illustrations; Rep. Q2, 1879, p. 220.

[93] J. J. Stevenson, Sec. Geol. Surv. Penn., Rep. K, many references.

[94] J. E. Hyde, "Desiccation Conglomerates," *Amer. Journ. Sci.*, IV., Vol. XXV., 1908, pp. 400–408; letter of January 12, 1912.

shale. Some layers are crowded with tubes resembling those of annelids. The overlying sandstone contains limestone fragments in the lower portion. A conglomerate limestone in Belmont county, and very near the top of the Conemaugh, shows shrinkage in the limestone fragments. The Monongahela limestones in the same county vary from hard to soft, often becoming calcareous shale. Shrinkage cracks are so numerous at times as to give a brecciated structure. These limestones contain several species of minute ostracoids which are very abundant, and in some beds one species of ostracoid is well represented. These cover the bedding planes and are shown especially well on sun-cracked surfaces Conglomerate layers are frequent, varying in thickness from half an inch to 3 or 4 inches, and the fragments are from pea-size to several inches in diameter. Hyde thinks the deposits are of freshwater origin like the freshwater limestones in some of the western states and he conceives that they represent the calcareous mud laid down in probably shallow bodies of water. During the summer, the water was evaporated and the ostracoids with the *Spirorbes* were left on the muddy surface, which, exposed to the heat, became sun-cracked. A similar explanation was suggested by Haast[95] who, in describing some Tertiary marls, says that they must have been "left high and dry, exposed to the effects of a powerful sun, is well shown by numerous cracks in the clay marls, which are several inches wide and deep."

Brecciated limestones have been reported frequently from other lands and the explanations offered are not wholly concordant. Roeder[96] found in the Lancashire field a succession of red shales and clays with thin coals and two limestones, in all somewhat less than 900 feet thick. At Slade lane he saw 206 feet of measures, mostly red, green or variegated shales with in all 21 feet 4 inches of limestone. Some of the limestones are brecciated locally and the passage from breccia to the normal structure is gradual. The frag-

[95] J. Haast, "Report on Geology of the Malvern Hills, Canterbury," Rep. Geol. Surv. N. Z., 1872, pp. 63, 64.

[96] C. Roeder, "Notes on the Upper Coal Measures at Slade Lane, Burnage," *Trans. Manch. Geol. Soc.*, Vol. XXI., 1890, separate, pp. 7–22.

ments are from pinhead to 2 inches and the larger ones are angular, the edges at times jagged; the smaller pieces are more rounded. In weathering, the fragments give way first, which leads Roeder to suppose that they must have suffered from subaerial exposure before entombment. He regards the condition as proof of occasional elevation and exposure, when older limestones were broken up and either transported or left *in situ*. Additional evidence in favor of this conclusion was found in his discovery of angular fragments of the *Spirorbis* limestone in sandstone at Ardwich. He cites Hull and Williamson to show the wide occurrence of brecciated limestone in England.

De Dorlodot[97] discussed the great breccia in the upper part of the Carboniferous within the Franco-Belgian basin. He says that some geologists have supposed it to be due to dynamic action, but he believes it sedimentary, due to destructive attack by waves and the rapid accumulation of the products. The elements vary much in size and the paste, filling spaces between large and small blocks, is itself partly limestone. The fragments, large and small, have their angles but slightly rounded. In any event, they could not have come from far.

Stainier[98] took vigorous exception to de Dorlodot's explanation, because nothing of the sort is known in actual times. The supposed conditions exist at many places along the coast of Great Britain, but no breccia forms. If, by change in conditions, the shallow Carboniferous sea should be dried up completely, the exposed limestone would be a desert surface. The contrast in temperature would break up the rock and give material for the breccia. When the sea returned and invaded the area, it would sort the materials. The coarse blocks would be moved little, the less coarse, farther; by insensible gradation one passes to the compact limestone which, east from Namur, occupies the breccia horizon.

It is difficult to believe that the brecciation was caused by ex-

[97] H. de Dorlodot, "Sur l'origine de la grande brèche Viséene," *Bull. Soc. Belge de Geol.*, Vol. XXII., 1908, Mem., pp. 29–38.

[98] X. Stainier, "Du mode de formation de la grande brèche du Carbonifere," *Bull. Soc. Belge de Geol.*, Vol. XXIV., 1910, P. V., pp. 188–196.

posure after the limestone had become consolidated; the features in most cases are those observed where a moist material, still soft, is exposed to the air; the brecciation is that of cracking due to loss of moisture. Haast's explanation, more or less modified by later students, is evidently the one most closely related to the facts.

Perhaps some reader may hesitate to believe that limestones as thick as those of western Pennsylvania can be of freshwater origin; but they are not greater than some recent marl deposits within the United States. Davis[99] has discussed the whole subject showing the mode in which the material accumulates and its relation to peat deposits. D. J. Hale, in the same volume, described many Michigan deposits, 20 to 47 feet thick. Blatchley and Ashley[100] have shown that conditions are the same in Indiana as in Michigan. They are convinced that the supply of calcareous matter was ample in later Coal Measures times, for limestones must have cropped out in extensive areas and the springs in much of the region must have been charged with dissolved limestone. But both the Appalachian limestones and the western marls are insignificant when compared with those of the Tertiary lignite area of l'Aude in France.[101] The section at Cavonetti shows at top a freshwater limestone, nearly 80 meters thick. Some of its beds are rich in river shells and others are equally rich in *Lymnæa* and *Planorbis,* which are found also in the shales and in the lignite. A similar limestone, 10 to 15 meters thick, is lower in the section and the lowest member exposed is of the same type.

The presence of *Spirorbis* has been regarded by some as an objection to acceptance of freshwater origin for the limestones, for beyond all doubt that form is related to marine types. It occurs throughout the Coal Measures column, sometimes in deposits which are certainly marine and at other times in deposits which are dis-

[99] C. A. Davis, "A Contribution to the Natural History of Marl," Geol. Surv. Mich., Vol. VIII., Pt. III., 1903, pp. 65–96.

[100] W. S. Blatchley and G. H. Ashley, "The Lakes of Northern Indiana and their Associated Marl Deposits," Twenty-fifth Ann. Rep. Geol. Surv. Ind., 1901.

[101] (M) de Serres, "Observations géologiques sur le Département de l'Aude," *Soc. des Sci. Lille,* 1835, pp. 453–455.

tinctly not marine. The best summary of the conditions was given by Barrois,[102] who was led by the apparently contradictory modes of occurrence to make thorough investigation of the whole subject. Some of his conclusions will find place in another connection but others are of interest here. He found *Spirorbis* shells attached to living plants, to plant débris, to brackish and even to essentially salt water animals. In the larval condition, the type is free but in the adult, fixed. It is allied to *Vermetus* and *Spirorbis* of the present time, all marine. To reconcile the existence of such forms on plants essentially terrestrial, one must admit that the original Carboniferous *Spirorbis* lived fixed on marine shells; that the descendants became habituated to brackish water, where they attached themselves to *Carbonicola;* and at last to fresh water, where they became fixed on ferns. It is very evident that the conditions noted by Barrois exist in the Appalachian basin, so that the presence of *Spirorbis* cannot be regarded as evidence for or against any hypothesis respecting the character of the water.

It is quite possible that the occurrence of *Naiadites* may be evidence of brackish water invasions.

Reference has been made to very dark carbonaceous or bituminous limestones, of which the Brush Creek may be taken as type. They are not numerous. Their fauna is marine, they are often fetid and, at times, have some vegetable matter. The Brush Creek limestone, as has been shown, occupies a long narrow area, bordered by shales and sandstones and, at some localities in both Pennsylvania and Ohio, it suffered severely from erosion prior to deposition of the overlying rock. De Dorlodot[103] has discussed the origin of sapropelic limestones and his conclusions seem to require examination at this point. Some crushed polyps, exhibited at a meeting of the Geological Society, were in a gangue which had undergone slow compression, such as that which Potonié had recognized as characterizing sapropelian muds. A. Renier had accepted sapro-

[102] C. Barrois, "Sur les Spirobes du Terrain Houiller de Bruay (Pas-de-Calais)," *Ann. Soc. Geol. du Nord.*, Vol. XXXIII., 1904, pp. 50 et seq.

[103] H. de Dorlodot, "Sur les conditions de dépot des marbres noirs dinantiens et des sapropelites marines en général." *Bull. Soc. Belge de Geol.*, Vol. XXV., 1911, P. V., pp. 146 et seq.

pelian origin for the black limestone of Hun and F. Kaisin had done the same for the Dinant marbles. De Dorlodot agrees with Renier that the limestone is marine but dissents from the opinion that it is a coast deposit. The conditions and stratigraphical relations had led him to believe that it was deposited far from shore, for the deposits are not local, they are extensive and their lithological character suggests deep-sea origin.

According to de Dorlodot, Renier's decision in favor of shore deposit depends upon the presence of terrestrial plants and of sapropelic matter in the limestone; but presence of remains of terrestrial plants is irrelevant, for A. Agassiz found them far from shore and in deep water off the Pacific coast as well as in the Gulf of Mexico. Sapropel deposits can be formed along coasts only in lagoons or in bays protected against movement of the waves. Proximity to the coast is not possible, for action of the waves would cause continuous oxygenation of the water. The deep sea would be most favorable to accumulation. He supports his opinion by reference to carbonaceous shales of the Toarcien, asserting that their geographical extent is proof that they were not deposited in isolated bays, while their fauna proves deposit in the maximum of immersion—and those shales contain remains of land plants. The fact that deep sea soundings in our day show no sapropelian deposits is not final. The problem is not to explain why the old marine rocks are so rich in kaustobiolithic materials, but why modern deep sea deposits are so poor. The problem may be stated in another way. How is aerobian life possible in great depths of the ocean so as to cause destruction of the organic matter which the plankton must afford? This is explained by the bottom-creep of oxygenated water from the poles; in the Black sea, which is beyond the influence of that creep, there are only anaerobic organisms in its depths. Sapropelic character does not prove shore origin—it rather tends to establish and at times to demonstrate deposition at distance from the shore and at great depths. De Dorlodot believes that the limestones under consideration were deposited far from the coast and in calm water.

It is difficult to discover the force of this reasoning and equally difficult to understand the bearing of some of the arguments upon others. That from geographical extent is unimportant for the Brush creek limestone has been traced 150 miles and it must have had a notable area in the now eroded region at the east. Nor does it seem essential to deposition of sapropel that the water be calm. Potonié has told of extensive lakes in Germany, formerly navigable but now choked with sapropel. The surface of navigable lakes, great or small, is apt to be churned into waves. No reason can be assigned why the Frische Haff, at the mouth of the Vistula, may not be filled with sapropel, provided conditions remain as now. The presence of fragments of land plants is not of itself final evidence of deposit in shallow water or on an offshore area; but the discoveries by A. Agassiz hardly relate themselves to the matter, for he did not report the presence of sapropel material in mud holding fragments of rotten wood, though the region is one as favorable to accumulating such material according to de Dorlodot's conception as one can imagine. The arctic creep must be at its minimum in the Gulf of Mexico. One may hardly refrain from suggesting that de Dorlodot has not conceived the problem fairly. Unquestionably the absence of kaustobiolithic materials from deep sea deposits of this day is as perplexing as interesting and the explanation offered by that author may or may not be correct. But that is not the serious problem, for most of the Coal Measures marine limestones are as free from sapropel as are the present deep-sea limestones, so that conditions then were very much like those of this time. The assumption throughout the discussion is that the marine fauna of the limestone indicates very considerable depth of water, the maximum of immersion. Even this is open to question. True, it is in accord with the prevailing opinion, which, having been unchallenged for a long period, has become, for many, one of the fundamental pillars of geology. Studies by palæontologists in the Appalachian areas lend no support to the belief that deep water covered the Appalachian basin during the Palæozoic and the stratigrapher hails their conclusions with gratification, as they coincide with his own. These conclusions and the arguments supporting them will be found on a later page. The arguments are applicable equally to conditions in other lands.

The use of the term currents to explain local conditions is apt to be misleading. There is no good reason for supposing that there were any currents in the Appalachian basin. The close succession of often coarse sandstones upon marine limestones, even upon sapropelic limestone, shows that the deposits were near a shore.

A review of the conditions leads to conclusions the same as those suggested by deposits of other materials. The marine limestones are local, are in areas which, for the most part, can be determined closely. Those of the earlier formations are found on both sides of the Alleghenia ridge, but the localities, at which observations have been made, are too widely separated to admit of an attempt to determine their relations. The Beaver and Allegheny limestones, however, have been traced in detail. On the western side, within the Ohio basin (of Schuchert), they followed in a general way the direction of the pre-Beaver valley in Ohio but as they approached the Pennsylvania line, they turn eastward into that state. This variation becomes notable in the Vanport, which seems to have followed rather closely in Pennsylvania the lines of valleys eroded during the immediately preceding times. There can be no question that the early drainage line, established prior to Beaver time, persisted until the middle of the Allegheny and that it determined the area of sea-invasion, as the old river valleys along the Atlantic coast have done in recent times. The extent of the limestones, though they follow the same line in great part, shows that the estuaries, due to drowning of the valleys, were not of equal length. When one examines the conditions on the eastern side, he finds that, in the Beaver and Allegheny, the marine limestones occur within a small area in West Virginia. Erosion has removed the Pennsylvanian from a great expanse on the eastern side so that the relations of these limestones cannot be determined beyond the present exposures, but the deposits seem to mark the upper portion of successive estuaries along the same general course. The sea-invasion on this side may not have reached so far north as on the western.

In the early Conemaugh, the conditions were somewhat different.

The long serpentine course of the Brush Creek limestone from Maryland to central Ohio shows that, while there had been no great topographical change and the whole area was still lowland, there had been enough change during deposit of the underlying sandstone to make possible, by slight submergence, a broad, continuous drowned valley across nearly the whole bituminous region,—from very near the eastern outcrop westward to the line of the pre-Beaver valley. This depression did not affect the southwestern part of the region as there is nothing there answering to the Brush Creek; the invasion was from the east. But during the next interval, the earlier conditions were restored and one finds the Cambridge limestone following approximately the course of the Vanport in Pennsylvania, Ohio and Kentucky, though reaching farther eastward in the latter states. But at about the same time, there was a new invasion on the eastern side along the line of Brush Creek estuary, for a marine limestone is present in western Maryland while farther west near the Monongahela River in West Virginia, there is a non-fossiliferous limestone, which may represent the shore phase of the same deposit.

The Cambridge limestone marks the temporary culmination of a long continued subsidence which brought a constantly widening area on the west side to sea-level and eventually below it. That area continued to widen eastward and reached its maximum when the Ames limestone was deposited. Peneplanation of the bituminous region had become far advanced; for a long period only fine material had been brought down by the streams and a very great part of the region had become converted into mud flats through which the streams meandered in shifting channels, sorting the fine clays and sands. The rivers must have emptied into estuaries around the border for marine conditions existed as far north as the southern line of Pennsylvania just prior to the Ames. Limestone deposition began first at the west, the thickness and purity of the rock being best marked in Ohio, and advanced east and northeast until the bed covered a great part of the bituminous region. The efflux of the cleaner water was abrupt, but the limestone is followed by fine deposits at most localities and it was not until 70 feet of shales had been laid down in much of the region that the normal conditions were restored. It is possible that the 70 feet of muds, in which there is evidence of marine life, may be the measure of the extreme possible depth at which the Ames limestone was deposited. Indeed one is tempted, in view of conditions observed on islands in mid ocean, to suggest that the abrupt appearance of muds above the Ames might be regarded as evidence that the limestone was deposited in very shallow but very clean water; and the temptation is the stronger, because stream-sorting appears in the arrangement of materials composing the overlying shale.

Were these limestones deposited in deep water? The testimony of the fossil remains in answer to this question will be examined on a succeeding page; but there are several matters to be considered here. In some cases, the limestones can be followed to their disappearance. The Vanport limestone in Pennsylvania ends in long prongs within Pennsylvania, gradually passing into sandstone, débris from the sides of the valleys in which the limestone terminates. And fossils continue after the change has begun. The western edge of the Ames limestone was reached by Condit in Meigs county of Ohio, where that rock, still fossiliferous, is rippled and is conglomerate with quartz pebbles. This condition is not unknown in other limestones of the Carboniferous; if verbal statements of geologists, who cannot recall localities, may be accepted, the condition is familiar. The writer is indebted to Butts[104] for specific instances in earlier formations. Shrinkage cracks and wave marks are abundant in marine fossiliferous rocks of Stones River and Black River age in southern Tennessee, where the deposits, he is convinced, are of shallow water origin. In the Cahaba valley of Alabama, on the border between the Bessemer and Montevallo quadrangles, he discovered at the base of the Stones River (Chazyan) limestone, a pebbly bed, which was examined in an area of several square miles. At one locality, the pebbles are comparatively few and occur in a layer never more than 2 feet thick; but elsewhere the vertical distribution is much greater, becoming 20 feet, in which fragments are abundant, while small pebbles occur throughout the higher portion of the bed. The pebbles are of quartz, quartzite and chert, varying in size from three fourths of an inch down. Many are

[104] C. Butts, letter of June 21, 1912.

well rounded, but those which are angular or subangular are quite as abundant. *Maclurea magna* and a considerable number of other forms are present in the limestone containing the pebbles. This locality must have been very near a shore line; there is no evidence to suggest that the shore was precipitous and one must agree with Butts that deposition in shallow water is indicated, although, according to accepted doctrine, the fossils suggest deep water. The presence of fossils in the Chazyan limestones as well as in the Ames and Vanport, where the rock is changing into merely calcareous sandstone, makes clear that the presence of marine fossils is not to be taken as final evidence of deposition in deep water.

The Testimony of the Fossils.—There are few fossiliferous horizons in the Appalachian basin and collections have been made at not many localities. But, if one bear in mind that the areas of marine deposits are comparatively insignificant, the number of collections will appear sufficient.

A systematic collection of Mercer forms was made in the Zanesville-Newark region of Ohio[105] and some notes respecting the fauna of the same horizon in Pennsylvania were given by I. C. White. In the Ohio area there were obtained species as follows: One crinoid, 1 coral, 5 bryozoans, 3 inarticulated brachiopods, 13 articulated brachiopods, 40 pelecypods, 14 gastropods and 2 cephalopods. Raymond[106] has given a list of forms collected by him from the Vanport at several localities in Beaver county of Pennsylvania; it shows 3 corals, 2 bryozoans, one inarticulated brachiopod, 14 articulated brachiopods, 3 pelecypods, 20 gastropods and 3 cephalopods. I. C. White added to this list from Lawrence county 2 crinoids, 1 articulated brachiopod, 7 pelecypods, 5 gastropods and 1 cephalopod. Twenty-three species are common to the Mercer and Vanport in these lists. Probably the Vanport list is incomplete, as a consider-

[105] Clara G. Mark, "The Mercer Limestone and its Associated Rocks in the Zanesville-Newark Region." *Bull. Sci. Labor. of Denison Univ.*, Vol. XVI., 1911, pp. 267–314; I. C. White, Sec. Geol. Surv. Penn., Rep. Q, p. 68; Rep. Q2, p. 61.

[106] P. E. Raymond, "A Preliminary List of the Fauna of the Allegheny and Conemaugh Series in Western Pennsylvania." Topog. and Geol. Surv. [of Penn.], 1911, pp. 83, 84.

able number of the Mercer forms are not recorded, though they have been found in the Conemaugh of Pennsylvania and West Virginia. It is equally probable that the Mercer list is local only, as some forms mentioned in the Palæontology of Ohio are not given.

The first deposit of the Conemaugh is the Uffington shale, which is rich in fossils at some places within northern West Virginia. The important list is that by Meek[107] of forms collected at Morgantown, a few miles south from the Pennsylvania line. There are 4 articulated brachiopods, 8 pelecypods, 11 gastropods, 3 cephalopods, to which Stevenson in later collections added 1 coral, 2 crinoids, 4 pelecypods and 3 cephalopods. The rock is a black shale, more or less ferruginous, the conditions being very different from those of the Vanport and Mercer, yet, in this collection of 26 species made at an exposure of about 25 square feet, there are 14 species in common with the Vanport and 12 with the Mercer. The Brush Creek limestone and associated shales are separated from the Uffington below by the Brush Creek coal and the Mahoning sandstone. Lists from Pennsylvania have been given by Raymond and White and a brief list of forms collected in western Maryland has been published by Martin.[108] The list by Raymond contains 1 coral, 1 inarticulated brachiopod (*Lingula*), 12 articulated brachiopods, 9 pelecypods, 15 gastropods, 5 cephalopods. To these, White adds one pelecypod and Martin adds a crinoid and an articulated brachiopod. Thirteen species are in common with the Mercer and 16 with the Vanport. Omitting the Cambridge, to avoid repetition, one comes to the Ames limestone, which is actually continuous over a greater area than that of any other deposit in the whole column. Raymond's[109] list from five localities on the Pennsylvania railroad, east from Pittsburgh, contains 1 coral, 2 inarticulated brachiopods, 15 articulated brachiopods, 6 pelecypods, 10 gastropods and 4 cephalopods. The inarticulate brachiopods and the pelecypods are rare. Stevenson gave lists

[107] F. B. Meek, "Lists of Carboniferous Fossils from West Virginia," *Third Rep. Regents of W. Va. Univ.*, 1871, pp. 68–70.

[108] P. E. Raymond, loc. cit., pp. 85–87; I. C. White, Rep. Q, p. 34; G. C. Martin, West Va. Geol. Surv., Vol. II., 1903, pp. 280, 281.

[109] P. E. Raymond, loc. cit., pp. 89–92; J. J. Stevenson, Ohio Geol. Surv., Vol. III., 1879, pp. 207, 223.

of forms occurring in Guernsey and Harrison counties of Ohio, where the rock is a fairly good limestone. He found 2 corals, 1 crinoid, 1 inarticulated brachiopod, 15 articulated brachiopods, 2 pelecypods, 7 gastropods and 1 cephalopod. Condit in 1909 published a list from Meigs county, Ohio, which adds two species of articulated brachiopods. Meek's list from near Morgantown is in contrast with that just given, for it shows one species of inarticulated brachiopods, 10 articulated, 12 pelecypods, 7 gastropods, 2 cephalopods, to which Stevenson at a later date added one articulated brachiopod, 6 pelecypods and one gastropod. The contrast is due to the fact that the collection, studied by Meek, was made at a locality where the Ames limestone is obscured in a mass of fossiliferous shales extending downward into the horizon of the Pittsburgh reds. At a mile north, the limestone is distinct and has no pelecypods except *Myalina* and *Aviculopecten*. In comparing these lists with those from earlier deposits, one finds 23 species in common with the Vanport and 24 with the Mercer. The Ames limestone is succeeded in Pennsylvania by shales, at times 70 to 80 feet thick, in which Raymond found marine forms at several levels. They are not abundant, but 2 species of articulated brachiopods, 6 of pelecypods and one cephalopod were recognized and an *Orbiculoidea* was found near the top of the deposit at 75 miles east from Pittsburgh.

It would seem that distribution of the organic types depends often upon the character of the rock. Miss Mack observed that pelecypods are more abundant in the shaly layers and brachiopods are more abundant in the purer limestone. Raymond's lists indicate that brachiopods are very numerous in his Vanport localities, where the limestone is good; it may be that, where White obtained so many pelecypods, the limestone is broken by calcareous shale. The Ames limestone is comparatively pure where Raymond's collections were made and in Ohio it is a good limestone; pelecypods are very rare —6 species are recorded but individuals are very few. Near Morgantown, West Virginia, the Ames yields no pelecypods except *Myalina* and *Aviculopecten*, whereas pelecypods and gastropods are abundant in the associated shale, the latter, at times, making up the greater part of the mass. Brachiopods are less common in these shales, but they are of the same species as in the overlying limestone and of equal size.

The lists, as has been said, are local; they do not suffice for comparison of faunas at the several horizons; but that is unimportant here. Each locality has been examined with such care as to give a just conception of the manner in which the several groups of organisms occur. It should be kept in mind that fossiliferous beds are not only fewer in number within the Appalachian Pennsylvanian than in the region west from Cincinnatia, but also very much less prolific in species and less commonly so prodigal in individuals. These features suggest to the paleontologist that marine conditions in the Appalachian basin were abnormal.

The cœlenterates give no information respecting the conditions. Only two species of coral have been found and one of them has no preference for limestone over shale, individuals being equally abundant in both. One of the crinoids has a similar distribution.

Few species of bryozoans have been reported but these abound at several horizons. They are found in pure and impure limestones as well as in shales containing very little calcareous matter. They are characteristic of somewhat sandy shales in the Waverly of northern Ohio. Ulrich[110] says that bryozoans of recent time flourish best in water depositing slightly argillaceous limestone—relatively quiet water—and at depths little beyond the zone of violent wave action. The habits of these animals seem to justify the conclusion that the limestones and other beds in which they abound, the Mercer, Vanport and Cambridge, were deposited in comparatively shallow water, probably less than 100 feet deep; and this conclusion is strengthened by the fact that in some localities the area of those limestones was so restricted that violent wave action would be hardly possible.

The brachiopods, at first glance, are less definite. According to Schuchert,[111] among recent species of inarticulated brachiopods 24 live between high tide and 90 feet; 7 between 90 and 600 feet, and only one at great depths. *Lingula* and *Discina* are unknown below 90 feet but *Crania* and *Discinisca* occur at greater depth. The inarticulated forms have changed comparatively little in character since

[110] E. O. Ulrich, *Bull. Geol. Soc. Amer.*, Vol. 22, 1911, p. 252.

[111] C. Schuchert, *Bull. Geol. Soc. Amer.*, Vol. 22, 1911, pp. 258–275.

their first appearance and, in all probability, as little in their habits. For the most part, they cling closely to the strand in recent times. Articulated brachiopods of the present day require deeper water and 84 of the living 129 species belong between 90 and 600 feet. Rhynchonellids are never found in shallow water; but this was not always the condition, for in the older rocks they often occur abundantly with thick-shelled lingulids in coarse sandstones and mud beds. The terebratulids range from between tides downward. Of all living brachiopods, 81 per cent. are bound to shallow waters, 7 per cent. are found in the deeper waters of continental shelves and only 11 per cent. occur at greater depths.

Applying Schuchert's results to the Appalachian basin, one finds that *Lingula* and *Orbiculoidea* (*Discina* of authors) are common in the dark roof shale of the Middle Kittanning coal bed of Ohio and that *Lingula* is found in several roof shales within Kentucky. It is present at the Brush Creek horizon. *Orbiculoidea* is reported from the Mercer and the Ames, one species being common to both, and the same genus has been obtained from the upper part of the muds and shales following the Ames. These forms are not numerous in the limestones but they abound in some shales. The individuals are seldom more than five eighths of an inch long but that size is excelled only by forms in coarse rocks. Of the articulated brachiopods, the rhynchonellids, which now prefer deep cold water, and the terebratulids, most of which now inhabit the deeper shallow zone, are feebly represented in the Pennsylvanian—perhaps because these brachiopods were little differentiated at that time. Of the other types, practically all belong to families now extinct and one must determine their habits by the record which they have left in the rocks. The productids attained noteworthy size in the later Devonian coarse sandstones, where they are associated often with heavy-shelled *Lingula* or *Discina*. They are abundant in both the pure and the muddy limestones of the Maxville. Eight species of *Productus* are reported from the limestones and shales of the Pennsylvanian within the bituminous region, one being common to all the lists, 2 to four of them, 2 to three, two belonging to the Conemaugh and one being confined to the Vanport. Five species are found in limestone and shale alike and two are abundant in shale which contains only a trace of calcareous matter. The Spirifers are represented by two species, one of which is in shale as well as limestone and its size is the same in both. Sandstones with marine forms seem to be few in the Appalachian basin and the fossils are rare; but such sandstones are numerous in the Devonian of that basin. Spirifers of the later type attain great size in the coarse Oriskany sandstone where they are associated with huge *Discinæ;* while in the later Devonian they are present in the coarser beds of the Chemung, often appearing in great numbers. The athyrids are the same throughout, whether the rock be limestone or shale. A few of the Pennsylvanian brachiopods occur only where the limestone is free from sand or clay, but that proves only that they preferred the cleaner water; it has no bearing on the question of depth, for within a few yards the limestone shades off into calcareous shale. Condit's discovery of the Ames fauna near the western shore line, where the rock is sandy, conglomerate and wave marked, shows that the animals existed in shallow water. Butts's observations on the Ordovician fauna are equally definite. The evidence is so clear respecting the Pennsylvanian brachiopods, that one is tempted to believe about all the genera, as Schuchert has suggested respecting the rhynchonellids, that they were originally forms belonging to shallow water, and that the tendency of so many modern forms to prefer deeper water is a modification due to subsidence of coastal areas. As far as the testimony of brachiopods is concerned, there is every reason to suppose that the marine deposits were laid down in shallow water.

The pelecypods of the Pennsylvanian within the Appalachian basin are allied, for the most part, to families which in recent times have great vertical distribution. Pectens range from 2 to 200 fathoms; Limas from 10 to 150; Arcas from low water to 200; but aviculoid forms seem to go no deeper than 20 fathoms. At the same time, one must bear in mind that, while many genera have great vertical range, there is, in most of them, a large number of species which are confined to water as shallow as that preferred by *Lingula* and *Discina.* It is certain that most of the Coal Measures pelecypods thrived best where the water carried clay or sand and thrived poorly where pure limestone was deposited. Few pelecypods were obtained from the limestone at the Mercer horizon but they abound in the calcareous shale; the Brush Creek limestone and black shale has abundance of brachiopods and pelecypods, the latter especially numerous in individuals; the Ames limestone has few pelecypods, specimens of the six recorded species being rare everywhere; whereas the underlying shales have yielded 17 species, most of them represented abundantly—and with them are several species of brachiopods. Wholly similar conditions exist in Devonian and earlier formations where pelecypods abound in sandstones and even in calcareous muds but are comparatively rare in the limestones.

Gastropods of the present day have great vertical as well as geographical distribution, but many genera and species of other genera have very limited vertical range. Respecting those of the Pennsylvanian, little can be said. Their mode of occurrence gives little clue to their habits, for many of the species are almost equally abundant in shale and limestone. The migratory tendencies of gastropods makes the evidence of scattered, even that of comparatively numerous individuals of doubtful value; but where a clay shale is crowded with specimens of two or three species, as is the case many times, there is little room for doubt respecting the habitat preferred by those species. One who has made collections at several localities would not hesitate to assert that many species of gastropods found in the Allegheny and Conemaugh preferred to live near the ingress of muddy water.

If one were to conclude from the occurrence of cephalopod remains, he might decide that the character of the water has been a matter of indifference, for, from the earliest appearance of those forms, they have been distributed in limestones, shales and sandstones, sometimes attaining great size in the last. In so far as the Coal Measures of Pennsylvania and Ohio are concerned, the writer has obtained few specimens from the limestones but he has collected very many from the shales. The distribution would indicate that muddy water was preferred. But this inference has no good basis. Cephalopods are migratory; modern types prefer pure water; but after death, the shell freed from the animal may float great distances to be dropped in any kind of bed. The presence and the distribution of cephalopods give no certain information respecting the conditions. At the same time, it does appear strange that, if the older forms preferred clear water, they are found so seldom in the Mercer and Vanport limestones, formed in long estuaries, while they are so abundant in the muds which are associated with the Brush Creek and in those underlying the Ames.

It would appear that the distribution and the habits of invertebrate animals forms lend no support to the belief that the Appalachian basin, during Coal Measures time, was ever covered in whole or in part by deep water. The passage of muddy-water-loving pelecypods and gastropods into the more calcareous and even into the limestone areas, the occurrence of such forms in shale patches, lying within limestone areas with different but interlocking fauna, suggest that in the areas of limestone deposit also the water was shallow, that those were merely estuaries, bordered in great part by lowland areas with very sluggish drainage.

Cornet,[112] in discussing the lowest Coal Measures deposits near Mons in Belgium, regards the absence of gastropods, the abundance of pelecypods with byssus, especially of mytiloids, aviculoids and pectenoids, as evidence that the deposit was littoral. Modern conditions on the Belgian coast strengthen his conviction. The abundance of ammonoids might indicate deep water, but this cannot be decisive in the presence of contrary evidence. One can easily understand the presence of cephalopods in littoral deposits, but it would be difficult if not impossible to explain the great abundance of molluscs with byssus in deposits made far off shore. He says that Barrois had come to the same conclusion respecting the alum-bearing shales at Marly, but E. Haug has placed generally among deep sea deposits the shales and fine shaly sandstones with *Goniatites* and *Pseudonomya,* constituting the Culm. While the life indicates littoral deposition, the fine grain of the H la sediment seems to accord better with a certain distance from the shore. But this objection means nothing for, as actual conditions show, the coarseness or fineness of shore deposits depends on features of the area, its lithology, altitude and climate. The coal terrain, excepting intercalations only a few

[112] J. Cornet, "Le terrain houiller sans houille (H la) et sa fauna dans le bassin du couchant de Mons," *Ann. Soc. Geol. de Belgique,* Vol. XXXIV., 1906, Mem., pp. 139–152.

meters thick, is formed of very fine sediments. Clay shales make up about 70 per cent. of the column; nevertheless the Upper Coal Measures of the Franco-Belgian basin cannot be regarded as a deposit of the deep sea. He feels compelled to believe that the neighboring areas were lowlands and that the continent was in an advanced stage of peneplanation.

Jukes-Brown had reached the same conclusion respecting the English coal terrain.

Schuchert,[113] in the work already cited frequently, asserts that, during the periodic invasions in the Palæozoic, the depth of water in the Appalachian sea was very shallow, rarely exceeding 200 to 300 feet. On the west shore of Appalachia, conglomerates, sandstone and coarse muds, with rippled surfaces, are common; while in calcareous periods, one finds shrinkage cracks, marking great mud flats inundated periodically with calcareous materials nearly devoid of life. In the New York basin, the northern division of the Appalachian, the later deposits are sands and muds without marine life, though containing some land plants, some fishes and some fresh-water bivalves. The sands are often red, oxidized materials in estuaries, dried out by sun and air. The shallowness of the sea is evidenced by the almost endless list of formation names applied by field geologists. These conditions existed at the close of the Devonian.

Ulrich[114] in some instances would go farther than Schuchert in limitation of depth. These students had covered a very great part of the United States either by personal observation or by study of collections made by government geologists and others. They agree wholly in asserting that seas caused by ocean invasions were shallow, but Ulrich feels justified in admitting for some extensive areas a less depth than that which Schuchert, with abundant caution, had named as a probable maximum in his general statement. He had examined about 20 marine embayments of Ordovician and Silurian age in the Nashville and Ozark uplifts—the former within the area of Cincinnatia and the latter much farther west. His con-

[113] Schuchert, "Palæography of North America," pp. 438, 439.
[114] E. O. Ulrich, "Revision of the Palæozoic Systems," pp. 361.

clusion is that the depth of water was never more than 100 feet in those localities and generally much less. His studies led him to conclude that the average depth of Palæozoic seas was even less than 200 feet and that none attained a depth exceeding 600 feet.

There is no reason to suppose that the non-marine limestones are other than shallow water deposits; they are sun-cracked and rippled in some extensive areas. Equally there appears to be no valid reason for supposing that the marine limestones are of deep sea origin; at times, they are sun-cracked and wave-marked; at others they are distinctly near-shore deposits; yet the fauna, characterizing them at a distance from the shore, is present and the individuals are of such size as to show that the conditions were not unfavorable. The only ground for asserting that the limestones are of deep sea origin is the time-honored conception that presence of certain groups of invertebrates is proof that the water was deep. This conception itself stands seriously in need of proof.

Mode of Deposition.

Before taking up the study of coal beds, it is necessary to ascertain, if possible, the conditions under which the deposits already considered were laid down. Three possible hypotheses have been suggested.

The basin may have been a Mediterranean sea, 250 miles wide and more than 800 miles long, 4,000 to 6,000 feet deep, into which streams delivered débris until the whole area was filled.

The basin, originally almost wholly dry land, was brought under water by gradual but interrupted subsidence; inflowing streams formed deltas which eventually filled the basin.

The water-area, during most of the period, may have been comparatively insignificant. The two longitudinal valleys may have had each its own important river, with tributaries, which formed dejection cones, to be remodeled by floods and by meanders of the streams, while the whole region was subsiding slowly though not continuously.

The first hypothesis is altogether improbable. It involves the conception that the surface of the sea within the basin was at tide level and that the water was excluded finally by deposition of mineral matter on the bottom. Under such conditions, it would be impossible to account for the formation of fossiliferous limestones and shales within narrow well-defined areas at 2,000 feet below the water-surface. It would be impossible to account for the distribution of conglomerates and pebble rocks, almost free from argillaceous matter, over great areas in the central parts of the basin, 100 or more miles from the shore and at a depth of several thousand feet below the surface. It would be impossible to explain the occurrence of sun cracks, ripple marks and clumps of plants *in situ*, which are found at so many horizons throughout the column. It would be almost impossible to discover a source for the material, which has filled this vast basin of not less than 200,000 square miles to a depth of 4,000 to not less than 6,000 feet. The Appalachian land at the north would have been very narrow, for Carboniferous beds, with coal, were forming in New England less than 175 miles away at the east; the lowland of Cincinnatia separated the basin from the Indiana region where coal deposits were forming, no more than 175 miles distant; while, at the northwest, the Michigan area was filling, at less distance away. The land area would be insignificant on all sides except due north; but one cannot accept that as the source, unless willing to assign to the Pennsylvanian a duration which would stagger the credulity of even the most generous geologist. The suggestion that the Appalachian basin was bounded at the east by a great fault seems to be inadmissible for there is no evidence that the fault exists. The Appalachian system of folding originated far back in the Palæozoic and continued through the Devonian and Carboniferous. Its faults with insignificant exception are overthrusts toward the west; but such overthrusts cannot explain the origin of the basin, which could be formed, if formed by a fault, only by a normal fault with hade toward the west.

Each of the other suggestions, somewhat modified, would seem competent to explain the phenomena; but this statement is general. In discussing a matter of this kind, one must endeavor to gain a birdseye view of the whole area, for a problem so vast in extent cannot be studied with a microscope. Many details have much importance for the local observer but are without weight in a discussion of the whole; while there are others, apparently unimportant, of which the importance cannot be exaggerated. The difficulty is to distinguish essentials from non-essentials, for one's convictions long entertained exert much influence. In any case, this personal equation must affect interpretation of the record, so that the student must be content to offer only a contribution, leaving to another the completion of the work. It is necessary first of all to have a knowledge of present conditions.

Fayol,[115] in the third part of his work, has discussed the constitution, origin and formation of deltas, as bearing upon the deposit of sedimentary rocks and has given the results of experiments in the extensive settling vats at Commentry. After exposing the errors into which geologists have been led by imperfect observations in too limited areas, he proceeds to show that the lack of horizontality is not necessarily evidence of dislocation, first referring to Wegmann's[116] experiments on deposit of sediments upon an inclined surface. Where beds have been laid down on such surfaces, they pass by insensible slopes and curved lines from horizontality to inclinations more or less strong and modeled on the surface below; the same beds, thick in the low parts, become thinner in rising and imbricate with beds previously existing. In discussing delta deposits, one must distinguish carefully between the Alluvial or emerged and the Neptunian or submerged portions. The material may be either coarse or fine and the inclination may vary considerably.

Lake deltas, such as are seen in alpine areas, have abrupt affluents and the material near shore is coarse while fine stuff is beyond. The slope at the upper edge is from 25 to 35 degrees

[115] H. Fayol, Études sur le terrain houiller de Commentry. Lithologie et stratigraphie," Saint-Etienne, 1887, pp. 356–531. Though the writer dissents energetically from many of Fayol's conclusions, he cannot withhold the expression of admiration for the manner in which that author has recorded every observation, making the work a treasury house of suggestion and information. It can serve as a model. If other observers had followed the same method, one engaged in preparation of a monograph would not have so frequent occasion to lament the folly which led him to begin the work.

[116] *Bull. Soc. Geol. de France,* Vol. 7, 1850, p. 187.

but decreases until it is the same with that of the lake bottom. The slope at the shore varies greatly. In Lake Geneva, that of the Thonon delta is 30 degrees, but that of the Rhone is much less. As the delta advances, the river's mouth is carried forward, while the stream meanders and covers the Neptunian beds with alluvium, which is horizontal. This formation of the alluvium is sometimes so slow as not to interfere with vegetation, as in the chief deltas of the Alps, those of the Reuss, Aar and Rhone. Fayol describes some natural and artificial sections of lake deltas as illustrating the amount of transported material: he says that, above the confluence of the Aar and the Thiele, all lake basins have disappeared up to the Jura; alluvium from the streams, the growth of peat bogs and the work of man have converted them into prairies. Marine deltas differ from those of lakes as the waves and tides interfere with regular development. The deltas of great rivers differ yet more; the Neptunian deposits are more extensive and less inclined, there being beds of several thousand square kilometers with inclination of only some centimeters per meter. Little however is known respecting these deltas, information having been obtained from only a few borings. Enough, however, is known to prove that great deltas contain deposits of vegetable matter, that the beds are less coarse and less inclined than those of lacustrian origin. The arrangement of the beds is closely dependent on the agitation of the water, which in turn is dependent on the size of the basin.

After recounting his experiments, which he regarded as amply confirming his conclusions respecting the origin of the Commentry sands, shales and coal beds, Fayol returns to discuss the primitive inclination of sedimentary rocks. As the doctrine of primitive horizontality has had important influence in the formulation of doctrines respecting the formation of coal beds, he thinks useful to examine it to the foundation and to prove its falsity. He cites Steno, Elie de Beaumont and Dufrenoy, Lyell and Credner in favor of the doctrine, following the notes with a long quotation from Lyell[117] in which are described the irregular and steeply inclined deposits near Nice, which that author thinks had the present abrupt

[117] C. Lyell, "Elements of Geology," sixth ed., New York, 1866, pp. 18, 19.

dip from the beginning. Fayol regards this as an astonishing exhibition of inconsistency on Lyell's part, since the facts contradict Lyell's conclusions respecting original horizontality. The reader can determine for himself, by consulting the original work, how much reason exists for this exultation.

Fayol examines the facts. He asserts that Steno generalized after having examined only the alluvial deposits. The arrangement of pebbles parallel to the bedding is no proof of original horizontality; the slight average slope of the ocean bottom has no bearing on deposits upon lake bottoms, for the latter often have a comparatively steep slope. The average of the Mediterranean bottom is slight, yet deposits at the mouth of the Var have a dip of 25 to 30 degrees. Beds of vegetable matter are buried in the depths of present deltas, and these have been considered as beds formed on the surface above sea-level and carried down by subsidence, in some cases, to a depth of 150 meters; but geologists have reasoned erroneously from local accumulations of mud and peat in certain deltas, for from those they have reasoned to accumulations of hundreds of meters and to widespread oscillations of the surface. In fine, he accepts de Lapparent's conclusions respecting the stability of the earth's crust and fortifies his position by a long citation from that author. He is convinced that he has destroyed two errors: that the vegetable accumulations in delta deposits were of local origin at the surface; that alternations of freshwater and marine deposits are evidence of oscillation of the surface.

It is certain that no one can doubt the accuracy of Fayol's recorded personal observations and many of his conclusions are in full accord with those of other observers in the same field during the last half century. But one must hesitate before accepting some of the broader generalizations; they are clearly based on observations within too limited areas and apparently on a not wholly clear understanding of what observers elsewhere have recorded. His experiments on sedimentation were ingenious, were executed with great skill and perseverance; they excel, in all respects, the earlier investigations by Rozet, Wegmann, Constant-Prevost and others, yet, in reading the record, one is reminded of Hebert's remark that it is not always possible in experiment to reproduce the complicated conditions existing in nature. It is well to learn the phenomena as recorded by others at some localities mentioned by Fayol.

De Rosemont[118] says that between Aspremont and Nice one sees the great mass of pebbles marking the Var delta. He notes some features which appear to have been overlooked by Fayol. This deposit extends northwardly to the rocks of Saint-Martin-du-Var, westwardly to Cheiron and southwardly to the sea. The homogeneous mass is 350 to 400 meters thick and plunges beneath the sea between Aspremont and Cheiron with a thickness of 500 meters. It is rudely stratified and the dip varies from 10 to 30 degrees. This is the delta of the Var, which was formed prior to the Pliocene. It is cut, almost half way to the bottom, by an old valley, now filled with bluish and yellowish clays, holding a Pliocene fauna. Still later, this Pliocene deposit was trenched along its whole length by the present river Var, which flows in a deep channel-way. The phenomena described by de Rosement show that, under certain relations of land and sea, the first deposit was laid down; that under other relations, the river dug for itself a broad channel-way in the coarse deposit; that under still other relations, the valley was filled with Pliocene muds; and that last of all, the whole mass being once more above sea-level, the river cut its way down in the muds. It may well be that the steep dips referred to by de Rosemont, Lyell and Fayol originated in a way different from that conceived by the last two authors.

The Aar delta, very small, was studied long ago by Martins,[119] whose investigation was extremely detailed. The stream enters at Meyringen an alluvial valley, along which it meanders for about 5 miles, until, in approaching Lake Brienz, it divides to form a petty delta, 85 meters wide at the lake shore. Coarse material is dropped at Meyringen and only fine stuff reaches the lake, where it forms a submerged talus. The lake is 8 miles long and a mile and a half

[118] A. de Rosemont, "Sur le delta du Var et la période pluviare," *Bull. Soc. Geol. de France,* III., Vol. V., 1877, p. 799.

[119] C. Martins, "Note sur le delta de l'Aar, à son embouchure dans le lac de Brienz," *Bull. Soc. Geol. de France,* II., Vol. II., 1845, pp. 118–122.

wide. The slope of the talus is 30 degrees near the shore but, within 300 meters, it falls to 20 degrees. The surface is covered with fine silicious sand, a homogeneous black mud, which also covers the lake bottom throughout nearly the whole extent. The talus must become continuous with the bottom deposit within three fifths of a mile. Martins thinks that the slope of the delta proper is 20 to 23 degrees, but is certain that the deposits are horizontal in most of the area, for Martins found the bottom a level plain.

The delta of the Rhone, at the head of Lake Geneva, was studied by De la Beche,[120] whose results have been presented summarily by Lyell. The lake is 37 miles long and 2 to 8 miles wide. The depth is more than that of Lake Brienz, varying from 20 to 160 fathoms, but only from 120 to 160 along the middle line. The Rhone enters at the head as a turbid stream but is limpid at the outlet. An old Roman town, at the shore 8 centuries ago, is now a mile and a half inland. The older portion of the delta, above that town, extends 5 or 6 miles and is a flat alluvial plain, little above the stream and covered with swamps. The surface of the submerged cone sinks very gradually and, at a mile and three quarters, merges with the bottom of the lake, which is covered with river mud. Fine and coarse materials alternate in the delta deposit. When snows melt on the mountains, the increased flow brings down sand, mud, vegetable matter and driftwood. In 8 centuries there has accumulated a formation, perhaps 600 to 900 feet thick and nearly two miles long, with strata only slightly inclined. Conditions are somewhat different where a delta is formed by a torrent having great speed and a moderate quantity of water. The depth opposite the torrent of Ripaille is 80 fathoms at half a mile from shore, so that dip of strata in that minor delta must be not less than twice as great as in that of the Rhone, or apparently not far from 10 degrees.

Gilbert's[121] descriptions and figures of the well-dissected deltas

[120] H. T. De la Beche, *Edinb. Phil. Journ.*, Vol. II., 1820, p. 107; C. Lyell, "Principles of Geology," New York, 1872, Vol. I., pp. 413–415.

[121] G. K. Gilbert, "Lake Bonneville," U. S. Geol. Surv. Monographs, Vol. I., 1890, p. 162.

of the Bonneville area show that the dips of layers are from 15 to 20 feet degrees near the top but they diminish downward, the layers being disposed in sweeping parallel curves.

Dejection cones are merely deltas formed in the air. They are all due to stream transportation, but they differ greatly in form. More than 35 years ago, Gilbert advised that the broad deposits with gentle slopes be termed alluvial fans, and that the term alluvial cones be restricted to forms with steep slopes and formed by the smaller rapid streams. The distinction is important, as confusion of the types in descriptions seems to have caused some misconception, and the steep slopes described by some writers are seemingly regarded as typical of all. Hogard[122] long ago found a slope of 35 degrees in dejection cones composed of solid and angular fragments. The greater slope is always shown by the less friable material and cones made in air have much steeper slope than those made in water. Surell's[123] studies in alpine areas were made in search of means for protecting mountain areas from ravage by rainfall. He found that the slope of a dejection cone depended greatly on the material of which it is composed. Mud usually accompanies torrents and, where abundant, it is the first material gathered. If the flow be thick, the mud surmounts obstacles and in drying, especially if calcareous, it becomes tough, preventing access of air and destroying vegetation. If it carry blocks or pebbles, it cements them and in this way many breccias were formed in the areas examined. The steepness of the slope, on which a deposit may be laid down, depends on fluidity of the mass. Gravels are deposited on slopes not exceeding two and a half per cent.; fragments, 25 centimeters in diameter or side, may be checked on slopes of two and a half to 5 per cent.; while blocks of half a cubic meter come to rest on a slope of 5 to 8 per cent. If the blocks be very large, the current drops them on rapids; in any event they are dropped at the head of

[122] H. Hogard, "Quelques observations sur les nappes et cônes d'eboulement et sur les lits de déjection des torrents," *Bull. Soc. Geol. de France*, II., Vol. VII., 1850, p. 186.

[123] A. Surell, "Étude sur les torrents des Hautes-Alpes," 2d ed., 1870, Vol. I., pp. 37–39.

the fan. These usually fall from the mountains, and the torrents, no matter how strong, cannot carry them far. The fine mud and sand are not deposited along the torrents but are carried out by the rivers to become fertile alluvium. He describes dejection cones made by the Adour, Garonne and other streams, which have become confluent and which are now gashed by diverging currents. In discussing modes of protection against devastation by torrents, Surell says that it is unnecessary to wait until the region has become reforested. "It suffices if the surface be carpeted with grass, brush or shrubs. The herbaceous plants and the brush, as completely as the trees, protect the surface of the soil, divide the streams which tend to ravine it, prevent abrupt concentration of the waters and absorb a certain portion in the spongy humus, which has formed at their foot." He devotes several pages to discussion of this topic and gives a long list of plants which take possession of devastated areas, some of them growing on naked rock.

One who examines only the illustrating figures given in textbooks is in danger of supposing that alluvial fans are of limited extent, confined mostly to comparatively narrow river-valleys with abrupt sides; but the conception would be erroneous. Gras,[124] in writing of alpine diluvium in southeastern France, says that a great area between the Rhone and the first calcareous mountain of the Alps is filled with clay, sand and pebbles. This thick mass extends northward to beyond Dijon and the Saône Valley and follows the Rhone southward to the Mediterranean shore. The chief development is in the Département of Isere, whence it becomes thinner southward. He recognizes a vast dejection cone, or, better, alluvial fan on the Dauphiny plain, whose summit is in the Grand Chartreuse chain and whose base has a radius of 70 to 75 kilometers. The materials came from the mountains at the east and contain the characteristic rocks of Mount Blanc and other areas, so that they have been transported far. The streams have heaped up pebbles to the thickness of hundreds of meters.

[124] Sc. Gras, "Sur la période quaternaire, dans le vallée du Rhone et sa division en cinq époques distinctes," *Bull. Soc. Geol. de France*, II., Vol. XIV., 1857, p. 207.

Drew's[125] description of conditions along the upper Indus are equally illustrative. Alluvial fans of tributary streams issuing from the highlands have a radius of about a mile and a slope of about 5 or 6 degrees, the extreme limits being 3 and 8 degrees. There are, however, other fans with steeper slope, but they are not alluvial—they originated as talus. The streams subdivide on the fans, which increase with regular form as each stream yields its contribution. The fans, originally independent, become united. Drew gives a figure representing the conditions along 30 miles, where the fans have become continuous and extend two miles into the valley. The boundaries of the original fans are still recognizable. Rivers cut across the deposits and the tributaries, in lowering the channels, form new fans at their outlets.

The conditions described by Drew resemble those seen along the upper Rhone. There one finds some cones with steep slopes at their head near the wall, clearly of talus origin, for they were formed by streams issuing from hanging gorges, like the very steep deltas in some Italian lakes, described by Taylor.[126] The high angle of slope reported by some authors must be due to this mode of origin. Along the upper Rhone as well as along the Adige, just as in the western states, the slopes of the greater alluvial fans are usually gentle almost throughout. Even the gigantic landslide, on the Adige near Rovereto, has a gentle slope where cut by the railroad, though covered with huge blocks. The areal extent of the fans depends on the width of the valley and the transporting power of the streams. There would be notable variations in a slowly subsiding area, especially if the subsidence were not continuous.

One may link this type of deposit with that of the great river-plains by a reference to conditions observed on the upper Nile. Falconer[127] cites Russeger, who says that between Khartoum and Sennaar, not less than 200 miles, the deposits are:

[125] F. Drew, "Alluvial and Lacustrine Deposits and Glacial Records of the Upper Indus Basin," *Quart. Journ. Geol. Soc.*, Vol. XXIX., 1873, pp. 441–471.

[126] F. B. Taylor, "Post-Glacial changes of Altitude in the Italian and Swiss Lakes," *Bull. Geol. Soc. Amer.*, Vol. 15, 1904, pp. 369–378.

[127] H. Falconer, "On the asserted Occurrence of Human Bones in the ancient Fluviatile Deposits of the Nile and the Ganges," *Quart. Journ. Geol Soc.*, Vol. 21, 1865, pp. 372–379.

1. River mud, like the Nile mud of Egypt, containing calcareo-argillaceous concretions.

2. Friable, fine and coarse conglomerate of quartz grains and pebbles, cemented by ancient mud.

3. Ancient Nile mud, indurated, with embedded iron-shot clay, silicious limestone and, in the ferruginous portions, marly concretions.

4. Fine and coarse conglomerate, cemented by ancient Nile mud and calcareo-argillaceous matter. It is very hard.

5. Dark gray freshwater limestone.

The beds are horizontal and 30 to 36 feet deep. Vegetable remains occur throughout, except in the uppermost bed; the whole is of freshwater origin, the fauna consisting of species now living in the Nile, accompanied by some land forms. These deposits are in the region of widespread floods, whose great areal extent is due to vegetation in the river channel, which the river cannot tear out. The type of deposit is different below the first cataract. Newbold[128] says that at Thebes one can recognize mica spangles from granite of the first cataract, but at Asfet in the Delta, the spangles are so minute that they can hardly be recognized even with aid of a lens. Pebbles are very rare in the delta area; but the composition and texture of the deposit vary according to position, coarse material being confined to the main channels and their borders; fine material alone reaches the Mediterranean.

In examining the great delta regions in search of possible explanation of conditions during Coal Measures times, one must not confine his attention to the lowland areas; he must consider also the alluvial plains extending at times hundreds of miles above the technical head of the delta, even to the region where tributaries bring down coarse materials. The story is continuous from shore to mountains.

The immense plain of eastern China is described[129] as curving around the mountainous region of Shan-tung and as extending southward from near Peking for about 700 miles with width of 150

[128] Lieut. Newbold, "On the Geology of Egypt," *Quart. Journ. Geol. Soc.*, Vol. 4, 1848, pp. 341, 342.

[129] R. K. Douglas, "China," Encyc. Brittan., 9th ed., Vol. V., p. 630.

to 500 miles. The greater part of this plain descends very gently toward the sea and, being generally below the level of the Hoang-ho, it is exposed to disastrous inundations attending the rise of that river. The flood of 1911 is said to have covered an area 45 miles wide and several hundreds of miles long. The plain is the work of the Hoang-ho conjointly with the Yang-tse-kiang. It is a vast swampy area, in great part devoted to rice culture. Pumpelly[130] has shown that the Hoang-ho has shifted its course many times during the historical period. A Chinese work, published in 1705, states that the course of the river was regulated by Yu, which makes probable that diking had been undertaken and the plain placed under cultivation fully 2,000 years before the Christian era began. Pumpelly republished nine charts, showing changes in the channel-way during 3,000 years. The stream is mighty, turbulent, subject to enormous annual increase of volume, due to rainfall on the distant Kuen-Luen mountains, and it has always been a source of terror to the millions inhabiting the plains. Dikes have caused elevation of the stream bed, which, prior to the last great change, was apparently higher than the adjacent areas from Whang-ho to the mouth, a distance of 400 miles. Before that change, which took place about 1850, the river flowed westwardly to the Yellow Sea, entering it south from the Shan-tung peninsula, about 50 miles in the same direction from Pei-chow or about 150 miles north from the Yang-tse-kiang. The breach occurred near Fungpeh in Suchan and the water flowed away to the Gulf of Pechele on the north side of the Shang-tung area. The passage was by way of the Tat-sing river, whose waters were increased to six times their former volume. The new mouth is more than 350 miles west of north from the old one. By 1858, the old mouth was dry; but in 1863, the river had not yet determined its new channel and water still spread over great tracts north from Tsinan, the capital of Shan-tung.

Blanford[131] states that the Ganges-Indus-Brahmapootra plain of northern India embraces about 300,000 square miles and is from 90

[130] R. Pumpelly, "Geological Researches in China, Mongolia and Japan," Smithson. Contr., Vol. XV., No. 202, 1866, pp. 46 et seq.

[131] W. T. Blanford, "A Manual of the Geology of India," Calcutta, 1879, pp. 391, 394, LX.

to nearly 300 miles wide. The lowest point on the divide between the Indus and the Ganges is 924 feet above tide, but, in fact, there is no dividing ridge between the two systems and a very trifling change would divert the water from one side to the other—and very probably such changes have occurred. No traces of marine conditions appear in upper India since the early Tertiary. There is no proof that the whole of the plain was at any time under water, nor is there any proof that is was not. The Eocene sea occupied the Indus valley to the foot of the Himalayas and extended eastward to Kuchann. But thence to the Gano hills, no trace of marine condition exists. If the Eocene sea occupied the Ganges area, it is strange that no marine forms have been found. The same statement applies to the Brahmapootra plain, which now is in great part too swampy for cultivation.

Medlicott[132] says that the Lower and Middle Siwalik formations are composed of immensely preponderating sandstone, with occasional thick beds of red clay and rare, thin, discontinuous bands of nodular earthy limestone—the sandstone itself being occasionally calcareous. Conglomerates prevail in the Upper Siwalik and they are often made up of the coarsest shingle, precisely like that in the beds of the great Himalayan torrents. Brown clay occurs frequently with the conglomerate and at times wholly displaces it. This clay, even when pushed to the vertical, cannot be distinguished, in hand specimens, from the recent plains-deposit and no doubt it was formed in the same manner as alluvium. The sandstone of the zone is exactly like the sand forming the banks of great rivers, but is more or less consolidated. The suggestion that the Siwalik hills are merely an upraised portion of the India plains was not wholly misleading. At one time, the mass was supposed to be of marine origin—a relic of the old notion that a water-basin was an essential condition for extensive accumulation of deposits, and that a sea-margin was needed for such a spread of shingle as is found in the Siwaliks. The same opinion prevailed concerning the plains themselves. But the ocean had nothing to do with the matter. The mountain torrents are laying down great masses of shingle and clay on the margins of

[132] H. B. Medlicott, ibid., pp. 524, 525, 541, 672.

the plains; the thick sandstones and sandy clays of the Tertiary are, in form and composition, similar to the actual deposits of the great rivers. The vast extent of the alluvial fans is illustrated by one example:

"In the range between the Jumna and the Ganges, clays are very subordinate and the conglomerates are formed of the very hardest quartzite pebbles, just like the shingle now found in the great mountain torrents. This portion of the range is, in fact, an ancient diluvial fan of the rivers Tons, Jumna and Ganges. The Jumna, after its confluence with the Tons, now flows very obliquely across the dūn and passes through the outer range far to the west of the point where it leaves the high mountains, having had to double around the immense accumulation of hard materials it had formerly laid down in front of that gorge."

The Indus is forming alluvial plains in several parts of its valley within Ladak. Medlicott asserts that there is no difficulty in distinguishing lake from alluvial deposits. The former are fine laminated and horizontal; but the latter are irregular, coarse and may or may not be horizontal.

The same author,[133] in a later publication, remarks that the whole plain seems to be covered deeply with alluvial deposits, for even at Ambala, in the upper Indus region, a boring has shown alternations of sand, clay and gravel with some calcareous clay. The sands are one to 41 feet thick; the clays, 3 to 40 feet; but the calcareous beds are thin, none exceeding 2 feet. On the Jumna, within the Gangetic area and at about the same distance from the Siwalik or sub-Himalayan range, large bowlders were found at 40 feet, whereas the largest fragment at Ambala is only five by two and a half inches and pebbles of moderate size are not of frequent occurrence. It is important to observe that no organic material has been found in the deposits on either side of the divide. Borings and excavations in all portions of the plain find the same alternation of sands and clays. The "technical" head of the Ganges delta, as it now exists, is where the Hoogly is set off, at 170 miles above Calcutta, which is 70 miles from the sea; the nearest edge of the recent alluvial plain is 80 miles west from that city—an immense area of level strata. The submerged portion extends far into the sea and its

[133] H. B. Medlicott, Rec. Geol. Surv. of India, Vol. XIV., 1881, pp. 220, 224, 225, 232, 234.

deposits are approximately horizontal. The depth of water in the Bay of Bengal is small, but outside of the delta area, there is a deep depression known as the "Swatch of no ground." All around it, soundings give a depth of 5 to 10 fathoms, but in the "Swatch" that increases abruptly to 300 fathoms. Fergusson,[134] cited by Topley, has shown that this space is kept open by currents, which may have kept it clear while the adjoining area was filling. In that case, the alluvial deposit would be at least 1,800 feet thick. A boring at Calcutta has proved it to be not less than 481 feet.

Lyell[135] relates that at no place in the delta proper or for 400 miles from the sea does one see any gravel, the whole plain of Bengal being overspread with Himalayan mud, homogeneous but becoming more sandy near the hills and occasionally containing abundance of land shells. Those who sail down the river in time of flood see nothing but a sheet of water in every direction, except here and there where the tops of trees emerge above its level. No reference to vegetable matter is made by Lyell or by any other observer to whose work the writer had had access—though the mud is exposed in river cliffs, 80 feet high near Calcutta. Lyell mentions the boring at Calcutta in which peat was pierced at 50 feet. Blanford, in the work already cited (p. 400), says that this peat bed is found at 20 to 30 feet from the surface in all excavations around the city and that it seems to extend under a large area in the surrounding country, having been met with in borings even to 35 miles southeast and to 81 miles east by north. Lyell states that this was considered to be an old soil, carrying a vegetation similar to that of the present Sundurbund. Logs and branches of red-colored wood occur above and below the peat, so little changed as to be identifiable, and they were recognized as the Soondri tree, now prevalent at the foot of the delta. In this Calcutta boring, clay, sand and pebbles were pierced at 120 feet and another forest bed was reached at 380 feet, while the boring ended in beds of pebbles, sands and bowlders. The conditions throughout suggest that, before sub-

[134] W. Topley, "India," Encyc. Brit., 9th ed., Vol. XII., p. 736.

[135] C. Lyell, "Principles of Geology," 1872, Vol. I., pp. 476, 477; "The Geological Evidences of the Antiquity of Man," New York, 1871, pp. 336, 337.

sidence began, the area was diversified with hills and valleys, now reduced to a common level by the mud deposit. One is not justified in referring to the evidence respecting the peat accumulations as unimportant; the observations embrace an area greater than that of all the coal basins within central France.

But similar conditions exist elsewhere on the India peninsula. Medlicott[136] published with comments the notes made by G. E. Ormiston during excavations for a government dock on Bombay island, on the west coast of India. In a space of about 30 acres, 382 trees and stumps were uncovered, of which 223 were erect. Some of the prostrate stems were without roots, but others had been overthrown in place, for the roots were still partly embedded in the soil. The stumps are rooted in a thin soil of decomposed basalt and are surrounded by a stiff blue clay on which rests black marine mud, 4 to 5 feet thick. Stumps projecting above the clay into the black mud have been drilled by *Teredo;* in some cases the holes pass downward through the trunk towards the roots and are filled with indurated clay. Medlicott states that the trees are *Acacia catechu;* two drifted logs of teak wood were found in the clay. This clay deposit must have been made very quietly, for a prostrate stem shows its branches and even delicate twigs in place. The soil was very thin and the roots spread out horizontally; the trees were large, one of the prostrate trunks being 46 feet long. How far the forest extends is unknown, as no investigations were made beyond the excavation of 30 acres.

But while the region of the Ganges and Indus have been subsiding more or less since the late Tertiary, there have been local elevations of no mean extent within recent time; and their character is such as to leave no room for doubting that they had many predecessors. Fergusson[137] notes the comparatively recent elevation of the Madorpora Jungh, at whose southern extremity the city of Dacca was built. This uplifted area is 75 miles long with an extreme width of 35 miles and a height of 100 feet on the west side toward the Brahmapootra. Fergusson describes in detail the shiftings of

[136] Records Geol. Surv. of India, Vol. XIV., 1881, pp. 320–323.

[137] J. Fergusson, "On Recent Changes in the Delta of the Ganges." *Quart. Journ. Geol. Soc.,* Vol. XIX., 1863, pp. 329, 333–350.

the channel-ways in the delta region, which is covered with silt. MacMurdo[138] published in the *Asiatic Journal* an account of the India earthquake of 1819. An extract was published in Edinburgh, which has been utilized by Lyell. This earthquake was felt within a radius of 1,000 miles from Bhooj, central in the Indus delta. The previous depth of the shallow eastern arm of the river was only one foot at ebb tide, but it was deepened to 18 feet; the village of Sindree, farther up the stream, was submerged and a lagoon was formed with area of 2,000 square miles. Immediately after the shock an elevated area was observed at the northeast, where previously there had been a level plain. This, the Ullah Bund, is more than 50 miles long, 16 miles wide and has an average height of 10 feet above the delta surface. The course of the Indus, as Lyell related, was much unsettled during several years, but in 1826 the river threw a great body of water into the eastern arm, which cut through all artificial dams as well as the Ullah Bund itself. The natural section, thus exposed, showed that the upraised land is of delta material. By 1838, the Sindree lagoon had become almost filled with detritus.

The area drained by the Po, the great plain of northern Italy, has received voluminous treatment from many geologists. A summary description of the area was given by Collie,[139] who says that the plain contains 11,000 square miles and that the mountain area, drained by it, is 16,000 square miles. Borings in the plain show that it is covered with approximately horizontal sand, clay and marsh deposits. The river, in spite of the enormous mass of inorganic materials brought down from the mountains, does little toward aggrading the lower channel, as the load is deposited in lakes whence clear water flows. The stream is thoroughly diked from Cremona to the delta marshes, and the dikes are placed at some distance from the channel, enabling the stream, when in flood, to overflow a considerable space before reaching them. This intermediate space is

[138] Captain MacMurdo, "Account of the Earthquake which occurred in India in June, 1819," *Edinb. Phil. Journ.*, Vol. IV., 1821, pp. 106–109; C. Lyell, "Principles of Geology," Vol. II., pp. 98–102.

[139] G. L. Collie, "Basin of the Po River," *Bull. Geol. Soc. Amer.*, Vol. 15, 1904, pp. 566–568.

covered in many places with willows and thick underbrush, so that the current's speed is reduced and there is little erosion of the dikes. The deposits on the plain of the upper Po are irregular and cross-bedded, consisting of cobbles, coarse gravel and pebbles with occasional wedges of sand. At times, local deposits of stratified silt and clay are seen, such as that near Turin, covering 40 acres. The deposits are more regular along the lower Po, much of the material being clay or fine sand, often laminated. In extended exposures, long, flat lenses of sand are shown, which are enwrapped by the finer sediments.

The plain of northern Italy receives drainage and deposits from the Alps and Appenines by way of the Po and its tributaries; from the Tyrolese Alps by way of the Adige; while smaller streams, flowing directly to the Adriatic, contribute their share toward extension of the plain. Taramelli[140] has gathered the information bearing on the development of the plain, with its sands, clays and occasional coral limestones. At the beginning of the Pliocene, it was in great part dry land, for great valleys were excavated, in which gravels were deposited. The topography, in its broader features, was well-defined at that time. During the later Pliocene, the region was invaded by the sea and deposits, termed marine Pliocene, were laid down. These have been recognized in much of Italy, which must have been an archipelago. But at the close of the Pliocene, irregular differential elevation took place, as appears from the altitudes correlated by Taramelli. It is clear that, after the Miocene, a great area was converted into dry land, to be brought again under the sea, but afterwards to be elevated in some localities to 700 meters above that level, while in others it is still below it. These Pliocene beds are the terraces of diluvial deposits.

De Collegno[141] has shown the wide extent of pebbly and sandy deposits in northern Italy and the relations of those deposits to the rivers. On the plain of Milan, the pebbles are often consolidated into a conglomerate, which is exposed along the river and in rail-

[140] T. Taramelli, "L'Epoca glaciale in Italia," *Atti Soc. Ital. Progr. Sci.*, Riunion IV., 1910, separate, pp. 5, 6.

[141] De Collegno, "Note sur le terrain erratique du revers méridional des Alpes," *Bull. Soc. Geol. de France*, II., Vol. II., 1845, pp. 284–286.

road excavations. He found that, south from Milan, the gravel is too fine for use in maintaining the roads, whereas, north from the city, ample material for that purpose is found just below the surface. From Turin to Verceil, the bowlders rarely exceed 50 centimeters; but, in ascending from Chivasso toward the valley of Aoste, by Ivrée, one finds great blocks of 40 to 50 cubic meters. This deposit is 400 meters thick at Ivrée, where one often sees 100 meters of conglomerate; it is 60 to 80 meters thick on the Adda and some borings on the left bank of the Po have been pushed 60 meters without passing through the detrital mass.

Martins and Gastaldi[142] remark that the alpine diluvium underlying moraine material is composed of pebbles, which decrease in size as one leaves the Alps. At the foot of the mountains they have a diameter of 40 to 50 centimeters, but at Turin they are rarely as large as a man's head. Small and large pebbles are present together and are mingled with sand and gravel.

Tacconi[143] studied collections from about 100 borings in and around Pavia, which is at the junction of the Po and the Ticino. He distinguished readily between the contributions made by those rivers, for glaucophane characterizes the Po material and staurolite abounds in that from the Ticino. Pebbles and gravels are wanting in the exposed deposits, diluvial in the terraces but alluvial in the valley; in some collections, however, especially in those from the deeper borings, coarse sand and small pebbles are abundant. The usual color of the sands is ashen-gray, but some specimens are yellowish, the tint being due to alteration of ferruginous constituents. These are from different depths and Tacconi conceives that these layers of alluvium may have been exposed to the air for considerable periods before burial under later deposits. The distribution of minerals leads him to suppose that, during the diluvial epoch, the great rivers, descending from the Alps, united in the Lombardy plain

[142] C. Martins et B. Gastaldi, "Essai sur les terrains superficiels de la vallée du Po, aux environs de Turin, comparés a eux de la plaine Suisse," *Bull. Soc. Geol. de France,* II., Vol. VII., 1850, pp. 587–589.

[143] E. Tacconi, "Sulla composizione mineralogica delle alluvioni constituenti il sottosuolo di Pavia e dintorni," *Rendic. R. Ist. Lomb.,* II., Vol. XXXIV., 1901, pp. 873–881.

and covered a vast area with water, so as to spread the mingled sediment of many water courses over the whole.

The north-central portion of the Italian plain certainly resembles closely a confluent flood-plain. The Adige emerges from its valley just above Domigliana and, before reaching Verona, it is flowing in the broad plain. It has brought down immense quantities of very coarse material; for many miles it flows on a thick bed of pebbles, derived in great measure from the Tyrolese Alps. At Ala, where the river enters Italy, bowlders, 2 feet in diameter, are not uncommon, but the surface material of the flood plain is not coarse, except along the lines of filled watercourses. West from Verona, along the railroad there is no rock exposure, all is river detritus. At many places, the cobbles are so large that the peasants gather them for construction of fences; pebbles large and small are shown in the railroad excavations between Verona and Milan, but they are in sands; the lines of stream flow are not shown in any excavation visible from the road. The material decreases in coarseness very quickly toward the south. Pavia is about 30 miles south from Milan, but no coarse material is found there; Piacenza is about 40 miles south from Brescia where the deposit is very coarse, but at the former city the materials are fine. The Po has been crowded to the south side of the plain, but it has changed its course many times and the deserted channels are distinct.

Morlot maintained that advance of the plain into the Adriatic has been continuous in spite of long slow subsidence and he asserted that, within the historic period, this subsidence has amounted to 5 feet; but the grounds for his assertion have been disputed. Evidence exists which cannot be disputed, which proves long continued subsidence. Challaye[144] reported that a boring made by Dagousse at Venice on the Piazza-de-Santa-Maria-Formosa passed through 132 meters of sand, clay and peat. Micaceous sand prevailed to the depth of 25 meters and beds of peat were pierced at 29, 48, 85, and 126 meters. He asserts that the peat in these beds is absolutely the same as that forming now at several places within the lagoon. Challaye finds evidence in this boring that, including the growth

[144] C. A. Challaye, *Bull. Soc. Geol. de France,* II., Vol. V., 1848, pp. 23, 24.

on the present surface, five forests have flourished on this spot. Many borings have been made in this immediate area and the evidence is consistent throughout. Tacconi[145] has discussed the record of one, which was driven 197 meters without passing beyond the clays and sands. Well-marked peat beds were found at 18.80, 29.15, 32.80, 46.50, 56.70, 86.80, 129.80, 151.50 and thin streaks down to 165 meters. It is quite possible that some of the very thin streaks of carbonaceous material may be composed of vegetable matter brought down during floods, but the suggestion of similar origin for the thicker deposits, as made by some writers, cannot be entertained. In view of what is known respecting the ability of floods to remove the plant cover, the suggestion must be regarded as pure assumption; the Po of the present day is confined within dikes, yet it cannot sweep the enclosed narrow flood plain clear of willows and underbrush; there is no reason to suppose that the unconfined stream was more efficient. Moreover, the material brought up from the borings is peat, not a mere agglomeration of vegetable material, but peat, such as now accumulates at the surface. Tacconi emphasizes the fact that peat is more abundant in the upper portion of the deposit, the important beds being within 18 and 59 meters; and he notes especially the bed at 18.80, which is 2.6 meters, and that at 29.15, which is 6.25 meters thick, and, like some of the others, contains wood. The lower beds are thinner and increasingly impure, which leads him to suppose that conditions were less stable, that the river courses were changed more frequently in the earlier than in the later stages of deposit. The materials pierced by this boring are mostly fine, only one layer of coarse stuff having been found. The thickest clay bed is 8 meters and the thickest sand deposit is 24 meters.

The Mississippi region has been described so minutely by many authors that only passing reference to some details is necessary here. The delta, as usually limited, begins at a little way above the Red River of Louisiana, but in Tertiary times the water area

[145] E. Tacconi, "Sulla composizione mineralogica della sabbia di un pozzo trivellato al lido di Venezia," *Atti R. Ist. Veneto,* Vol. LXX., 1911, pp. 655–665.

reached almost to the mouth of the Ohio, so that the river bluffs show Tertiary and Quaternary deposits. The broad space, covered with alluvium, extends northward to St. Louis and is continuous thence up the Missouri, which is the main stream, the upper Mississippi being only a tributary. This alluvial area, subject to flood prior to construction of levees, is 40 to 70 miles wide from the mouth of the Ohio to the head of the delta, below which it expands to a maximum of about 130 miles. The area contracts above the Ohio, so that, along the Upper Mississippi and the Missouri, it frequently is less than 5 miles wide.

The nature of the river bed varies. From the head of navigation to the mouth of Maria's river, the Missouri, with velocity of 2.7 miles per hour, flows on loose gravel; but farther down in the loess region the bed is shifting silt. In the lower course of the Mississippi, the river has cut its way to the Tertiary beds, which for long distances are swept clear of later sediments by the current. But samples, taken from the bottom at many localities between the Ohio and the Gulf, show that immense deposits of pure silicious sand and fine gravel, wholly free from river mud, exist in the channel-way. These are found below channel-chutes, at all angles to the direction of flow, sometimes even parallel with it; but they rarely extend from one side to the other. The velocity of the water at such places is too great to permit much deposition but is insufficient to wash away the sand. The materials become finer as the Gulf is approached. The bar at the mouth of Southwest pass is of sand and mud, soft mud being inside and around the shoal, while the surface material is much harder, containing much sand. The bar at the mouth of South pass is chiefly sand with spots of soft mud, but away from the shoal, the bottom is covered with soft yellow and blue mud of the passes.

Studies were made in 1851 to ascertain whether or not material was pushed along by the river. A keg was laid on the bed in such fashion as to retain suspended matter while permitting unimpeded flow of the water. Coarse sand with some clay was obtained at many localities, while at others only coarse sand remained in the keg. Near the mouth of Red River, at the head of the delta, the samples consisted of small gravel and coarse sand with very little clay. No coarse material is carried beyond New Orleans but pebbles occur in the lower alluvium near that city and the bars at the mouths of the passes show very distinctly the effect of sorting. The source of the coarse material was not determined, but in any event it is certain that the gravels had travelled hundreds of miles.[146]

The story has been continuous along the Mississippi since early in the Tertiary. The river has made its valley in the soft rocks forming its bluffs, where successive deposits are exposed. In the later Tertiary as well as in the alluvial deposits, one sees the cypress swamps which at one time were at the surface. The erect stumps and fallen trunks are present, the condition being wholly like that in recent swamps, except that the trees are dead. Forested and buried swamps are numerous and of great extent on the alluvial plain below Red River, but their area has been diminished by drainage and the protection afforded by levees. The buried swamps, supposed at one time to be composed of drifted vegetable matter, are known now to be *in situ*.

It is not always easy to draw the line between delta deposits and those made on flood plains, as is evident from Medlicott's observations on the Indo-Gangetic region. Belt's[147] studies in a portion of the Siberian plain may be taken as complementary to those by Medlicott, for they show how widely coarse material may be distributed by rivers. Leaving Ekaterinburg, he reached the level, sandy region of the steppe within 60 miles and continued his journey in east-southeast direction to Ischim, on a tributary of the Irtisch, where the steppe wall, 80 feet high, is composed of sand without pebbles and partly cross-bedded. Thence to Omsk on the Irtisch, the plain is monotonous but at that city he saw a section showing 60 feet of the steppe deposit, in which the sand, at times cross-bedded, contained lines of pebbles, none larger than a cherry, with here and there broken shells of *Cyrena fluminalis*. At Omsk, he

[146] A. A. Humphreys and H. L. Abbot, "Physics and Hydraulics of the Mississippi River," 1876, pp. 45, 90, 92, 147, 673.

[147] T. Belt, "The Steppes of Siberia," *Quart. Journ. Geol. Soc.*, Vol. XXX., 1874, pp. 490–498.

changed his course and ascended the river 253 miles to Pavlodav. The numerous natural sections had the same structure and composition as at Omsk, except that the pebbles increased in number and size, becoming as large as a walnut within 100 miles. The section of the deposit at Pavlodav is

	Feet.
1. Soil.	
2. Stratified red sand, with lines of small gravel	20
3. Light colored sandy silt	8
4. Coarse, clean sand, with lines of small pebbles and one line of coarse pebbles	15
5. Clayey silt, not laminated; fragments of bed rock in the lower half	6

resting on magnesian limestone. The river at this place flowed on the edge of an alluvial plain 6 miles wide. He crossed at Pavlodav and travelled southwest seeking the source of the pebbles. At about 60 miles from that city, his wheel jolted on the first stone encountered during the ride of nearly 1,000 miles. Thenceforward, angular fragments of quartz were abundant and within a short distance he reached exposures of crystalline rocks. Belt was inclined to believe that ice had impounded the fresh water into a lake, but Ansted had asked, whence came the water to make the freshwater lake of nearly 3,000,000 square miles, in which the steppe deposits were laid down, and also, if there had been the lake, what has become of the water. Ramsay[148] conceived that, if we could imagine the vast flat territory of Siberia with its mighty rivers facing south to a sub-tropical sea, we would have something like the Carboniferous. Coal beds do not indicate old lakes but continental areas, through which rivers meandered.

Reference was made on an earlier page to Kuntze's[149] description of conditions in the Paraguayan region, but other writers have gone into more detail respecting some features requiring consideration here. Church[150] says that a vast area in the Plata region is

[150] G. E. Church, "Argentine Geography and the Ancient Pampean Sea," *Rep. Brit. Assoc. Adv. Sci.*, for 1898, pp. 932–934.

[148] A. C. Ramsay, "Physical Geology and Geography of Great Britain," 5th ed., London, 1878, p. 139.

[149] O. Kuntze, "Geogenetische Beitrage," 1895, pp. 67, 68.

covered to a depth of 20 to 100 feet with a reddish-yellow semi-plastic earth, frequently marly with calcareous nodules, due to percolation of calcareous water from the rivers. No stones or pebbles are seen in this deposit, but it grows more sandy toward the west. Church believes that these Pampean deposits were laid down in a sea, 1,400 miles long and with an area of about 600,000 square miles, this being the region now drained by the Paraguay and its tributaries, the Pilcomayo, Bermejo and Salado at the west, and the Lourenço, Parana and Uraguay at the east. To this area he would add about 115,000 square miles at the northwest, now drained into the Amazon by the Madeira River, the areas being connected by a narrow strait. This inland sea communicated with the ocean near the present outlet of Rio de la Plata, but the area of deposit extended farther southward, almost to the latitude of Bahia Blanca. The Pampean beds have been displaced and made irregular in some places, but they are undisturbed in the southern portion of this Gran Chaco region between the Bermejo and Salado Rivers. Church estimates the present area of the muds at about 400,000 square miles and believes that they were deposited in shallow water. The rivers are all very crooked, have very uncertain channels, at times deserting the old course for a new one several miles away. They frequently divide and subdivide so as to break the plain into narrow but extensive islands.

Kerr[151] has described the central part of the plain. The Bermejo River, entering from the west, is 1,000 miles long but very tortuous, the distance in direct line from its source to the Paraguay River being not more than 450 miles. The speed is 4 to 5 miles per hour and an enormous amount of solid matter is carried in suspension—whence its name, "The Red." In flood time, it is almost liquid mud. The rainfall is very heavy and the maxima are marked by inundations covering immense areas to the depth of several feet. Areas subject to inundation are characterized by palm forests, and one may always see on the trees a dark line at 3 to 5 feet above the ground, marking the flood level. The surface layer,

[151] J. G. Kerr, "The Gran Chaco," *Scot. Geogr. Mag.*, Vol. VIII., 1892, pp. 74–77.

deposited by the flood, divides during the dry season into pentagonal columns. Remedi, in the same magazine for 1897, says that the Bermejo drops its heavy load, fills its channel and is compelled frequently to take a new direction. Trunks of trees, lodged on the bottom, soon lead to formation of dams and to diversion of the stream.

The Chaco Oriental is north from the Pilcomayo River, which enters the Paraguay near Asuncion, somewhat more than 100 miles above the mouth of the Bermejo. This part of the area was studied by Smith.[152] The Paraguay River, north from Asuncion, is very near the highland at the east, but west from the river the Chaco is always low and the plain extends far inland to the high table land of Bolivia, which is said to fall off abruptly toward the east. The Chaco is covered with water during heavy rains. Above the mouth of the Bermejo, the region is forested, but farther north are great areas with only scattered Carauda palms and no other vegetation. In lat. 21° 26′ 40″ S., the river issues from a gorge through rocky hills, which, toward the east, are well connected with the Brazilian highlands; but, west from the river, there seems to be a series of isolated hills rising from the Chaco, whose relation to the Bolivian highlands is unknown, as the region has not been explored. Above this gap, known as Fecho dos Morros, vegetation changes, the palms disappear and one sees only open grass land with bushes and a forest fringe on the river banks. These upper lands are covered almost wholly when the river, which rises 50 feet, is in flood. All this flat country from Fecho dos Morros to Villa Maria, a distance of 400 miles, is subject to floods, which are greater toward the north. At the mouth of São Lourenço, the area flooded during high water is not less than 150 miles wide. The whole is a labyrinth of lakes, ponds, swamps and channels in a grassy plain, there being forests only near the river bank. It is more remarkable in this respect than the Amazon flood plains, for even at low water one fourth of the area is covered. When the river is highest, the whole

[152] H. H. Smith in J. B. Hatcher, "Origin of the Oligocene and Miocene Deposits of the Great Plains," *Proc. Amer. Phil. Soc.*, Vol. XLI., 1902, pp. 113–131. The communication by Smith is pp. 128–130.

region is a vast lake with floating grass and weeds, only a few islands remain here and there, on which wild animals find refuge.

Near Bahia Blanca, just beyond the limits of the Pampean deposits, Darwin[153] found pebbles of quartz on the coast which must have travelled 45 miles. The Tertiary beds of Patagonia are capped by a conglomerate, extending northward from the Strait of Magellan about 800 miles with an average width of 200 miles and an average thickness of 50 feet. Its porphyry pebbles came from the Cordillera. The rock was derived from masses falling on old coast lines and on river banks. The country is terraced, which leads Darwin to see in the phenomena the influence of wave action on the rising coast. He describes graphically the clashing of fragments as they are driven along by torrents in flood.

Conclusions.

That a sea or an ocean is needed for accumulation of thick sedimentary deposits has been long a prevalent opinion among geologists. It is a survival of the period when observation within narrow areas provided a warp of fact to be filled in with a woof of fancy, when cataclysms were thought the rule of nature and modern conditions were believed to be exceptional in the earth's history. It so pervades geological literature that one, in disputing the doctrine, is very apt to employ conventional phrases which concede it. When the study of actual conditions had been prosecuted systematically, when phenomena in great and widely separated areas had been ascertained and compared, it became evident that the accepted doctrine was at least defective. During the last quarter century, intimate study of Quaternary deposits in Europe and America, as well as detailed investigations in physical geography—due largely to the initiative by W. M. Davis in America and A. Penck in Europe—has developed anew the conception that, great as has been the work of ocean forces, that of land forces has been vastly greater. As Ramsay saw for Siberia and Medlicott for India, the activities of rivers in conveying and distributing deposits far from the sea have brought about almost

[153] C. Darwin, "Journal of Researches," New York, 1846. Vol. I., pp. 96, 137, 138, 219.

inconceivably great results. Apparently the first distinct formulation of the new presentation in America was made simultaneously by Barrell and Grabau,[154] each of whom utilized phenomena of the Appalachian basin in illustration. Barrell's elaborate memoir discusses the subject in all its phases and merits careful study. He exhibits clearly the important part which river plains played in the Appalachian history down to the close of the Carboniferous. Grabau lays stress on the progressive overlap away from the source of supply, which, when associated with other facts, becomes an important element of the argument.

Study of the facts presented on the pages of this memoir has forced the writer to a conclusion very different from that hoped for when this investigation was begun.

The widespread horizontality of the Coal Measures deposits, coarse and fine alike, recalls conditions observed on the Siberian Steppe and other river regions. The folding of the beds proceeded from a common cause, lateral pressure applied at the east. The violence of plication decreases with notable regularity toward the west, until in western Pennsylvania and in Ohio, along a line of more than 100 miles, the folds become so gentle that they can be traced only by close study. Dips of more than one degree are unusual, while at times and for considerable distances the dip is barely one half of a degree. The same condition exists in a great part of West Virginia. The regular decrease in steepness of the folds leads to the belief that originally the beds were, to all intents, horizontal throughout the basin, the condition being that observed on the great river plains of comparable extent. The rare occurrence of driftwood in the widespread deposits is characteristic not only of the Coal Measures but also of vast river deposits, those of the Amazon, as described by Brown, and of the Ganges as described by Medlicott and Lyell. The long narrow areas of coarse to pebbly sandstone, often with driftwood, recall the filled valleys of the Sierra, described by LeConte, as well as filled deserted bows on the

[154] J. Barrell, "Relative Importance of Continental, Littoral and Marine Sedimentation," *Journ. of Geol.*, Vol. XIV., 1906, pp. 337, 338, 539–541; A. W. Grabau, "Types of Sedimentary Overlap," *Bull. Geol. Soc. Amer.*, Vol. 17, 1906, pp. 635, 636.

Mississippi and the filled channels so often disclosed when a stream in flood cuts across its "bottom." The distinct evidence of sorting of materials in the red shales, where clay and sand are in dovetailing lenses, as well as in some conglomerates, where hardly enough fine material remains to bind the pebbles, leaves little room for doubt that the work was done by streams moving rapidly in some cases, slowly in others. The pebbles are not flat, such as one may find on a shore, but oval or sub-spherical, river pebbles, and their gradual decrease in size as well as number in certain directions shows that the materials were rehandled many times. The rounded pebbles of coal and carbonaceous shale prove equally with those of quartz and sandstone that the deposits, whence they came, cropped out and were exposed to attack by streams of water. The marine limestones, with one exception, are in definite, long, narrow and comparatively insignificant areas, and pass, at the borders, where those remain for observation, into sandstone, chert or shale, the condition being that of an estuary surrounded by lowland, whose rivers bring a minimum of sediment. The shallowness of the water by which sediment was distributed and the short duration of the flooding are disclosed by wave marks, sun cracks and footprints of animals, occurring at so many horizons, while the moderate depth of the estuaries, in which limestone was formed, is apparent from the shore conditions of the limestone. The testimony of the fauna is confirmatory; that life needed not deep water, for it persisted to the very shore line in Ohio. Unconformability by erosion or by overlap marks the contact of Pennsylvanian with the underlying Mississippian in almost the whole basin, showing that the great part was dry land.

The record appears to show that the Appalachian basin, between the Alps-like Appalachia at the east and the low-lying Cincinnatia at the west, was divided longitudinally by the flat-topped and only moderately high Alleghania. The deepest portion of the eastern valley lay close to the foot of Appalachia, whence the surface rose westward almost inperceptibly to the crest of Alleghania. The western valley extended as a plateau with its low line crossing eastern Ohio in a south-southwest direction and deepening southwardly. The thickness of deposits in the two valleys is no index to the difference in altitude of the surface; the eastern valley is coincident with the ancient trough of great subsidence, where deposits, throughout the Palæozoic, attained great thickness and whence they decrease quickly toward the west. The assertion of greater altitude for the western valley is based on absence of all deposits earlier than those of the latest New River in the northern half of the area.

Each basin had its longitudinal river. That of the east, rising in the present confines of New York, flowed with low gradient for more than 1,000 miles, receiving many tributaries from the bold Appalachia and many, perhaps, unimportant tributaries from the gentle slope at the west. Flowing at first close to Appalachia, it was pressed constantly westward by alluvial fans and cones, which became confluent and finally were modeled into a vast river plain. The main stream was sluggish and often interrupted; during high floods, the surface was covered broadly by a sheet of water and the débris from different streams was mingled. The river in the western basin received no débris-laden tributaries from east or west, except at the extreme north; it was more rapid than that in the east and pushed its coarse materials far southward. Progressive overlaps show that subsidence prevailed throughout the basin until the later stages, when it was confined to the contracting area of deposit; but it was differential and not constant. There were long intervals of slight or no movement during which rivers, reduced to base-level, distributed mostly fine material along their lower reaches. At the close of the Pottsville, the valleys had been filled and Alleghania had become buried; the whole area of deposit was an irregular marshy plain. But the old drainage systems continued until near the close of the Conemaugh and determined the lines of sea invasion; they disappeared only with changes in the topography, induced by the forces which were eventually to obliterate the basin. During the whole of the Pennsylvanian, a very great part of the basin was near sea-level. After the close of the Pottsville, few portions of the area of deposition seem to have been more than 300 feet above tide and there is no reason to suppose that any portion was at any time much more than 100 feet below tide.

The writer has become convinced that one must seek explanation of the phenomena of the Appalachian basin in those of the great river plains of modern times; and the phenomena of the Appalachian basin are those of coal regions elsewhere.

AN AUTOCOLLIMATING MOUNTING FOR A CONCAVE GRATING.

By HORACE CLARK RICHARDS.

(*Read April 20, 1912.*)

"For most spectroscopic problems Rowland's concave grating is an almost ideal aid," says W. Voigt in a recent article.[1] Its focal property enables us to dispense with lenses or mirrors, and so avoid the accompanying aberration, absorption and scattering of the light, and when once it is adjusted it is in focus for all orders of spectra. The usual form of mounting, however, is perhaps not quite so ideal. A large, perfectly dark room is required, the apparatus is heavy and cumbersome, or else lacking in rigidity, and what is still more important in some kinds of work, the position and direction of the emergent light change with each change of wave-length. Moreover it is not readily adapted to astronomical purposes.

The theory of the Rowland mounting is well known. If the source is placed at any point of the circumference of a circle constructed on the radius of the grating as a diameter, in the plane perpendicular to the ruling, the spectra will all be brought to a focus at points on the same circle. Of these spectra Rowland selected that which was at the center of curvature of the grating as giving a normal spectrum of constant scale. The necessary conditions were insured by placing the slit at the angle of a rectangular track, along the two arms of which moved the grating and the camera or eyepiece, the two rigidly connected by a rod of the proper length (Fig. 1). It is easily seen that while the source is fixed, the image is displaced in passing through the spectrum.

To avoid this objection, Lewis[2] interchanged the slit and camera, and Abney[3] fixed the position of the grating and camera and

[1] W. Voigt, *Phys. Zeits.*, **13**, 217 (1912).

[2] E. P. Lewis, *Astrophys. Jour.*, **2**, 1 (1895).

[3] W. deW. Abney, *Phil. Trans.*, **177**, II., 457 (1886).

mounted the slit on an arm pivoted at the center of the line joining them (Fig. 2). These methods however require the source of light to be movable, which is usually undesirable and in some cases impracticable. Wadsworth[4] suggested several arrangements to overcome the difficulty, using auxiliary mirrors and more or less complicated mechanism, but these involve additional adjustments and loss of light. It may be added that the grating has also been used

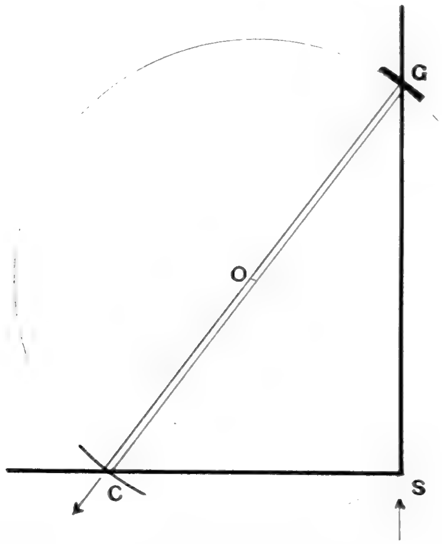

FIG. 1.

with parallel light in astronomical work, but the aberration is much greater than with Rowland's mounting.[5]

The method here discussed is briefly that of autocollimation. That part of the light is used which after being diffracted is returned toward the slit. If therefore the slit is on Rowland's circle, the spectrum will be formed on the same circle and one point of it will coincide with the slit (Fig. 3). The ingoing and outcoming beams may be separated when necessary by the usual reflecting prism, or by slightly tilting the grating. Thus a double slit may be

[4] F. L. O. Wadsworth, *Astrophys. Jour.*, **2**, 370 (1895).

[5] F. L. O. Wadsworth, *Phil. Mag.* (6), **6**, 119 (1903).

used, the light being sent through one slit and returned through the other. The wave-length of the light which is returned through the slit is given by the formula

$$\lambda = \frac{2e}{m} \sin \phi,$$

where e is the distance between consecutive rulings, ϕ the angle made by the light with the grating-normal, and m the order of the spectrum. It follows that at a given angle the order is twice that which is produced at the center of curvature.

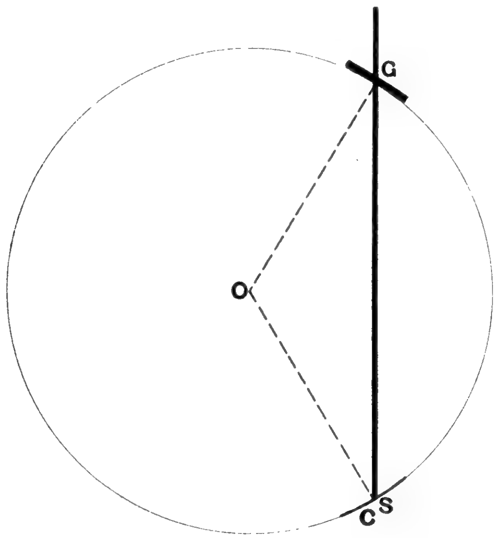

FIG. 2.

The principle of autocollimation has been often used with prism spectroscopes since it was first suggested by Duboscq[6] and Littrow.[7] It was first used with a plane grating by Liveing and Dewar,[8] and is employed in many recent grating spectroscopes. It has however, as far as I know, not been used with the concave grating, although one of the chief objections to this form of mounting—the reflec-

[6] See H. Kayser, "Handbuch der Spectroscopie," I., 511.
[7] O. v. Littrow, *Wien. Ber.*, **47**, II., 26 (1863).
[8] G. D. Liveing and J. Dewar, *Cambridge Proc.*, **4**, 336 (1883).

tion from the inner surface of the collimating objective—would be done away with. Perhaps the reason lies partly in the fact that the focal length changes in passing through the spectra, so that not only the inclination of the grating but also its distance from the slit must be altered, and in addition the focal plane is inclined to the direction of the light by an angle which varies with the setting. Thus in Fig. 3 the normals to the grating and to the spectrum make

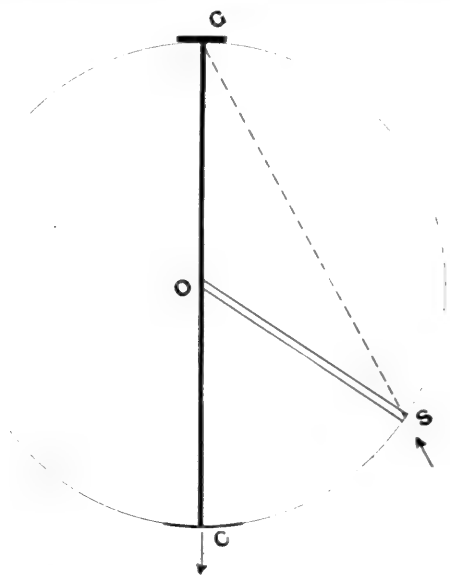

FIG. 3.

the same angle ϕ with the light, and the distance *GS* between grating and slit is $\rho \cos \phi$, where ρ is the radius of the grating. As the inclination of the grating is altered, that of the spectrum must be altered by an equal amount, and the distance *GS* properly changed.[8]

[8] Since writing the above my attention has been called to an article by A. Eagle (*Astrophys. Jour.*, 31, 120, 1910) describing an autocollimating mounting for a concave grating. The mounting has the disadvantages mentioned, namely that the distance of the grating and inclination of the camera must be separately adjusted for each angle of incidence; disadvantages which it is sought to overcome in the mounting described in this paper. The advantages of the autocollimating mounting are discussed at length by Mr. Eagle with conclusions similar to those given here.

These adjustments however may be automatically made in the following manner. As in Rowland's mounting, let the slit be fixed at S (Fig. 3) and the grating be capable of sliding along the line GS and also of rotating about a vertical axis passing through its center. Now if two equal horizontal arms of length $\rho/2$ be pivoted at G and S respectively and hinged together at their other ends at O, and the arm OG be attached to the grating holder so as to be parallel to the grating-normal, the grating will keep the proper inclination as it slides along GS, for G and S are constrained to remain on the Rowland circle. This is in fact exactly equivalent to one half of a Rowland mounting. Moreover, if the camera is mounted to rotate about a vertical axis through S, and the arm OS is similarly attached normally to the photographic plate, the plate, if bent as usual into the arc of the proper circle, will continue to fit this circle throughout its motion and the spectrum will be in focus on all parts.

In practice the arms OG and OS would be excessively long and inconvenient, and would tend to bend the vertical axes at G and S. They could of course be balanced by a pair of similar arms on the other side, but the apparatus would then be still more cumbersome. The same effect may however be attained by a series of links of the "lazy-tongs" pattern, the total length when open being equal to the radius of the grating (Fig. 4). The first and last link on one side will correspond in direction to the arms OG and OS, and these are fixed normal to the grating and plate respectively. It is obvious that as either side may be used, all of the grating spectra become available.

A wooden model of the apparatus has been constructed for use with a six-foot grating, which exhibits the proposed arrangement and which in spite of its crudity renders excellent service. A more efficient mount is in process of construction. Sliding along a horizontal track is a block carrying a vertical pin on which as an axis turn the ends of the link motion and the platform for the grating. This latter may be clamped in any position to either of the adjacent link bars. At one end of the track is a fixed block with a similar vertical axis. This axis carries the other end of the linkage, a platform for the camera or eyepiece, and a support for the slit. These pieces may rotate independently[10] and the camera platform may be clamped to either bar.

The linkage is supported at its intersection by blocks which slide along the track. The arms of one of the parallelograms should be adjustable in length so that the framework may be exactly set to the grating, and so that gratings of slightly different radius may be

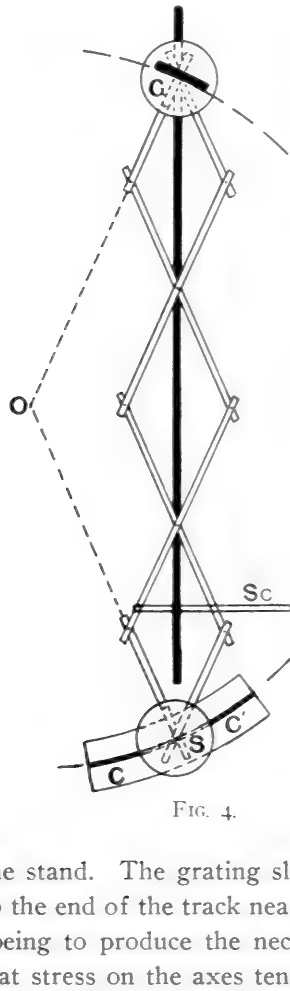

Fig. 4.

used on the same stand. The grating slider is moved by a rod or screw running to the end of the track near the slit, the only function of the linkage being to produce the necessary rotation. There is therefore no great stress on the axes tending to bend them.

[10] Rotation of the slit is convenient in making the adjustments.

The grating and slit are provided with the usual adjustments and also may be shifted on their platforms until their centers fall exactly in the axes of rotation. The camera is mounted on its platform on either side of the slit or preferably just above it, and may be adjusted so as to bring the plate into coincidence with the focal circle. If the latter position is used the grating must be raised until its center is in a horizontal plane midway between the slit and camera. For visual observations the plate holder may be replaced by an eyepiece which may be fixed if mounted above the slit, or if placed at one side is kept directed toward the grating by a simple device. The slit is provided with a reflecting prism and is made double so that light may be sent through one part and returned through the other. It is thus possible to obtain a monochromatic beam of high purity which will be sent always in the same direction. The apparatus is thus available for a threefold use: as a spectrograph, as an observing spectroscope, and as a monochromator; and it may be arranged so that no alteration need be made in passing from one to another of these forms.

The diagonal of any parallelogram of the linkage perpendicular to the track is proportional to sin ϕ, and therefore to the wave-length. A scale of equal parts placed across any part of the linkage perpendicular to the track, as at *Sc* (Fig. 4), will therefore give an approximate measure of the wave-length. Moreover by properly selecting the points on the bars across which the scale is placed, any scale may be adjusted to read wave-lengths directly. A more open scale may be placed on the track, but this will not be one of equal parts.

As everything is supported on one track, the apparatus may be made quite rigid, and at the same time, with the smaller gratings at least, portable. It will take up much less space than the other mountings. It is also more convenient as everything is in reach at the same time from the end of the track-source, slit, camera and handle for controlling the position of the grating. There is but one track to make true, and the other adjustments are no more difficult, and in some cases much easier, than in the Rowland mounting. A very desirable feature is that the slit, grating and camera may be connected by a light-proof bellows or other enclosure, so that the instrument may be used in an undarkened room. This bellows may be supported partly upon the blocks which carry the linkage.

The only part of the construction that may seem to offer difficulty is in making the linkage true, but this should not prove a serious obstacle. All that is necessary is that the four arms of each parallelogram shall be of equal length and that there shall be no play at the joints, and it should easily be possible to do this with sufficient accuracy. It may be added that the linkage, though extremely convenient, is not essential. The grating may be turned by hand to the angle corresponding to the wave-length desired, and then moved along the track until the light is focused on the slit. The camera may then be rotated until the spectrum is in focus.[11] In this way it may be possible to use gratings of much larger radius, and so avoid the errors produced in ruling on a surface of too great curvature.

The great compactness of the mounting makes it available for use in astronomical spectroscopy, from which the concave grating is practically barred when the Rowland mounting is used. The instrument may be mounted upon a telescope in the prolongation of its axis so that the slit lies in the focal plane of the objective. In the case of a star image the slit could be dispensed with, and the astigmatism of the grating would produce a spectrum of finite width. A more rigid and more convenient arrangement would be to mount the guides for the grating upon the tube of the telescope on the side opposite to the declination axis. The light could be brought to a focus by the objective at the side of the field nearest the slit and thrown upon the slit by totally reflecting prisms. No harm would be done by any possible astigmatism which would merely be added to that of the grating, and slight irregularities in driving would be equally harmless.

It remains to consider the character of the spectra produced. The chief advantages of Rowland's mounting are that the spectrum is normal and always of the same scale, and that the plate is per-

[11] This is in fact the arrangement described by Eagle (l. c.).

pendicular to the direction of the light. In the autocollimating mounting none of these conditions are fulfilled. These disadvantages are shared by all prism spectrographs. They are however less with the grating, and, a matter of great importance, the amount of the variations may be readily calculated and allowed for.

The deviation of the spectrum from a normal one might seem to be a serious objection, but as a matter of fact the deviation is much less than might be thought. Thus on a plate of the usual size, the maximum deviation from a normal scale is about one Ångstrom, and when using a comparison spectrum the maximum difference between the corrections for two lines say ten Ångstroms apart would be about one twentieth of an Ångstrom. Moreover the deviation from the normal scale may be accurately allowed for, being of the form

$$\frac{\lambda s_1 s_2}{4\rho^2},$$

s_1 and s_2 being the distance of the line in question from the two lines selected to establish the scale, and λ_0 the wave-length which is returned through the slit. This correction is the same as that necessary when using a plane grating in the autocollimating position.

The varying amount of dispersion is an objection in some classes of work, especially where plates are taken in different regions of the spectrum. The scale varies as sec ϕ, and therefore is somewhat larger than that of the same order in the normal mounting, especially when the angle is large. Moreover, in a given direction the order of the spectrum is doubled and therefore the dispersion is more than twice as great. This is an important property of the autocollimating mounting, since twice as many orders are available for observation. Thus with a 15,000 grating, four complete spectra may be observed instead of only two.

The inclination of the photographic plate will sometimes be a more serious objection. Great care should be taken in its register. This objection as somewhat weakened by the increase of the dispersion with the inclination, so that an error due to imperfect register is proportional to sin ϕ instead of tan ϕ. The error is greatly reduced when using comparison spectra on the same plate.

Finally as to the definition. Kayser[12] gives for the greatest permissible length of a grating used in the customary position—*i. e.*, the length when the difference in phase between the extreme rays amounts to π—the expression

$$L = 2\rho \sqrt[4]{\frac{2e \cot \phi}{m}}$$

and the same formula holds for the autocollimating position. Comparing the same order of spectra we see that as ϕ is less in the second case (and therefore cot ϕ greater) the limiting length of grating would be greater; so that a given grating will be farther from this limiting value and hence will have better definition. The grating is in fact in the position of minimum deviation, and the aberration is equally divided between the incident and diffracted beams and is therefore a minimum.

To sum up: the mounting here described differs from the usual mounting for a concave grating by employing the principle of autocollimation. It possesses the advantages of the Rowland mounting of having all spectra automatically in focus, but differs from it in having greater compactness, convenience and rigidity. The adjustments are easier and the necessity of a dark room is avoided. The definition in the same order is somewhat greater, and twice as many orders may be observed. The deviations of the spectrum from the normal type are small and may be accurately allowed for. The instrument may be readily adapted to work in astronomical spectrography.

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[12] H. Kayser, "Handbuch der Spectroscopie," I., 458.

THE OBJECTIVE PRISM.

BY EDWARD C. PICKERING.

(Read April 20, 1912.)

Three methods may be employed for studying the spectra of the stars. First, the slit spectroscope. This is the method most widely used. The light of the star is concentrated on the slit of the spectroscope, and the linear spectrum widened, if necessary, by a cylindrical lens, or by moving the image of the star. Secondly, by the diffraction grating. As in the first method, the image of the star is concentrated on the slit. But little use has been made of this, and other diffraction methods in studying stellar spectra, owing to the great loss of light. Third, the objective prism. A prism of small angle is placed over the objective of the telescope, and the image of every star in the field is thus spread out into a linear spectrum. Any desired width may be given by allowing the star to traverse the plate slowly, parallel to the edges of the prism. This method cannot well be applied to reflectors, or to other telescopes of large size, owing to the size of prism required. Another objection, in the case of reflectors, is that the prism must be placed so far from the mirror that the definition is injured. These difficulties may be remedied by the focal plane spectroscope, in which the cone of rays from the star is rendered parallel by a concave lens, then passed through a mirror, and brought to a focus by a convex lens. All the light falling on a large mirror may thus be concentrated into a small space, so that the spectrum of a very faint star may be photographed. But little use has been made of this method, although it appears to have great possibilities.

The principal advantages of the objective prism are the small loss of light, and the large number of stars which may be photographed simultaneously. Also, that it is not necessary to follow, as when photographing star charts. The best authorities claim that of the entire light entering the telescope, less than one per cent. reaches the photographic plate, when a slit spectroscope is used. The proportion of light transmitted by the objective prism must be at least fifty times as great. In fact, the principal loss of light is from the absorption of the objective. Consequently, far fainter stars can be photographed with an objective prism than with a slit spectroscope, the difference amounting to several magnitudes. Another great advantage of the objective prism is that the spectra of all the stars in the field of the telescope can be photographed simultaneously, while with a slit spectroscope only one star can be taken at a time. With the Harvard 8-inch doublet as many as three or four hundred spectra are often photographed on a plate, including all stars of the ninth magnitude and brighter, in a region ten degrees square.

A comparison spectrum cannot be used with an objective prism, and it is accordingly difficult to obtain absolute wave-lengths, which are needed to determine the motion of stars in the line of sight. This constitutes the principal objection to the objective prism. Various plans have been proposed to remedy this difficulty, and how far they are successful will be described by another speaker. This does not affect the ordinary measures of wave-lengths, as hydrogen lines are present in the spectra of nearly all the stars, and since these lines are affected by the motion, other lines can be referred to them.

The first photograph of the lines in the spectra of the stars was taken by Dr. Henry Draper of New York. In 1886, Mrs. Draper established, at the Harvard College Observatory, the Henry Draper Memorial, to prosecute the study of stellar spectra. The objective prism has been used almost exclusively in this work. Two photographic doublets of eight inches aperture have been mounted, one at Cambridge, the other at Arequipa, Peru. With these the entire sky has been covered many times. On one plate more than a thousand spectra were classified. The late Williamina P. Fleming, Curator of astronomical photographs, from an examination of these plates, discovered several thousand objects having peculiar spectra. In fact, probably few bright objects of this class escaped her. Of the nineteen new stars, known to have appeared during the progress of this work, she discovered ten, and five more were found by other observers here. In this work also, the number of stars of the peculiar class known as fifth type, has been increased from seventeen to one hundred and eight.

For a more detailed study of the bright stars, prisms have been attached to the 11-inch Draper Telescope at Cambridge, and to the 13-inch Boyden Telescope at Arequipa. Spectra of the brightest stars have thus been obtained, six inches long, and half an inch wide, showing at least five hundred lines. Prisms twenty-four inches in diameter have been used with the Bruce Telescope in Arequipa, and sixteen inches in diameter with the Metcalf Telescope in Cambridge. The latest and largest investigation undertaken here, as part of the Henry Draper Memorial, is a catalogue giving the class of spectrum of a hundred thousand stars of the eighth magnitude and brighter, shown on the photograph taken with the 8-inch doublets. The classification of spectra used in the Draper Memorial, has been accepted by the superintendents of the principal nautical almanacs in their standard catalogue of three thousand stars, and also at the leading observatories. The preparation of the catalogue mentioned above has been undertaken by Mrs. Fleming's successor, Miss Annie J. Cannon, who has devoted a large part of her time during the last fifteen years to the detailed study of stellar spectra. Her classification of one thousand stellar spectra published in Volume 28 of the *Harvard Observatory Annals,* occupied her for three years. To complete, in a reasonable time, a catalogue of one hundred thousand spectra evidently required the most careful study of the methods of "scientific management." As a first step, her contribution to the work, which required the greatest skill, was reduced from one hundred to six per cent., the remainder being performed as a great piece of routine work, by less experienced assistants. The utmost care has been taken to maintain the highest degree of accuracy, the probable error of the result for each star being about a tenth of one interval, corresponding to four one-hundredths of a stellar magnitude. Miss Cannon is now classifying five thousand spectra a month, and has already classified twenty-seven thousand spectra. The completed catalogue will fill four of the quarto volumes of the *Annals* of the observatory, of about two hundred and fifty pages each, and will give the class of spectrum of nearly all of the stars of the eighth magnitude and brighter, besides many others. Some of these are so faint that they are not contained in the *Cape Photographic Durchmusterung.*

Dr. Draper thus placed in our hands a wonderful tool for analyzing the stellar universe. His memorial furnishes not only a permanent record in print of great extent, but, through the collection of photographs, will permit in the future a vastly greater number of facts to be derived from them.

NOTES ON PLATES OF NOVA GEMINORUM OF 1912 TAKEN WITH THE BRUCE SPECTROGRAPH OF THE YERKES OBSERVATORY.

By STORRS B. BARRETT.

(*Read April 20, 1912.*)

1912, March 15. Displacement of sharp H and K lines indicates a velocity of 17 km. recession. This velocity does not differ greatly in all the photographs. Many titanium lines are represented by absorption lines displaced about 7 Å. toward the violet. The relative brightness of the emission components of the hydrogen lines β, γ, δ, as compared with the continuous spectrum is less than in all subsequent plates.

March 21. The centers of the bright bands are now 2 Å. toward the red, as compared with 10 Å. on March 15. Note the sharp bright line at λ 4,526. A second absorption band now accompanies each bright band.

March 24. Shows marked increase in intensity of the second absorption band for each hydrogen line.

March 29. Two bright maxima may be seen near the red edge of the bright $H\delta$ band. They are also present in $H\epsilon$. A similar line near the beginning of the bands is more difficult to see on the print.

March 30. There are two conspicuous bright maxima near the beginning of the bright $H\gamma$ band and one or two near the red edge. On a short-exposure plate of April 1 three conspicuous maxima are seen near the red edge of β, γ and δ.

April 1 and 2. The hydrogen bands are concentrating their intensity toward the red edge. Note that there are two bright superposed bands for each hydrogen line, one much longer and fainter than the other. This is first indicated plainly on March 29. The broad bright band at λ 4,640 has been gradually gathering intensity.

Yerkes Observatory,
Williams Bay, Wis.,
April 18th, 1912.

RELATIONS BETWEEN THE SPECTRA AND OTHER CHARACTERISTICS OF THE STARS.

By HENRY NORRIS RUSSELL.

(*Read April 20, 1912.*)

To the student of the stars, who attempts to arrange our existing knowledge in such a manner that some light may be thrown upon the problems connected with stellar evolution, the spectral classification developed at Harvard is of vital importance.

In such investigations, we must deal, if possible, not with single instances, but with representative averages for groups of stars. But really representative averages are often much harder to obtain than might be supposed. Consider, for example, the actual brightness of the stars. We can find this only when we know the distance of the star—and out of the hundreds of thousands of stars which have been catalogued, we know the distance of barely five hundred. But even if we knew the exact distances of the 6,000 or more stars which are visible to the naked eye, we would not have a fair sample of the general run of stars. To explain how this may happen, let us suppose that there were only two kinds of stars, one equal to the sun in brightness, and the other 100 times as bright as the sun, and that these were distributed uniformly through space, in the proportion of 100 stars of the fainter kind for every one of the brighter. To be visible to the naked eye, a star of the fainter sort must lie within about 55 light-years from the sun; but all the stars of the brighter kind which lay within 550 light-years would be visible. We would therefore be searching for these stars throughout a region of space whose volume was 1,000 times greater than that to which our method of selection limited us in picking out the fainter ones, and our list of naked-eye stars would consequently contain ten stars of the brighter kind to every one of the fainter—though if we could select instead the stars contained in a given region of space, we would find the disparity to be 100 to 1 the other way.

It is therefore a fortunate circumstance that the stars whose distances have been measured have for the most part been chosen, not on account of apparent brightness, but because of relatively rapid proper-motion—which is found by experience to be a fairly good indication of actual nearness to our system. These stars, therefore, represent mainly the sun's nearer neighbors, without such an egregious discrimination in favor of stars of great actual brightness as we have seen must occur if we choose our stars by apparent brightness alone. Some traces of this discrimination will still be unavoidable, for our knowledge of the proper-motions of the fainter stars is still imperfect, and stops short at a little below the ninth magnitude.

In addition to the stars whose parallax has been directly observed, we have data for many more, which belong to clusters whose distances have been found by combining data regarding their proper-motions and radial velocities. In this case too the absence of proper-motion data (which decide whether or not a star really belongs to the cluster) prevents us from obtaining information about stars fainter than a certain limit; but otherwise our knowledge is probably fairly complete.

In the present discussion of the relation between the spectral type and the real brightness of the stars, those directly measured parallaxes have been employed which are confirmed by the work of two or more observers, and also a few results obtained by single observers whose work is known to be of high accuracy, and free from sensible systematic errors. To these have been added the members of the Hyades, the Ursa Major group, the "61 Cygni group" and the moving cluster in Scorpius discovered independently by Kapteyn, Eddington, and Benjamin Boss. The spectra of a very large number of these stars have been determined at Harvard especially for this investigation, and the writer takes pleasure in expressing his most hearty thanks to Professor Pickering and Miss Cannon for this generous and invaluable aid.

The actual brightness of the stars may best be expressed by means of their "absolute magnitudes"—*i. e.,* the stellar magnitudes which they would appear to have if each star was brought to the standard distance of 32 light-years (corresponding to a parallax of 0".10). The absolute magnitude of the sun on this scale is about 4.7.

On plotting these absolute magnitudes against the spectral types it becomes immediately evident that most of the stars belong to a series in which the fainter members are redder than the brighter, while a few outstanding stars of each spectral class greatly exceed in brightness those belonging to this series (except for class B, all of whose stars are very bright). The existence of these two series was first pointed out by Hertzsprung,[1] who has called them by the very convenient names of "giant" and "dwarf" stars—the former being of course the brighter.

With the large amount of material now available, especially for the dwarf stars, the results derived from the stars with directly measured parallaxes and from those in the clusters are in striking agreement, as is shown in Table I.

TABLE I.

MEAN ABSOLUTE MAGNITUDES OF DWARF STARS.

Spectrum.	Stars with Measured Parallaxes.			Stars in Clusters.			Formula.
	Number.	Abs. Mag.	Light.	Number.	Abs. Mag.	Light.	Abs. Mag.
B–B3 }	14	−1.7	380.	21	−1.2	240.	−1.0
B5–B9 }				8	0.3	60.	0.1
A	6	0.7	42.	13	0.5	50.	0.5
A2–A5	6	1.9	14.	26	1.7	17.	1.6
F	6	4.0	2.0	18	3.0	5.0	2.7
F5	7	3.6	2.9	7	3.3	3.7	3.8
F8	7	4.5	1.3	7	4.5	1.3	4.5
G	21	5.4	0.55	19	4.9	0.87	4.9
G5	11	5.6	0.46	9	5.5	0.50	6.0
K	16	6.6	0.18	10	6.3	0.24	7.1
K5	16	8.3	0.04	7	(6.6)	(0.18)	8.2
Ma	10	9.7	0.01				9.3

In the above table, the quantity given under the heading "Absolute Magnitude" is the mean of the individual values derived from the observed magnitude and parallax of each star in the corre-

[1] *Zeitschrift für wissenschaftliche Photographie,* Bd. V., p. 86, 1907.

sponding group (giving half weight to a few stars of relatively uncertain parallax or spectrum)—except for the stars of spectrum B with directly measured parallaxes. In this case the parallaxes are so small that a reliable value could be obtained only by taking the mean of the observed magnitudes and parallaxes for the whole group. These stars are of much greater apparent brightness than most of those of class B, and their actual brightness may be greater than the average for the class. No similar error of sampling need be suspected in other cases, except for the faintest stars in the clusters, where it is obvious in going over the lists that only a few of the brightest stars of class K5 are above the limit of magnitude at which our catalogues of stars belonging to the clusters stop, and probable that some of the fainter stars of class K are also excluded.

With the exceptions just explained, the results of the two independent determinations from the measured parallaxes and the clusters are in remarkably good arrangement, considering the small numbers of stars in many of the groups. The absolute magnitudes of stars of the same spectral class in different clusters are in equally good agreement. The relation between absolute magnitude and spectral type appears therefore to be independent of the origin of the particular star or group of stars under consideration.

This relation seems to be very nearly linear, as is shown by the last column of Table I., which gives for each spectral type an absolute magnitude computed by the formula

$$\text{Abs. Mag.} = 0.5 + 2.2\ (\text{Sp.} - \text{A}),$$

in which spectrum B is to be counted as 0, A as 1, F as 2, etc. It is of interest in this connection to remember that the difference of the visual and photographic magnitudes of the stars is also nearly a linear function of the spectral type.

The individual stars of each spectral class are remarkably similar in real brightness. Excluding those for which the parallax or spectrum is considerably uncertain, there remain in all 218 stars. Of these only 11, or 5 per cent. of the whole, differ more than two magnitudes in absolute brightness from the value given by the formula for the corresponding spectral class, while 150, or 69 per cent., have absolute magnitudes within one magnitude of the computed value.

The series of stars so far discussed does not however comprise all those in the heavens. Most of the stars of the first magnitude have small parallaxes, and are of great absolute brightness; and a study of proper-motions shows the same to be true of the naked-eye stars in general. It follows that there exists another series of stars, of great brightness, differing relatively little from one spectral class to another. These "giant" stars can be seen at enormous distances, and consequently form a wholly disproportionate part of the stars visible to the naked eye, as has been explained above. The illustration there given greatly understates the actual situation for the redder stars. The dwarf stars of class M, for example, are so faint that not one of them is visible to the naked eye (though one of them is the second nearest star in the heavens), and so the naked-eye stars of this class are all "giants."

Relatively few of these giant stars are near enough for reliable measures of parallax, and even for these it is safer to take the mean observed parallaxes and magnitudes of groups of stars, to diminish the effect of errors of observation. Confining ourselves as before to parallaxes determined by two or more observers, or by observers of high accuracy, the existing data may be summarized as follows.

TABLE II.

Mean Absolute Magnitudes of Giant Stars.

Spectrum.	Stars with Measured Parallaxes.					Stars in Clusters.		
	Number.	Mean Obs'd. Mag.	Mean Parallax.	Corresponding.		Number.	Mean Abs. Mag.	Light.
				Abs. Mag.	Light.			
B	14	2.2	0".017	−1.7	380	21	−1.2	240
A to G	5	0.8	0 .033	−1.6	350			
K	7	1.9	0 .032	−0.5	130	11	0.3	60
K5 and M	4	1.4	0 .047	−0.2	100	1	−3.8	2,600 (Antares)

The stars of class B are repeated here, since they may be regarded as belonging to either series.

Here again the stars whose parallaxes have been directly measured have been selected on account of their apparent brightness, and are probably brighter than the average of all the giant stars. Individual stars are in some cases still brighter; for example, Antares, which is clearly shown by its proper-motion and radial velocity to belong to the moving cluster in Scorpius, with a parallax of about 0″.010, and hence must be fully 2,500 times as bright as the sun. Canopus and Rigel, whose parallaxes are too small to measure, are probably equally bright or brighter. Whether there are many more stars of such enormous luminosity, and, in general, whether the giant stars of a given spectral class resemble one another in brightness as closely as the dwarf stars do, cannot be determined from existing data, at least of the kind considered here.

The giant and dwarf stars are fully separated only among the spectral classes which follow the solar type in the Harvard classification. For class A the two series are intermingled, and even for class F, where the average brightness of the two differs by four magnitudes, it would be difficult to say whether a star of absolute magnitude near 1.0 should be regarded as an unusually faint giant star or an unusually bright dwarf. From class G onward, the reality of the separation into two groups is unequivocally indicated by the observational data.

As a practical application of the principles just developed, we may consider the question of the distance of the Pleiades, a problem so far practically unsolved.

The spectra of the fainter stars which are known to belong to the cluster have been determined at Harvard, through the kindness of Professor Pickering and Miss Cannon. They exhibit a very conspicuous relation between apparent magnitude and spectral type, as is shown in the first four columns of Table III.

These stars evidently belong to the series of dwarf stars. The relative brightness of the different spectral classes is in good agreement with that previously found, except that the stars of class B5 in the Pleiades appear to exceed those of class A in brightness as much as those of class B0 to B3 do among the stars previously studied.

TABLE III.

STARS BELONGING TO THE PLEIADES.

Spectrum.	No.	Mean Obs'd. Magnitude.	Group Means.	Abs. Mag. of Stars in Other Clusters.	Difference.	Hypothetical Parallax.
B5	6	4.14	4.7	−0.5	5.2	0″.0091
B8	6	5.35				
B9	7	6.85	7.0	0.5	6.5	0.0050
A0	8	7.08				
A2	5	7.97	8.0	1.7	6.3	0.0055
A5	5	8.09				
F and F5	5	8.88	8.9	2.5	6.4	0.0052
G	3	9.43	9.4	(3.6)	(5.8)	(0.0066)

The fifth column in the table gives the mean absolute magnitudes previously found for stars of similar spectral type in other clusters (choosing the brighter half of those of class F, and a few of the brightest stars of class G, since it is evident that the limitation to stars above a given magnitude compels a similar choice in the Pleiades). From the differences between the observed and absolute magnitudes, we may compute the distances to which a group of stars similar to those already studied must be removed in order to appear equal in average brightness to the stars of the same spectral class in the Pleiades. The hypothetical parallaxes so obtained are given in the last column of the table. With the exception of that derived from class B, they are in extraordinary agreement. If they are treated as independent determinations of the parallax, of equal weight, the resulting mean is 0.″0063 ± 0″.0006, corresponding to a distance of 500 light-years.

This estimate of the distance of the Pleiades depends upon the assumption that, when we find in this cluster the same relation between the relative brightness of the stars of different spectral classes that exists elsewhere, wherever the real brightness of the stars can be investigated, the absolute brightness for each spectral class is also approximately the same as elsewhere. This assumption is made decidedly probable by the fact that it undoubtedly holds true for the stars of the four clusters whose distances are known, and for more than 100 other stars not belonging to clusters, with no serious exceptions. It should however be remembered that no account has been taken of possible absorption of light in space, and that there are unusually few very faint stars in the region of the Pleiades, which has been explained as the result of partial opacity of the nebulosity surrounding the cluster. Some of this nebulosity presumably lies between us and the stars of the cluster, and cuts off a part of their light, which would make the distance computed on the assumption that there was no absorption come out too great. If such absorption exists, it should be possible to determine its amount, and allow for it.

It is of obvious interest to inquire in what other respects besides brightness the giant and dwarf stars of the same spectral class differ from one another. One line of approach is furnished by the visual binary stars. It is well known that, when the orbital elements and apparent brightness of a binary pair are given, we can find what Professor Young calls the "candle-power per ton"—more exactly, the ratio L^3/M^2 where L is the combined light of the pair, and M the combined mass—without knowing the parallax. The writer has recently shown[2] that this principle can be extended by simple statistical methods to the stars known to be physically connected whose orbits cannot yet be computed. In this way about 350 stars have been investigated, and it is found that they fall into two series, similar in all respects to the giant and dwarf stars,—one marked by high luminosity per unit of mass, nearly the same for all spectral classes, and the other by small luminosity per unit of mass, diminishing very rapidly for the redder stars. By means of the parallactic motions of these groups of stars, an approximate estimate can be made of their distances, absolute magnitudes and masses, with results which may be summarized as follows.

TABLE IV.

Mean Absolute Magnitudes and Masses of Binary Stars.

Spectrum.	Giant Stars.			Spectrum.	Dwarf Stars.		
	Number.	Abs. Mag.	Mass.		Number.	Abs. Mag.	Mass.
B	44	−1.0	7	A–A5	57	1.2	5.
A–A5	52	−1.0	13	F–F5	61	3.0	3.5
F–G	26	−0.6	8	F8–G	32	4.7	1.4
K–M	38	−0.5	8	G5–K	26	6.3	0.5
				K5–M	8[3]	9.0	0.8

[2] *Science,* N. S., vol. 34, p. 524, 1910.

[3] From directly measured parallaxes.

The mean absolute magnitudes agree almost perfectly with those already derived for other groups of stars, showing that we have come again upon just the same giant and dwarf stars in still a different way. The computed masses, although subject to errors which may in some cases be as great as 50 per cent., show that the brighter stars are more massive than the fainter, but that the differences in mass are small compared with those in luminosity.

We may go farther with the aid of the information regarding stellar densities which can be obtained from the eclipsing variables, which are mostly of classes B and A. The average density of the eclipsing variables of class B is about one seventh of the Sun's density. We may therefore estimate that a typical star of the class, with seven times the sun's mass, is between three and four times the sun's diameter, and has about 15 times his superficial area. But we have already found that such a star, on the average, gives out more than 200 times as much light as the sun. Hence its surface brightness must be about 15 times as great as that of the sun. In the same way it is found that stars of class A must exceed the sun five-fold in surface intensity. On the other hand, the faint stars of classes K5 and M give off on the average about 1/100 of the sun's light, with masses exceeding half the sun's. Even if they were as dense as platinum, their surface brightness could not exceed 1/15 that of the sun.

This diminution of surface brightness with increasing redness, which has been proved to exist among the dwarf stars, is in obvious agreement with the hypothesis (now well established on spectroscopic grounds) that the principal cause of the differences between the spectral classes is to be found in differences in the effective surface temperatures of the stars; and the numerical results here obtained are in good agreement with those computed by Planck's formula from the effective temperatures derived by Wilsing and Scheiner from their study of the distribution of energy in the visible spectrum.

That the same law of diminution of the surface brightness with increasing redness holds true among the giant stars is highly probable, for giant and dwarf stars of the same spectral class are almost exactly alike in color and spectrum. If this is true, the giant stars, which are nearly equal in mass and brightness for all spectral types, must decrease very rapidly in density with increasing redness. If the relative surface brightness of classes B, G, and M is as given above, it is easy to show that the average density of the giant stars of class G must be about 1/40 of those of class B, or about 1/250 of the sun's density, and that the density of the giant stars of class M must average only about 1/15,000 of that of the sun. There is no escape from this conclusion unless we assume that the relation between spectral type and surface brightness is radically different for the giant and dwarf stars, in spite of the practical identity of the lines in their spectra and the distribution of energy in the continuous background.

The nature of the connection which class B forms between the two series is now evident. If all the stars are arranged in order of increasing density, the series begins with the giant stars of class M, runs through the giant stars to class B, and then, with still increasing density, through the dwarf stars, past those which so closely resemble the sun, to the faint red stars.

This arrangement is in striking accordance with the theoretical behavior which a mass of gas, of stellar order of magnitude, might be expected to exhibit if left to its own gravitation and radiation, at a very low initial density. While the density remains low, the ordinary "gas laws" will be very approximately obeyed, and, in accordance with Lane's law, the temperature must rise in order that the body may remain in equilibrium as its radius diminishes. At first the central temperature increases in inverse ratio to the radius, and that of the radiating layers near the surface also rises, though more slowly (because we see less deeply into the star as it becomes denser). As the density of the gas increases further, it must become more difficultly compressible than the simple gas laws indicate; and internal equilibrium can be maintained with a smaller rise of temperature after contraction. The temperature will finally reach a maximum, and the star, now very dense, will cool at last almost like a solid body, but more slowly, for contraction will still take place to some extent, and supply heat to replace much of that lost by radiation.

The highest temperature will be attained at a density for which the departures from the gas laws are already considerable, but probably long before the density becomes as great as that of water.

The density of the stars of classes B and A (which all lines of evidence show to be the hottest) is actually found to average about one fifth that of water, that is, of just the order of magnitude predicted by this theory. It appears therefore to be a good working hypothesis that the giant and dwarf stars represent different stages in stellar evolution, the former, of great brightness and low density, being stars effectively young, growing hotter and whiter; while the latter, of small brightness and high density, are relatively old stars, past their prime, and growing colder and redder. The stars of class B, and probably many of those of class A as well, are in the prime of life, and form the connecting link between the two kinds of red stars.

Princeton University Observatory,
May 25, 1912.

SOME FORMER MEMBERS OF THE AMERICAN PHILOSOPHICAL SOCIETY.

By THOMAS WILLING BALCH.

(*Read April 18, 1912.*)

The American Philosophical Society, the oldest learned society on this side of the Atlantic, and one of the most ancient in the world, was fortunate in its founder in a double sense. Franklin was not only a man of much learning and active in his advancement of "useful knowledge," but also he embodied in his own career the three classes of men from which most of our membership has been recruited since the founding of this society, whether we take it to begin with the founding of the Junto in 1727, as Du Ponceau so ably maintains,[1] or whether we place it as late as 1743. Franklin was a statesman, as his activites at Paris and London and here in Philadelphia sufficiently attest.[2] He was a scientist, as his numerous scientific discoveries prove, and he was a man of letters, as his papers abundantly show.[3] In the treaty negotiated in 1785 by Franklin for America with the then small kingdom of Prussia, two members of the

[1] Joseph G. Rosengarten, "The American Philosophical Society," Philadelphia, 1909, pp. 13–14.

[2] In 1780, before the adoption of the Constitution of the United States and when Pennsylvania was still an independent State at war with Great Britain, the General Assembly of Pennsylvania granted a most liberal charter to the Society which contains the following unique provision:

"That it shall and may be lawful for the said Society by their proper officers, at all times, whether in peace or war, to correspond with learned Societies as well as individual learned men, of any nation or country, upon matters merely belonging to the business of the said Society, such as the mutual communication of their discoveries and proceedings in Philosophy and Science; the procuring books, apparatus, natural curiosities, and such other articles of intelligence as are usually exchanged between learned bodies for furthering their common pursuits; Provided always, that such correspondence of the said Society be at all times open to the inspection of the Supreme Executive Council of this Commonwealth."

[3] The society possesses seventy-eight per cent. of Franklin's known papers.

brotherhood of nations agreed to abolish privateering between themselves. In that early step looking to free humanity from legalized sea pirates Franklin aided to inaugurate that aim of our American diplomacy that for a century and a quarter has pressed—and not without success, either—towards a greater and greater immunity from capture of private property on the high seas with resulting advantages to all humanity.[4] And of all three of these classes of men represented by the founder of the society himself, the society has upon its rolls, great and honored names.

Of statesmen, George Washington was a member of the American Philosophical Society. When in the usual course of events, his death was announced, the society adopted a resolution directing its members to wear crape on their left arm for thirty days, as a mark of respect, and commissioned Gilbert Stuart to paint his portrait for its hall. This portrait replica still hangs in the hall of the society, and since the society is a corporation, the picture is one of the very few still in the possession of its original owner. Thomas Jefferson, who was twice president of the Union, not only can be claimed by us as a member, but also as our president for a number of years. Not the least of the services that Jefferson rendered to mankind was the work that he did to advance the law of neutrality in a liberal and enlightened way. For, as the distinguished British international jurisconsult, Mr. Westlake—the holder for twenty years of the Whewell chair at Cambridge University, and an ex-judge of The Hague International Court (1900–1906)—has pointed out in his treatise on "International Law,"[5] the position that Jefferson as secretary of state in Washington's administration took on the rules of the law of nations involved in the efforts of the young American republic to maintain its neutrality during the war then in progress between Great Britain and France, the two most powerful

[4] Henry Wheaton, edited by R. H. Dana, "International Law," Boston, 1866; Émile de Laveleye, "Du respect de la propriété privée sur mer en temps de guerre" (*Revue de Droit International*), Brussells, 1875; John Westlake, "International Law," Cambridge University Press, 1907; Ernest Nys, "Le Droit International," Brussells, 1904–6; "Les États-Unis et le Droit des Gens," Brussells, 1908; J. de Louter, "Het Stellig Volkenrecht," The Hague, 1910.

[5] John Westlake, "International Law," Cambridge University Press, 1907, Volume II., pages 175–176.

nations of that day in Europe, exercised a powerful influence towards shaping the law of neutrality as it is to-day. Jefferson took advanced ground, both with France and Great Britain, on many of the questions that arose at that time. And the principles for which he then contended, several of them then hardly thought of, much less universally recognized, by nations, have in the course of a century become gradually imbedded into the acknowledged law of nations.[6]

Grover Cleveland, too, who stood as immovable as Gibraltar between a nation crazed by a generation of vicious financial legislation and the disasters and burdens of a debased currency into which it wished to plunge with the blind hope of curing the ills from which it suffered, made a third of our members whose fame as a great president of the United States has reached to the uttermost parts of the earth. Many other notable political men who have helped to shape the history of our country were members, such men as John Dickinson, Albert Gallatin, John Adams, Alexander Hamilton, Thomas Willing, Robert Morris, Charles Thomson, Francis Lightfoot Lee, DeWitt Clinton, John Quincy Adams, Alexander James Dallas, George Mifflin Dallas, Manasseh Cutler, Charles Jared Ingersoll, Nicholas Biddle, Robert C. Winthrop, Thomas Francis Bayard and Carl Schurz. And of foreigners who led active and important political lives many have been members: such men as the Count de Vergennes, the Marquis de la Fayette, George Douglas Campbell, Eighth Duke of Argyle, and William Ewart Gladstone, the latter two of whom both made their mark in the world of letters.

We have had among our membership a few representatives of the Fine Arts. And in this group it is gratifying to the local pride

[6] The society is fortunate in possessing an original imprint of the Declaration of Independence as well as a draft copy of the declaration in Jefferson's own hand, and many manuscripts of Indian vocabularies, most of them collected by Jefferson.

Dr. Holland possesses the diploma that the Royal Physical Society of Edinburgh—which was instituted in 1771 and confirmed by royal authority in 1788—awarded at Edinburgh on April 12, 1799, to Thomas Jefferson when that society elected him an Honorary Fellow. In the diploma Jefferson is addressed as President of the United States, though he was really Vice-President. At that time the Vice-President was the man who received the second highest vote, and it was the custom abroad to address the Vice-President as President.

of the home of our society that the first admitted to our ranks was a Pennsylvanian by birth, Benjamin West. He was elected on June 10, 1768. By the generosity of Colonel Joseph Shippen, himself a member of this society, who served under General Forbes in the capture of Fort du Quesne (1758), Andrew Allen, and the kind aid of other friends, West, after studying in this country, was enabled to study in Europe. Before his death, West had the pleasure of knowing that he had gained an international reputation. Another painter who was a fellow member, John Trumbull, a commissioner appointed by Washington to act under Article VII. of Jay's Treaty in the settlement of claims of American citizens against Great Britain, has left to America many a historic canvas. Charles Wilson Peale and Robert Edge Pine were both elected July 21, 1786. Peale was the founder of the Pennsylvania Academy of the Fine Arts, of which another of our members and a leading citizen of Philadelphia, George Clymer, signer of the Declaration of Independence, was chosen in 1805 the first president. Robert Edge Pine, the son of John Pine, an artist of distinction, was born in London, and died in Philadelphia, November 19, 1788. He won the first prize in 1760 of £100 offered by the society for the encouragement of the arts for the best historical picture presented that year, his "Surrender of Calais," with life size figures, and two years later gaining another prize with his picture "Canute Reproving his Courtiers," Pine rose into prominence. He painted portraits of John Wilkes, David Garrick and other well-known men of the day in Great Britain. About 1782 or 1783, Pine brought his family over to America. He had letters of introduction to Francis Hopkinson, whose portrait he painted. Hopkinson wrote to Washington introducing Pine and asking the general to sit to the latter for his portrait. This brought out from Washington the famous "In for a penny, in for a pound" letter. However, Washington sat for Pine, and the resulting portrait was engraved for Irving's "Life of Washington." On July 17, 1835, Thomas Sully, another portrait painter and a Philadelphian, was elected a member. The portrait of Thomas Jefferson, which belongs to the society, who sat in yonder chair when he drafted the Declaration of Independence, we owe to Sully's brush. And as you look upon the features of the third American President that hangs upon the south wall of this room, as rendered to posterity by Sully, do you not notice the marked resemblance to another Jefferson who was easily the prince of the American comic stage and also an author of no mean proportions.[7] John Sartain, the engraver, was a member. To this group we must not forget to add as a representative of the Fine Arts the French architect, Viollet-le-Duc. He was the author of "L'Histoire d'Une Cathedral"; and in the reign of Louis Napoleon, Viollet-le-Duc did good work for the preservation and restoration of many of the architectural treasures of France. He restored the justly famous feudal castle of Pierrefonds, once the property of the Duc d'Orleans, and arranged for the preservation of the yet greater feudal stronghold of Coucy-le-Château, whose lords boasted of their power in the famous motto:

> "Roi ne suis, ni prince, ni duc, ni comte aussi,
> Suis le sieur de Coucy."

Of famous jurists we have had John Jay, first Chief Justice of the Supreme Court of the United States, and negotiator of Jay's Treaty (1794); John Marshall and Roger Brooke Taney, who both have sat in that same chair; Justice Bushrod Washington, who sat on that same high tribunal; Robert R. Livingston, first chancellor of New York, and Lord Coleridge, Chief Justice of England. So, too, Thomas McKean, a signer of the Declaration of Independence and Chief Justice of the Supreme Court of Pennsylvania, and Edward Shippen, McKean's successor as chief justice of this commonwealth, were members. So, likewise, William Tilghman,[8] Shippen's successor, in the highest judicial office of the state, was elected a member and also president of the society from 1824 until his death three years later. Horace Binney, who won for the city of Philadelphia the Girard will case, was a member; and also James C. Carter, for many years the acknowledged leader of the American bar, and Edward J. Phelps, minister to the court of St. James. The latter two were our leading counsels in the Bering Sea Fur Seal case with the British Empire in 1893.

[7] Joseph Jefferson's "Autobiography," New York, 1890.

[8] See H. Binney's eulogium, appendix to 16 Sargeant and Rawle.

Another man to make his mark as a jurist and at the same time in the world of letters, who filled the presidential chair of this society, was Peter Stephen Du Ponceau. His picture by Sully hangs there on the northern wall. Born in the Isle de Rè off the western coast of France, June 3, 1760, Pierre Etienne Du Ponceau came to America in 1777 as secretary to Baron Steuben.[9] After the war was over, Du Ponceau studied law and was admitted to the Philadelphia bar in 1785 and made his mark in that profession. In the year 1810 he published in this city a translation under the title of "A Treatise on the Law of War," of the first book of Cornelius van Bynkershoek's "Quæstiones Juris Publici," prefixing to it a preface and introduction distinguished alike for style and learning.[10] Du

[9] Robley Dunglison, M.D., "A Public Discourse in Commemoration of Peter S. Du Ponceau, LL.D., late President of the American Philosophical Society, delivered before the Society pursuant to appointment, on the 25th of October, 1844," Philadelphia, 1844; Ernest Nys, "Les États-Unis et le Droit des Gens," Brussels, 1909, page 147.

[10] He translated into English two other books treating of two phases of international law. Neither has even been printed and the manuscript translations are now in the possession of the society. One, entitled the "Law of Neutrality," was translated from the German translation of the original work of the Abbé Galiani that was published in Italian at Naples in 1782: "De' doveri de' principi neutrali verso i principi guerreggianti, e di questi verso i neutrali libri due." The other, "On the Freedom of the Seas," is a translation of Gerard de Raneval's "De la liberté des Mers," published at Paris in 1811. To Du Ponceau the society is also indebted for the possession of a copy of John Selden's "Mare Clausum," London, 1635–36. From him also it received a copy of Richard Zouche's small book that first appeared in 1650, entitled "Juris et judicii fecialis, sive, Juris Inter Gentes, et Quæstionum de Eodem Explicatio, qua, quæ ad pacem et bellum inter deversos principes, aut populos spectant, ex præcipuis historico-jure-peritis, exhibentur." This little book is very likely the first manual of the *positive* Law of Nations and is rare.

Zouche was probably the first writer who deliberately used the name *Jus Inter Gentes* to designate a science which until that time had been nameless. "This collection of words," Dr. Holland says, "had, indeed, occurred, as it were accidentally, here and there in the pages of earlier writers, such as Victoria, Vasquez, Saurez and Grotius." In 1716, the Chancellor d'Aguesseau advised his son to study "ce qu'on appelle le Droit des Gens, ou, pour parler plus correctement, parceque le nom de Droit des Gens a un autre sens, le Droit entre les Nations." In 1789, Jeremy Bentham in his "Principles of Morals and Legislation" coined the term "International Law" as "calculated to express, in a more significant way, the branch of the law which goes

Ponceau's mental horizon was wide, and he wrote on many and various subjects. In the year 1815 he took an important part in the organization of an historical committee of this society. He first proposed such a committee in 1811. And it was as a result of this committee probably that the Historical Society of Pennsylvania was formed.[11] Among the members of this committee was William Thomas, the founder in 1812 of the American Antiquarian Society of Worcester, Massachusetts, the Abbé Correa da Sarra, David Rawle, subsequently the first president of the Historical Society of Pennsylvania,[12] Thomas Jefferson, Alexander James Dallas, Isaiah

commonly under the name of the Law of Nations." Thus Bentham translated Zouche's term *Jus Inter Gentes* into modern English from which has come the equivalents such as *Droit International, Diritto Internazionale, Derecho Internacional,* etc., of other languages. See Dr. Holland's edition of Zouche's "Jus Inter Gentes" in the "Classics of International Law," edited by James Brown Scott, Washington, 1911.

[11] "Early proceedings of the American Philosophical Society for the Promoting of Useful Knowledge, 1744 to 1838," Philadelphia, 1884, page 429.

"1811–June 21. (Patterson; and eight others.)

. . . .

"Historical Committee:

"'*Resolved,* On the motion of Mr. Du Ponceau, that a committee be appointed to report and devise a plan for organizing a committee or branch of this Society for making researches into and collecting materials for the History of the United States and of Pennsylvania in particular or any other plan for accomplishing the same object.

"'*Resolved,* That the Board of Officers be the Committee . . . to report in one month.'"

[12] *Transaction of the Historical and Literary Committee of the American Philosophical Society,* Philadelphia, 1819, Vol. I., pages v–viii: "At a meeting of the American Philosophical Society held at Philadelphia for promoting useful knowledge, March 17, 1815.

"*Resolved,* that a seventh committee be added to the six already established by the twelfth fundamental law, to be denominated 'The Committee of History, Moral Science, and General Literature.'"

The other six committees were:

1. Geography, Mathematics, Natural Philosophy and Astronomy.
2. Of Medicine and Anatomy.
3. Natural History and Chemistry.
4. Of Trade and Commerce.
5. Of Mechanics and Architecture.
6. Of Husbandry and American Improvements.

In 1843 the Historical and Literary Committee published its third volume.

Hosack of New York, William Short of Virginia, John Sargeant, William Tilghman, Thomas McKean, Charles J. Ingersoll, Nicholas Biddle and Caspar Wistar. Du Ponceau may therefore be considered to have been, with William Rawle and others, one of the founders of the Historical Society of Pennsylvania.[13]

As a result of this committee, Du Ponceau prepared a work on the "General Character and Forms of the Languages of the American Indians," that he read January 12, 1819, and which was printed in the *Transactions* of the committee. This work added to the author's reputation. On June 6, 1821, he delivered before the American Philosophical Society the annual address, taking as his subject the "Early History of Pennsylvania." Among many other writings, he gave in 1834 an address before the Law Academy of Philadelphia, of which he was then provost, on the "Constitution of the United States," of which a French translation was published three years afterwards at Paris. The next year the *Institut Royal* of France crowned his work in French on the grammatical languages of the Lenni-Lenape and some other North American Indians with the "Prix Volney."[14] On the second of December, 1836, Du

[13] In Du Ponceau's will this interesting passage occurs:

"The Historical Society of Pennsylvania is in danger of perishing for want of support. While almost every other State has an historical society, shall it be said that Pennsylvania wants one? Under the auspices of its illustrious founder, William Rawle, it has produced interesting and valuable memoirs: the honor of the State requires that the work should be continued. I recommend to them to increase the number of their members, and, perhaps, to raise the annual subscription to five dollars." A distinguished member of the Bar and so accustomed to sift evidence, a scholar, an antiquary, himself one of the principal participants in the foundation of the Historical Society and its second President (1837–1844), Du Ponceau in writing the above quotation probably knew whereof he wrote. Besides a man does not write anything in his will without careful consideration. See Robley Dunglison: "A Public Discourse in Commemoration of Peter S. Du Ponceau, LL.D., late President of the American Philosophical Society, delivered before the Society pursuant to appointment, on the 25th of October, 1844." Published by the Society, Philadelphia, 1844, page. 23.

[14] "Mémoire sur le système grammatical des langues de quelques nations, indiennes de l'Amérique du Nord; ouvrage qui à la séance publique annuelle de l'Institut Royal de France, le 2 mai, 1835, a remporté le prix fondé par M. le comte de Volney: par M. P.—Et. Du Ponceau, LL.D.," Paris, 1838.

Ponceau read before this society a long paper on "The Nature and Character of the Chinese System of Writing," which was printed in 1838 in the second volume of the *Transactions* of the Historical and Literary Committee.[15]

Besides being president of the American Philosophical Society from 1827 to 1844, a period of seventeen years, Du Ponceau was president of the Historical Society of Pennsylvania from 1837 to 1844, provost of the Law Academy of Philadelphia from 1821 to 1844, chancellor of the Law Association of Philadelphia from 1836 to 1844, and the president of the Philadelphia Athenæum for more than sixty years. Du Ponceau was elected as a result of his literary labors a corresponding member of many learned societies both at home and abroad, such as the American Antiquarian Society (1813), the Massachusetts Historical Society (1818), the New York Historical Society (1819), the American Academy of Arts and Sciences of Boston (1820), the French Institute (1827), the Royal Academy of Turin (1829), the Academy of Inscriptions, Belles-Lettres, History and Antiquities of Sweden (1831), the Academy of Sciences and Belles-Lettres of Palermo (1837), and many more that attest the high regard in which his work was held by scholars the world over. In addition, Harvard, the oldest of American universities, conferred in 1820 upon this scholar who was learned in the law the degree of Doctor of Laws, *honoris causa.*

Two sovereigns were members of this society, Joseph Bonaparte, who was designated on the list of members as "Joseph Count de Survilliers," King of Spain, from 1808 to 1813; and Louis Philippe, King of the French from 1830 to 1848. The former of these royal exiles presented to the society an Etruscan vase.

Anthony Wayne, the victor of Stony Point, and whose equestrian statue now mounts guard at Valley Forge, was chosen a member between April 16, 1779, and January 19, 1781.[16]

[15] "A Dissertation of the Nature and Character of the Chinese System of Writing, in a letter to John Vaughan, Esq.," by Peter S. Du Ponceau, LL.D., Philadelphia, 1838.

[16] Samuel Whitaker Pennypacker, "Pennsylvania in American History," Philadelphia, 1910, pages 30, 208.

George Gordon Meade, of Pennsylvania, commander of the Army of the Potomac, who held the supreme command for the Union during the three days' battle at Gettysburg,[17] where the flood tide of the Confederacy was halted and forced to ebb, was elected a member in 1871.

Charles Wilkes, of New York, the discoverer of Wilkes Land in East Antarctica,[18] who announced to a disbelieving world that in the Antarctic there was a land continental in size, was also a member. Like Meade, the hero of Gettysburg, the fame of Commodore Wilkes circled the globe, when early in the Civil War, Captain Wilkes, as he then was, in command of the *San Jacinto,* took from the British mail steamer *Trent,* Messrs. Mason and Slidell, two southern "gentlemen of distinction," who were on their way to Europe to try to represent the Confederate States respectively at the courts of St. James and the Tuilleries. Wilkes's bold action almost caused a war between this country and Great Britain, that was averted only by the prompt surrender of the Confederate "envoys" to Great Britain. That act established the rule of international law, that the representatives of a belligerent to a neutral power when navigating the high seas under a neutral flag cannot be captured. At the time, the action of Wilkes was condemned generally outside of the United States as a flagrant breach of the law of nations, and by none more so than by distinguished British publicists such as Montague Bernard and Sir William Vernon-Harcourt, "Historicus." The passage of time, however, has brought out proof, through the then British Premier, Lord Palmerston, that in the opinion of the best international legal advisers at that time of the British crown—Sir William Atherton, Attorney-General, Sir Roundell Palmer, Solicitor General (afterwards Lord Selborne) and Dr. (afterwards Sir Robert) Phillimore, counsel to the Admiralty—Captain Wilkes had acted according to international law as upheld in practice by Great Britain herself by no less an authority

[17] *The Pennsylvania Magazine of History and Biography,* Philadelphia, 1911, pages 1–40.

[18] Edwin Swift Balch, "Antarctica," Philadelphia, 1902; "Why America should Re-explore Wilkes Land," *Proceedings American Philosophical Society,* 1909.

than the celebrated expounder and architect of maritime law—Sir William Scott, later Lord Stowell.[19]

The Rev. Charles Magnus von Wrangel, of the Church of Sweden, was a member. Bishop Wrangel was born in Sweden about 1730, and was descended from Karl Gustaf, Count Wrangel, a general of the Thirty Years' War, who served under Gustavus Adolphus and Bernard of Saxe-Weimar. Educated at Vestrås and the University of Upsala, Wrangel received in 1757 from the University of Göttingen the degree of D.D., and was shortly afterwards nominated as court preacher to the King of Sweden. In 1759 he was called to the provostship of the Swedish churches in "New Sweden," and arrived in Philadelphia the same year. He at once took charge of the Wicaco parish (*Gloria Dei*), which was first organized in 1677 and was the second oldest parish of the Church of Sweden in this state, the first having been established on Greater Tinicum Island shortly after Governor Printz landed there in 1643. Dr. Wrangel also had the oversight of all the Swedish congregations in Pennsylvania and New Jersey. Returning to Sweden in 1768, he was given the pastorate of Sala. In this country, according to the instructions of the Archbishop of Sweden, he cordially and actively coöperated with the German Lutheran ministers.

The Rev. Dr. Robert Blackwell, of the Church of England, was a member. A son of Colonel Jacob Blackwell, of Long Island, who belonged to the family that long possessed and from whom was named Blackwell's Island in the East River, he was ordained to the ministry of the English Church, and after serving several parishes in this country, he ministered to Saint Peter's church. His house, on the south side of Pine Street, number 224, still stands with its imposing front of alternating black and red bricks. While Dr. Blackwell lived in it, all the ground westward to Third Street formed

[19] Montague Bernard, "Notes on Some Questions suggested by the Case of the *Trent,*" Oxford and London, March, 1862; Sir William Vernon-Harcourt, "Letters by Historicus on Some Questions of International Law reprinted from *The Times,*" London and Cambridge, 1863; Arthur Irwin Dasnet, "John Thadeus Delane, editor of *The Times,* His Life and Correspondence," London, 1908; Arthur Christopher Benson, "The Letters of Queen Victoria," New York, 1907; Thomas Willing Balch, "The Removal of Mason and Slidell from *The Trent,*" *The Nation,* New York, February 11, 1909.

his garden. When the War for Independence broke out, he took sides with the colonists and having gained in his youth a knowledge of surgery, he offered his services to the cause, and served all through the trying winter at Valley Forge, as surgeon to the First Pennsylvania Line, having received his commission from Anthony Wayne. He died at Philadelphia, in 1831, having been a notable figure in the life of the city.

Another divine who was a member, was the Rev. John Witherspoon, of the Church of Scotland; he was elected on April 21, 1769. President of the College of New Jersey, now Princeton University, Witherspoon not only impressed his mark upon the youth of many of the leading men of our country in his work at the head of a great institution of learning, but also took an active part in the events, both in his own colony of New Jersey and in those of the Confederation, that secured our admission to the brotherhood of nations. Born at Yester, near Edinburgh, Scotland, February 5, 1722, the son of a pastor of the Scottish Church, and descended through his mother from John Knox, Witherspoon was educated at the University of Edinburgh, and became a minister of the Church of Scotland in 1745 at Perth. Of an active and literary turn of mind, he published in 1764 a work on "Regeneration," and three volumes of "Essays"; he received the same year the degree of D.D. from the University of Aberdeen. Calls came to him from Dundee, Dublin, Rotterdam and the College of New Jersey, all of which he declined. A few years afterwards, however, he accepted a renewed invitation from the College of New Jersey to become its president, and after publishing two volumes of sermons, he sailed for the New World in May, 1768. His inaugural address at Princeton on August 17 of the same year, of the union of piety with science, was delivered in Latin. At once he set himself to the task of developing the college. He raised money, procured books and instruments, among the latter the first orrery made by Rittenhouse. He said he had "become an American the moment he landed." Certainly, no one was more resolute in the cause of liberty. In 1774, just before the beginning of the active strife between the colonies and the mother land, he issued in Philadelphia a work on "Considerations on the

Nature and Extent of the Legislative Authority of the British Parliament." The sermon that he preached on "fast day," May 17, 1776, on the "Dominion of Providence over the Passions of Men," he dedicated to John Hancock, the president of Congress; it was reprinted at Glasgow, with notes in the loyal interest, to show the iniquity of rebels. He was a member of the New Jersey Convention that framed a constitution for that colony and showed much legal knowledge. Among other things he urged an omission of religious tests. He served in the Provincial Congress of New Jersey, and afterwards he represented that colony in the Continental Congress. He always wore his clerical garb, and considered himself to be "God's minister both in a sacred and a civil sense." In Congress he did his full share of work, opposing, with keen insight, the repeated issues of paper currency. The part that Witherspoon played in those years of trial has until now been much underestimated. Among his other services to America it should not forgotten that he was the only clergyman who signed the Declaration of Independence. The religious leaders of the nations have a profound influence on their development and destiny. For, as Paul Fredericq, of the University of Ghent, has so truly said:

"Perhaps all historians do not attach a sufficient importance to the action of religion on the development or restriction of public liberty. . . . As soon as you do not close your eyes you notice this historic truth: There are religions that put the peoples to sleep and there are religions that keep them awake."

And Witherspoon's religious teaching was not of a kind to lull a nation to slumber.[20]

[20] Montesquieu: "Esprit des Lois," Livre XXIV., chapitre V.; Thomas Balch, "Les Français en Amérique," Paris, 1872, pages 22–41; Émile de Laveleye, "Le Protestantisme et le Catholicisme dans leurs rapports avec la liberté et la prosperité des peuples" (*Revue de Belgique,* Brussells, January 15, 1875), reprinted in "Essais et Études," première série, 1861–1875, Ghent and Paris, 1894, pages 370–409; R. Treumann: "Die Monarchomachen: Eine Darstellung der revolutionaren Staatslehren des XVI. Jahrhunderts," Leipzig, 1895; Paul Fredericq, "Le Calvinism et le Self-Government" (*Journal de Genève,* July 10, 1909), reprinted in the *Journal of the Presbyterian Historical Society,* Philadelphia, June, 1910, page 270.

There are statues of Witherspoon in Fairmount Park, Philadelphia, on Connecticut Avenue in the City of Washington, and on the walls of the library of Princeton University.

Another notable foreign member was John Stuart Mill, philosopher, logician, economist, and a member of the British Parliament, author of a "System of Logic, Ratiocinative and Inductive," "Principles of Political Economy," and other works that influenced humanity. With the name of Mill can be coupled that of an American philosopher, Thomas Paine, the author of "Common Sense." Another of our early men of letters was Constantin François Chasseboeuf, Comte de Volney. Traveller, historian and senator of France, his fame rests chiefly upon his works: "Voyage en Egypte et en Sirie" (1787); "Les Ruines, ou Méditations sur les Révolutions des Empires" (1791); "La Loi naturelle, ou Catéchisme du Citoyen français" (1793), and "Recherches nouvelles sur l'Histoire ancienne" (1814–15).

Of political writers and international jurists we can claim a number: Noah Webster, who wrote "Sketches of American Policy" (1784); "Examination of the Leading Principles of the American Constitution" (1787); "The Rights of Neutrals" (1802); and on many other topics, and gave to America his "American Dictionary of the English Language"; Alexis de Tocqueville, the author of "Democracy in America"; Esquiron de Parieu, who wrote on political science; Henry Wheaton, our minister first at Copenhagen and then Berlin—worthy follower of his great prototypes, Albericus Gentilis, Hugo Grotius and Cornelius van Bynkershoek—whose treatise upon the laws of nations has held high authority among jurists; Theodore Dwight Woolsey, a voluminous writer on religion, political science, international law, President of Yale, a member of l'Institut de Droit International; and Sir Henry Sumner Maine, holder for an all too brief period of the Whewell chair at Cambridge University and expounder of the growth of law and legal customs among many nations in Europe and Asia.[21]

[21] The Society has among its endowments, The Henry M. Phillips' Prize Essay Fund founded in October, 1888. The interest of this fund is awarded for "the payment of such prize or prizes as may from time to time be awarded by the society for the best essay of real merit on the Science and Philosophy of Jurisprudence." The Phillips Prize was awarded in 1895 to George H. Smith, of Los Angeles, California, for his essay on "The Theory of the State." In 1900 the Phillips Prize was given to W. G. Hastings, of

With the names of historical scholars our rolls in the past at least are rich. Upon them we find Washington Irving, minister to Spain, biographer of Washington and author of "Rip Van Winkle," the "Legend of Sleepy Hollow," "The Alhambra" and the "Conquest of Granada"; Jared Sparks, American historian, who wrote of Washington and other parts of our history; William H. Prescott, who related the conquest of Mexico; François P. G. Guizot, prime minister of Louis Philippe, membre of l'Académie Française and author of "L'Histoire de la Civilization en France" and "L'Histoire de France"; Lord Mahon, Fifth Earl of Stanhope, statesman and historian, lord rector of the University of Aberdeen and a foreign member of the Academy of Moral and Political Sciences of Paris; Victor Duruy, French minister of public education and author of "L'Histoire du Moyen Age" and "L'Histoire de France"; John Lothrop Motley, who has told the world of the struggles of the Netherlands for freedom and independence; George Bancroft, who related for us our own history from the beginning of the nation until a little after its reception into the family of nations; Charles J. Stille, president of the Historical Society of Pennsylvania and provost of the University of Pennsylvania, who wrote of Anthony Wayne; Theodore Mommsen, author of the "History of Rome"; and his fellow countryman, Leopold von Ranke, who treated of the Middle Ages; James Anthony Froude, regius professor of history at Oxford, who wrote "The History of England from the Fall of Wolsey to the Defeat of the Spanish Armada" and many lesser works; the Rt. Rev. William Stubbs, Bishop of Oxford, author of many works relating to the history of England; Henry Martyn

Walker, Nebraska, for a monograph on "The Development of Law as illustrated by the Decisions relating to the Police Power of the State." In 1912, this prize was awarded to Charles H. Burr, of Philadelphia, for an essay on "The Treaty-Making Power of the United States and the Method of its enforcement as affecting the Police Powers of the States."

The Society also possesses the Thomas Balch International Law Fund. This endowment was established in 1911 as a memorial to Thomas Balch "for his share in bringing about the arbitration by the Geneval Tribunal of the Alabama claims." It is intended, subject to certain restrictions, to be used for the purchase of books relating to the law of nations and such other uses, when thought advisable, as may promote the study of that science.

Baird, who told us of the Huguenots; Frederick D. Stone, librarian of the Historical Society of Pennsylvania, who did so much to make the rich collections of that society accessible to scholars; Justin Winsor, of Harvard, editor of the "Narrative and Critical History of America." And last, but not least, our fellow townsman, the late Henry Charles Lea, whose portrait hangs in the north hall, one of the greatest historians that America has given to the world, and at the time of his death probably the most distinguished citizen of Philadelphia, was a member of this society.

Among economists we have had a number of well-known men: Dupont de Nemours, one of the famous French school of physiocrats, who finally settled in the neighboring state of Delaware, and presented to the society a bust of Turgot; Henry Carey, whose name is known wherever the science of political economy is taught; Michel Chevalier, who enlightened the world on many points of economy; Leon Say, the notable French minister of finance and president of the French senate, who by his able management of the French finances added new luster to a name already made famous among economists by his honored sire and grandsire and earned by his works on economics, "l'Histoire de la Théorie de changes étrangers," "l'Histoire de la Caisse d'escompte," "La Vie de Turgot," etc., election in 1886 to l'Académie Française; and Pierre Emile Levasseur, a member of l'Académie des sciences morales et Politiques of France.

The portals of the temple of letters had just opened before Albert H. Smyth when he was carried off to the silent majority. Those who were so fortunate as to hear his impromptu address in this hall, prepared only upon thirty minutes' notice, to the "Americanists," when they visited the society, a few years since, were impressed with the admirable manner in which, on that occasion, he received our guests. Every one who attended the annual dinner of the society in 1907, will remember how well he acted as toastmaster, drawing upon his abundant knowledge of Anglo-Saxon literature for many an apt quotation.

We have had noted poets, essayists and novelists, too: James Russell Lowell, John Greenleaf Whittier, Ralph Waldo Emerson, and Oliver Wendell Holmes. And let us not forget that a Philadelphian, George H. Boker, minister to Russia and author of Francesca di Rimini, was elected a member. Surely it is our loss that Samuel L. Clemens (Mark Twain) was not: his was a case of the "quarante et unième fauteuil" of the French Academy, for the name of Mark Twain will be remembered as long as our country lasts.

I should much like to speak to you of our living townsmen here, as well as in other parts of the country, who are members and have gained distinction in the world of letters; but there is not time to mention them *all,* and it is too difficult and ungracious a task to choose among them.

From the foregoing men whom we have learnt were members of this notable society, we see that in its bounds it has embraced all knowledge, and awarded the honor of its membership not to a single class of scholars or even to members of a few groups, but to savants to whatever branch of learning they may have devoted their time and powers. Membership in this society is an honor justly prized among scholars. And not the least of the causes for the esteem in which membership in the American Philosophical Society is held, is that it is so *universal* in its scholarship.

The greatest thinkers of the world were men whose mental horizon was not limited by the thought that that study upon which they devoted their best powers was vastly more important than any other, but recognized that knowledge extended in all directions and took an interest in many channels.

One of the best and most notable examples of a man whose learning was not confined only to his special branch, but who sought by every means in his power to gain as an aid to his cherished aim knowledge in every sphere of human activity, was the ablest of the Carthaginian generals, Hannibal. Master of everything that was known in his time that pertained to the carrying on of war, Hannibal was not only the school master of the Romans in the art of strategy, an art which he practically originated and drilled thoroughly into his Roman pupils by inflicting upon them all sorts and kinds of reverses, but also he was a scholar. For splendidly educated by the direction of his father, Hamilcar, he knew almost everything that was to be known in his day. His natural genius as a born military leader of men and able diplomatist was enhanced by vast learning. His scholarship, far from proving a detriment, aided him in that marvelous war that, with slender means, he waged against the Romans and their great resources, a war known to the latter as the war against Hannibal. Another active man of affairs who rejoiced in a broad education, was the Scandinavian warrior-statesman-king, surnamed the "Lion of the North and Defender of the Faith," Gustavus II. Adolphus of Sweden.[22] Other men of wide and di-

[22] Pennsylvania has especial interest in Gustavus Adolphus. For when William Usselinx found that he could not persuade the states general of his native Holland to take hold of his scheme for a Dutch trading and colonizing company in the New World, he turned with reluctance in 1624, to Sweden for aid. At Göteborg in October or November of 1624, Gustavus Adolphus granted him a six hours' interview to unfold his plans. On November 4, Usselinx had the draft charter of the proposed company ready; then the general prospectus of the proposed company was issued; and on December 21, 1624, the Swedish king gave "commission to William Usselinx to establish a General Trading Company for Asia, Africa, America and Magellanica." Finally, on June 6, 1626, King Gustavus Adolphus signed the charter of the South Company, to carry on trade beyond the seas and to colonize. It was the first forerunner of that later Swedish Company in whose service Lieutenant Colonel John Printz, subsequently starting from Göteborg with the two vessels, the *Fama* and the *Swan*, crossed the Atlantic in 1642, to become the fourth governor of New Sweden. Printz, like his three Swedish predecessors, landed at Fort Christina, the site of modern Wilmington in the present state of Delaware. But before the Swedish governors began to rule in the territory of the colony of Delaware, a Dutch settlement was started near the mouth of Delaware Bay, at Swanendael, and lasted for a few months, until all its members were killed by the Indians. In 1643, the year after Governor Printz had started from Sweden to cross the Atlantic Ocean to New Sweden, and had established himself at Fort Christina, he moved his seat of government from the territory subsequently called Delaware, to Great Tinicum Island (Tenakon as the Indians called it), a part of what is now Pennsylvania. And so Printz was the first man to represent in his own person a European sovereign, who established a seat of government in the territory of what is now the commonwealth of Pennsylvania. Thus Pennsylvania looks for the beginning of her sovereignty to Queen Christina of Sweden and her chancellor Axel Oxenstierna, and through them to Gustavus Adolphus. The thirteen colonies that sprang from three northern nations of Europe—England, Holland and Sweden,—and founded the United States of America, can look back to three historic figures,—Elizabeth of England, Father William of the Netherlands, and Gustavus Adolphus of Sweden, all three worthy prototypes of our own national father, Washington.

verse learning were Leonardo da Vinci, Grotius, Rabelais, Copernicus, Napoleon, Cavour and Bismarck. To all these men who looked through all knowledge for their guide and aid in their life's works are applicable the lines of Wordsworth:

> "Who with a natural instinct to discern,
> What knowledge can perform, is diligent to learn."

There are numerous societies devoted to one line of research, where men who are engaged in a comomn pursuit, can exchange ideas upon their favorite theme. Here in Philadelphia, the home of the society, we have, for example, the Historical Society of Pennsylvania (1824), the Academy of Natural Sciences (1812), and the Franklin Institute (1822), each one of which is devoted to a special field of research. So in other cities you find quantities of such societies devoted to a single, or at most two or three topics of investigation. But the American Philosophical Society is one of the very few associations in the world which by its membership has been *representative of all learning.* Other societies that represent all knowledge are the Hungarian Academy of Sciences of Buda-Pest (1825); the Institut de France of Paris (1795); the American Academy of Arts and Sciences of Boston (1780), the second oldest American society of learning;[23] the Académie Royale de Belgique of Brussells (1771); the Koniglische Bayerische Akademie der Wissenschaften of Munich (1759); the Royal Academy of Sciences and Lettres of Denmark of Copenhagen (1742); the Imperial Russian Academy of St. Petersburg (1725), conceived by Peter the Great, and organized and endowed by Catherine upon the plans of Leibniz and Wolff; the Koniglische Preussiche Akademie der Wissenschaften of Berlin (1700), whose first president was Leibniz and which numbered among its members Savigny, Schleiermacher, Bopp, Ranke

J. Franklin Jameson, "William Usselinx, founder of the Dutch and Swedish West India Companies," papers of the American Historical Association, New York, 1887, Volume II., No. 3; James M. Swank, "Progressive Pennsylvania: a record of the Remarkable Industrial Development of the Keystone State," Philadelphia, 1908, page 13; Amandus Johnson, "The Swedish Settlements on the Delaware, 1638–1664," Philadelphia, 1911.

[23] *Proceedings of the American Academy of Arts and Sciences,* Volume XLIV., No. 26, September, 1909.

and Wheaton; and the Royal Academy of the Lincei of Rome (1603), one of whose foreign members was the historian, Henry Charles Lea. A few more might be cited but their total number is small.

Surely some of the work performed by men of letters has redounded as much to the benefit and advancement of humanity as anything discovered by the exact scientists. What more difficult and beneficent task opens before the scholar than the effort to aid in solving the difficult problem of government? Like individuals, nations are born, grow up unless cut down in their youth, reach maturity and sooner or later die. Yet in both the case of the individuals and states the span of life can be shortened or lengthened according as sound rules of life are followed. In the case of nations this depends in great part on what manner of government they have. For thousands of years men have worked at that problem and the solution of it seems as far off as at the beginning. A little more than a century since, some of the ablest men of our then young country—some of them members of this Society—framed in yonder historic building, our old Pennsylvania State House (1735), in the shadow of whose steeple this also historic building stands, a form of government that at the time was admirably suited to the needs of this country. It was a distinct advance in government building. Yet, they originated little that was new, and most of that little proved in practice to be abortive. In framing the form of government under which this republic has prospered for over a hundred years, they ranged the whole past of humanity for the efforts of other races at government building. And from the experiments of other nations, as tried and tested in the sound school of experience, and the writings of the great commentators upon government and human rights, such as Locke, Grotius, Montesquieu and Burlamaqui,[24] they evolved their scheme of government.[25] That that

[24] J. J. Burlamaqui, "The Principles of Natural Law;—in which the true systems of Morality and Civil Government are established." Nugent's translation, London, 1748. There is a copy of this book in the Library Company of Philadelphia.

[25] Writing from Philadelphia, November 13, 1789, to Jean Baptiste Le Roy, Franklin says: "Our new Constitution is now established, and has an appearance that promises permanency; but in this world nothing can be said to be certain, except death and taxes."

plan is not working so smoothly now as in their day is due to the changed conditions that have grown up, especially the vast increase of population, largely congregated in small areas. Formerly it was a great deal easier for a man to rise to political leadership unaided except by the appeal that his abilities and force of character made upon his neighbors. And to-day many of the best political men rise in small communities. So in South Africa, where the population is sparse in the country districts and the cities and towns are still generally small, one of the Dutch farmers of the Orange Free State rose in the Anglo-Dutch three years' war to become the ablest general who held high command on either side, Christian de Wet. Such a career as his would be almost impossible in a densely populated country. To so adapt the governmental structure to the ever-changing conditions of population that the individuality of most men will not be strangled by the density of population in which they live is as difficult an undertaking as any problem within the range of science, as worthy of the efforts of the best minds as the continued attempts to conquer disease, or to win a reasonable safe and certain navigation through the air. In all times and climes there have been political leaders with but little knowledge of events and institutions before their own lives began, who have asserted that existing institutions and laws were inadequate and bad, and in glittering phrases have said that such conditions must be changed. But as a rule they have not presented any well thought out plans by which such conditions could be remedied to the advantage of the human race. For while men have found it easy to destroy governmental structures, only occasionally a leader like Charlemagne or Washington, for instance, has come forward possessed of the ability to build up something new for the advantage of humanity. And towards the efforts of such politcal leaders of the human race to devise a better and more acceptable system of government, publicists from Plato down, have made valuable contributions. Malthus in 1798 published his "Essay on the Principle of Population," in which he pointed out that population tends to increase faster than sustenance, with the result that poverty, misery and vice must ever be present with us. He explained and expounded the "struggle for existence" (those are his identical words) among mankind.[26] Studying his subject further, he found that Plato and Aristotle had grasped the same fact that the human race tends to increase more rapidly than the means of nourishment. Of such publicists, as Witherspoon, for example, a number, as we have seen, were members of the American Philosophical Society.

Thus as we look at the roll of this truly historic society, the oldest society of learning in the New World, we see that its membership has been recruited year by year with original workers seeking after truth in all branches of Knowledge, whether in the Republic of Letters, the Exact Sciences or the Mechanical and the Fine Arts, so as to keep the American Philosophical Society truly representative of *all learning*.

[26] T. R. Malthus, "An Essay on the Principle of Population, as it affects the future Improvement of Society, with remarks on the speculations of Mr. Godwin, M. Condorcet, and other writers," London, 1798, page 48.

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CORRIGENDA.

In Vol. LI, No. 203, Dr. T. J. J. See's paper on the Depth of the Milky Way:

page 12, 8th line from top, *for* "large" *read* "small."
" " 10th " " " " "decreasing" *read* "increasing."
" " 14th " " " " "large" *read* "small."

page 13, 8th line from bottom, *for* "enfeeblement of" *read* "enfeeblement to."

page 14, 4th line from top, *for* "million" *read* "thousand."

In No. 204, the same author's paper on the Dynamical Theory of the Globular Clusters.

page 119, 18th line from top, *for* "Stellar System" *read* "Stellar Systems."

page 122, equations (10), make denominator of first equation same as last two.

page 127, 7th line from top, *for* "$\frac{\partial}{\partial n}$" *read* "$\frac{\partial U}{\partial n}$."

page 139, 10th line from top, *for* "convected" *read* "connected."

page 144, last equation of (48) *for* "$\sum_{i=1}^{i=i}$" *read* $\sum_{i=1}^{i=i} Z_i$"

page 165, 9th line from top, *for* "mediation" *read* "meditation."

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OBITUARY NOTICES
OF MEMBERS DECEASED.

JULES HENRI POINCARÉ.

(*Read December 6, 1912.*)

In a much quoted sentence, Klein has said "We shall have a picture of the development of mathematics if we imagine a chain of lofty mountains as representative of the men of the eighteenth century, terminating in a mighty outlying summit,—Gauss, and then a broader, hilly country of lower elevation; but teeming with new elements of life." This was written in 1893 and would perhaps still be received as the truth by most observers. During the ensuing period it has, however, become more and more evident that two of the contemporary hills rise quite above the others, and it may be that when they are seen in perspective they will compare favorably with the more distant mountains.

Hilbert and Poincaré are associated and contrasted in the minds of all students of mathematics both by the brilliance of their achievements and the difference of their methods. To enter into a comparative study of these two great men would not be an appropriate exercise for this occasion, but to have suggested it may help to indicate the relation of Poincaré to the time in which he lived.

Aside from his intellectual triumphs, which one could adequately comprehend only by reading a series of his papers, the life of Poincaré presents little of interest. He was born at Nancy on the 29th of April, 1854. His unusual gifts were recognized early, so that he had an excellent education. He received the degrees of Bachelor of Letters and of Science in 1871 and that of Mining Engineer in 1879. He was attached in one capacity or another to the Department of Mines of the French government for the rest of his life, but not in such a way as to interfere with his scientific work.

In the year 1879 he also received his doctorate of Science from the University of Paris. He was immediately made a member of the faculty of science at Caen. From there he was called to the University of Paris in 1881. In 1886 he was appointed professor of physics and of the calculus of probabilities in the University of Paris and in 1896 became professor of mathematical astronomy at the same university. In 1904 he was also made professor of general astronomy at the École Polytechnique. Since 1902 he occupied the chair of electricity at the École professionnelle supérieure des Postes et des Télégraphes. He died on the 17th of July, 1912.

The importance of his scientific contributions was recognized from the very beginning of his career. He received practically all the distinctions which are open to a mathematician. Among the most notable were: Election to the Academy of Science of France (Section of Geometry) in 1887, election to the French Academy in 1908, and the Bolyai Prize for excellence in all fields of mathematics in 1905. He was elected a member of the American Philosophical Society in 1899.

Poincaré was particularly distinguished among his contemporaries by the wide range of his creative power. He left behind enduring works not only in the several branches of pure mathematics but in astronomy, physics and philosophy. He has often been described as the last of the universals. Indeed in this respect as well as in the brilliance of his individual works, he is like those earlier heroes of science whom Klein compared to the chain of lofty mountains.

It goes without saying that one could not expect to give an adequate account of Poincaré's complete work in a short address like this one. I shall try, however, to mention certain main divisions of his work, taking them up in an order which is roughly chronological. Naturally, the periods to which I shall refer all overlap but I shall try to arrange them according to the dates of the central papers in each subject.

Poincaré's doctoral dissertation, which was his first published work of importance, appeared in 1879. Its title was "On the Properties of Functions Defined by Partial Differential Equations" and it supplies the existence theorem for solutions in the neighborhood of singular points of a very general type. This memoir initiated a long series of brilliant contributions to the theory of differential equations, especially to that of linear differential equations. Most of these papers appeared in the period before 1886.

These studies led directly to his discoveries in the field of automorphic functions where Poincaré achieved his first great celebrity. Like most first-class things in modern mathematics, it is impossible to describe these functions briefly in a non-technical discussion.[1] We must be content to characterize them as the nearest lying and most beautiful generalizations of the trigonometric and elliptic functions. Poincaré deserves to be classed as one of the founders of this branch of mathematics, for to him are due some of the main outlines of the theory and the main existence theorems. Poincaré's last important contribution was his memoir on the zeta-fuchsian functions in the *Acta Mathematica* for 1884. Since then this work has been carried forward chiefly by Klein and his students.

This series of contributions to function theory was followed in 1885 by his epoch-making memoir on the figure of equilibrium of a rotating fluid mass. In this work he not only solved the problem of stability for the previously known figures of equilibrium, the ellipsoids of Maclaurin and of Jacobi, but he also discovered a whole class of new figures of equilibrium. This work is important not only on account of the particular new figures (the pear-shaped figures) which it put in evidence, but also on account of its method. I need mention only the theorem on the exchange of equilibrium.

In 1890 he made a still greater contribution to mathematical astronomy in his memoir "On the Problem of Three Bodies and the Equations of Dynamics." Here he brought into existence a general theory of periodic orbits and disproved the existence of further new integrals which are analytic functions of the masses. These matters and many others, such as the integral invariants and asymptotic solutions, are the subject of his three volumes (1892, 1893 and 1899) on "Les Méthodes Nouvelles de la Méchanique Céleste." Later on he published three more volumes entitled "Leçons de Méchanique Céleste" in which he developed some of the classical theories from new points of view.

The problems of celestial mechanics continued to occupy the mind of Poincaré till the end of his life. In his last paper, which

[1] This difficulty must indeed be my excuse for the summary way in which I shall have to refer to the rest of Poincaré's work.

appeared in print shortly after his death, he shows how to reduce one of the problems regarding the existence of periodic orbits to a geometric problem, which, however, he was unable to solve. He apologizes for putting forth such an incomplete result on the ground that at his age (he was only 58) he could not feel confident of returning to the problem in the future and solving it completely. One cannot avoid the impression that he felt that his career was very nearly at an end. It will doubtless interest this audience to know that a proof of Poincaré's theorem has already been found by a young American mathematician, Professor G. D. Birkhoff, of Harvard.

We cannot here dwell longer on the astronomical work of Poincaré. We must pass over without particular mention his work on the figure of the earth, on the tides, and on the lunar theory, as well as his recent book on *cosmogony*.

Poincaré is the author of at least fourteen advanced text-books in various branches of physics. Among the titles we find Capillarity, Elasticity, Vortices, Heat, Thermodynamics, Optics, Electricity, Wireless Telegraphy, etc. These are chiefly reproductions of his courses of lectures at the Sorbonne. He also wrote a large number of papers and memoirs on physical topics, especially on Hertzian waves and on the theory of electrons. On the whole, however, his work in physics cannot be compared in importance with his fundamental contributions to mathematics and astronomy. His work on the differential equations of physics and on Dirichlet's principle, which one might be expected to mention here, is of more consequence to mathematics than to physics.

We must now turn to another main division of his work in a domain of pure mathematics. Already in 1883 he had published an important paper (in the *Acta Mathematica*) laying the foundations of the theory of functions of two complex variables. In 1887 he published his memoir on the residues of double integrals, which furnished one of the chief tools for the theory of algebraic functions of two variables, a theory which has since been built up chiefly by his colleague Picard, by Poincaré himself, and by many brilliant Italian geometers.

The theory of algebraic functions of one variable has as its most striking auxiliary the manifolds of two dimensions known as Riemann surfaces, and the theory of the connectivity of Riemann surfaces is the main object of the analysis situs of two dimensions. A generalization of this theory to manifolds of any number of dimensions was foreseen to some extent by Riemann himself and to a larger degree by Betti, who discovered a set of invariants of n-dimensional manifolds which are known as the Betti numbers. Little real progress, however, had been made till Poincaré took the question up, modified the Betti definitions, showed how the modified Betti numbers satisfy a generalization of Euler's theorem for polyhedra, and introduced an entirely new set of constants, the coefficients of torsion. This work is contained in a series of memoirs of which the first appeared in 1892 and the last in 1904. They were accompanied and followed by a number of papers in which analysis situs is applied to the theory of algebraic functions of two and more variables.

I have now mentioned what appear to me the most important achievements of Poincaré, grouping them together in four classes which, as I said, correspond very roughly to a chronological order, The four sections of his work which I have signalized are his contributions (1) to the classical theory of differential equations and the theory of automorphic functions, (2) to the theory of stability and of the differential equations of celestial mechanics, (3) to physics and (4) to analysis situs and the theory of functions of several variables.

Another side of Poincaré's intellectual activity which has attracted more general attention than any of his capital achievements in pure science is represented by his semi-philosophical books, "Science and Hypothesis," "The Value of Science," and "Science and Method." These books have been translated into most of the modern languages, including English, and have received much attention and praise. They are characterized by a clarity and hard-headed "common sense" which is more often sought than found in this class of literature.

After noticing the works for which Poincaré was chiefly famous, there still remains a host of mathematical papers which would be sufficient to rank him ahead of most of his contemporaries. One thinks first perhaps of his two papers on the uniformization of a general analytic function which appeared in 1883 and 1908 respectively. Then there are his papers on transcendental entire functions and on analytic functions which have lacunary spaces. He made several contributions to the theory of Abelian functions, the reduction of Abelian integrals, the theory of the zeros of theta functions. His paper on linear equations of finite differences has stimulated a great activity of research in that field. In *Liouville's Journal* for 1890 he investigated sets of functions satisfying what he called a theorem of multiplication, including particularly a new class of functions which he named after Cremona. He also deserves credit for establishing the convergence of Hill's infinite determinant and wrote several papers on integral equations and their applications. Also several papers on continuous groups, on hypercomplex numbers, on number theory, and on the relation of automorphic functions to number theory.[2]

The mathematical style of Poincaré was intensely modern. There are few purely formal theorems to his credit. Few of his results depend on long or difficult computations. He said of himself with a furtive touch of humor—the remark came in a paper relating to his and Darwin's work on the pear-shaped figures—that he was poor at arithmetic. He was good, on the other hand, at divining a general principle after seeing the least possible number of special cases. He was tremendously powerful at the essentially modern game of finding out all about a function irrespective of whether it could be adequately described by formulas of the classic type. In any problem he felt instinctively for the fundamental group and for the invariants thereof. He had an almost visual grasp of the properties of a figure of any number of dimensions which remain invariant under a continuous deformation, and this either in case of the small deformations that are considered in problems of stability or in the larger ones that constitute the subject matter of analysis situs. All this was combined with a sound judgment which always directed his

[2] A satisfactory bibliography of Poincaré's publications is to be found in "Savants du Jour, Henri Poincaré," by E. Lebon (Paris, 1912).

energies towards problems of which the importance cannot be contested. Nearly everything that he did has been the starting point for the researches of a considerable number of other scientists.

The chief criticism that has been directed against Poincaré is that he never actually completed his work in any one branch of study. That after having discovered a few of the fundamental theorems, his curiosity was satisfied and he was ready to swing to another branch, again to pick the choicest fruit and leave the less exhilarating tasks to his slower contemporaries and to the future. There is truth in the charge. He could never have done what he did in any other way. But what critic would not be glad to do the same thing if he could? Indeed, it seems to me that both the blame and the praise which Poincaré deserves are condensed in the epigram of Borel: "He was a conqueror, not a colonist."

OSWALD VEBLEN.

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MINUTES.

MINUTES

Stated Meeting, January 5, 1912.

WILLIAM W. KEEN, M.D., LL.D., President, in the Chair.

Invitations were received:

From the Eighth International Congress of Applied Chemistry to be held in Washington and New York, September 4 to 13, 1912, to participate in its proceedings.

From the Committee of Organization of the Second Congress of Chemistry and of Pure and Applied Physics, in memory of Professor Mendéléeff, to be held at St. Petersburg on January 3 to 10, 1912, to participate.

From the Sociedad Astronomia de Barcelona to participate in the Exposition of Lunar Studies to be held from May 15 to June 15, 1912.

The decease was announced of:

Prof. George Davidson, at San Francisco, on December 1, 1911, æt. 86.

Sir Joseph Dalton Hooker, O.M., G.C.S.I., D.C.L., F.R.S., at Sunningdale, Eng., on December 11, 1911, æt. 94.

Dr Arthur V. Meigs, at Philadelphia, on January 1, 1912, æt. 61.

Prof. John M. Macfarlane offered some remarks on the life and services of Sir Joseph Dalton Hooker.

The following papers were read:

"The Physical History of the Grand Canyon District," by Prof. Douglas Wilson Johnson, of Cambridge, Mass.

"The Determination of the Depth of the Milky Way," by Dr. T. J. J. See, of the U. S. Naval Observatory, Mare Island, Cal.

The Judges of the Annual Election of Officers and Councillors held on this day between the hours of two and five in the afternoon, reported that the following named members were elected, according to the Laws, Regulations and Ordinances of the Society, to be the officers for the ensuing year.

President:

William W. Keen.

Vice-Presidents:

William B. Scott, Albert A. Michelson, Edward C. Pickering.

Secretaries:

I. Minis Hays, Amos P. Brown,
Arthur W. Goodspeed, Harry F. Keller.

Curators:

Charles L. Doolittle, William P. Wilson, Leslie W. Miller.

Treasurer:

Henry La Barre Jayne.

Councillors:

Elected in 1910.	Elected in 1911.	Elected in 1912.
Edward L. Nichols,	Henry F. Osborn,	William Trelease,
Samuel Dickson,	J. G. Rosengarten,	Francis B. Gummere,
Ernest W. Brown,	Edward W. Morley,	Robert Williams Wood,
Morris Jastrow, Jr.,	Henry H. Donaldson,	John Frederick Lewis.

Stated Meeting, February 2, 1912.

William W. Keen, M.D., LL.D., President, in the Chair.

Invitations were received:

From the Royal Society to be represented by a delegate at the celebration of the 250th anniversary of its foundation on July 16 to 18 next.

From the Academy of Natural Sciences of Philadelphia to be represented at the celebration of the centennial of its foundation on March 19 to 21 next.

From the Congrès International d'Anthropologie et d'Archéologie Préhistorique announcing that the 14th Congress will be held at Geneva in September next.

From the Congrès International des Orientalistes to be represented at the 16th session to be held at Athens in April next.

Prof. Leslie W. Miller, on behalf of the Curators, reported the receipt of a gift to the Society of some valuable relics of one of its honored presidents, Mr. Peter S. Du Ponceau, whose portrait by Sully is one of the most benevolent of those that look down upon us from our walls. They consist of two crosses, a larger and a smaller, of the order of St. Louis and the gold medal of the Institut de France. The relics were presented to the Society by Miss Aline Garesché, an elderly lady, who has lived for many years in Paris and who states that as the last decendant of Du Ponceau she feels that the Society is the proper custodian of these treasured heirlooms of the family.

Mr. Du Ponceau wrote a learned monograph on "The Structure of the Indian Languages" which was printed in the *Transactions of the Historical and Literary Committee* of this Society, of which he was secretary, and in May, 1835, the "Prix Linguistique" founded by the Count de Volney was awarded to him by the Institut de France for a memoir on the Indian Languages of North America, which was afterwards published in Paris. The medal is a beautiful example of the work of the distinguished medallist, Rambert Dumarest (1750–1806).

Mr. Du Ponceau's attention was also directed, at this time, to the structure of the Chinese languages and in 1838, when he was 78 years old, he published in the *Transactions of the Historical and Literary Committee* of this Society a memoir of 375 pages on this subject.

The Royal and Military Order of St. Louis (to give it its full title) was instituted by Louis XIV. in the year 1693. It is conferred on naval and military officers who have distinguished themselves in the service.

Mr. Samuel Dickson made the following remarks:

As more than three quarters of a century have elapsed since the death of Mr. Du Ponceau, and he can be little more than the shadow of a name to most of those present, I have been asked to say something about him.

The only source of information now available, is the sketch of his life, read before this Society by his friend, Dr. Dunglison, just after his death in 1844. From this, it appears that he was born June 3, 1760, in the Isle de Ré, a small island off the west coast of France. He early developed an exceptional talent for languages, and having mastered a French and Latin vocabulary before he was six, he was able when twelve years of age to speak and write both English and Italian with fluency and correctness. The death of his father, leaving the family in straitened circumstances, when he was less than fifteen years of age, made it necessary for him to earn his own livelihood, and after an unsuccessful experience as a teacher, he went up to Paris, having as his outfit, "a clean shirt and a copy of 'Paradise Lost,'" and there supported himself as a translator. This led to an acquaintance with Beaumarchais, known to us as the author of the "Barber of Seville" and the "Marriage of Figaro," but then largely engaged under the firm name of Hortalez & Co., in exporting supplies to the Colonies.—By the way, a very interesting sketch of Beaumarchais is given by Trevelyan in his American Revolution—Beaumarchais introduced Du Ponceau to Baron Steuben, who was about starting for America, and speaking nothing but German, needed a Secretary, as an interpreter, familiar with English and French.

They came to this country and landed at Portsmouth in December, 1777, and after going to Yorktown, where the Continental Congress was in session, they went to Valley Forge early in 1778, where Du Ponceau made the acquaintance of Washington and Lafayette. As Secretary of Steuben, he was made a captain, and served as an officer until July, 1781, when he resigned on account of his health and came to Philadelphia.

He was soon after appointed secretary to Mr. Livingston, the Secretary for Foreign Affairs, upon the recommendation of Judge

Peters, who wrote that he was "a good Latin scholar, French is his native tongue, English he has acquired perfectly, and he understands German, Italian and Spanish, he can translate Danish and Low Dutch with the help of a dictionary, and a little application will make him master of these."

At the close of the war, he entered the office of William Lewis, then the leader of the Bar, and was admitted in 1785. He soon acquired a large practice, and his command of languages must have contributed to the prominence which he attained as an admiralty lawyer.

In the bibliography, printed as an appendix to Dr. Dunglison's discourse, is a long list of his occasional papers and translations. He was especially interested in the study of philological questions, and his contributions upon the Indian and Chinese tongues attracted much attention and gained for him the medal which has been presented this evening.

While busily engaged in practice, he found time to take part in the proceedings of professional and literary associations with which he became connected.

He was elected vice-president of the American Philosophical Society in 1816, and president in 1827, holding the office until his death in 1844.

He was the first president of the Law Academy, and was annually reëlected until his death in 1844. The relations between the members and himself were of a most cordial and affectionate character, and the Law Academy presented to the Law Association of Philadelphia a copy of Sully's portrait.

He also became the president of the Historical Society, of the Athenæum, a trustee of the University of Pennsylvania; and in 1836 he was elected Chancellor of the Law Association, and, as in every other case, retained the office until his death in 1844.

Upon the occasion of the celebration of the centennial anniversary of the Law Association, Chief Justice Mitchell delivered an historical address, in the course of which, referring to the office of Chancellor, he said, "the office has justly come to be regarded as the highest honor that the Bar can pay a fellow member." This would naturally be inferred from the names of those who have held the office. Mr. Du Ponceau was preceded by Jared Ingersoll and William Rawle, and was followed by John Sergeant, Horace Binney, Joseph R. Ingersoll, William M. Meredith, and others, each prominent in his own day, until now the office is held by our fellow member, Hampton L. Carson.

No formal eulogy could give so adequate a notion of the character of Mr. Du Ponceau, or of the esteem and regard in which he was held, as this list of offices to which he was elected. The members of these institutions represented, if they did not constitute, the leading men in the professional and intellectual life of Philadelphia, and he could not have been elected and reëlected as their presiding officer if he had not been a man of great accomplishment, of sound learning, and of upright character.

Prof. John Bassett Moore, of New York, read a paper on "Contraband of War" which was discussed by Judge George Gray, of Wilmington, and Mr. Frederick R. Coudert, of New York.

Stated Meeting, March 1, 1912.

William W. Keen, M.D., LL.D., President, in the Chair.

The decease was announced of:

Prof. E. P. Crowell, at Amherst, on March 24, 1911, æt. 81.

Sir James M. Le Moine, at Quebec, on Feb. 5, 1912, æt. 87.

Prof. George J. Brush, at New Haven, on Feb. 6, 1912, æt. 81.

Rt.-Hon. Joseph, Lord Lister, at London, on Feb. 11, 1912, æt. 85.

Dr. W. W. Keen offered some remarks in appreciation of the services to Science of the late Lord Lister.

The following papers were read:

"The Chestnut Blight," by Dr. Haven Metcalf, of Washington.

"The Secular Variation of the Elements of the Orbits of the four Inner Planets," by Mr. Eric Doolittle.

"The Validity of the Law of Rational Indices and the Analogy between the Fundamental Laws of Chemistry and Crystallography," by Mr. Austin F. Rodgers. (Introduced by Mr. John C. Branner.)

Stated Meeting April 12, 1912.

William W. Keen, M.D., LL.D., President, in the Chair.

Letters were received

From the Committee of Organization of the IV. Congrés International d'Histoire des Religions to be held at Leyden from the 9th to 13th of September, 1912, inviting the Society to be represented at the Congress by a delegate.

From the Trustees and Faculty of Princeton University, requesting the presence of a delegate at the inauguration of John Grier Hibben, President of the University, on Saturday, May 11, 1912.

From the American Academy of Arts and Sciences, appointing Prof. A. Lawrence Rotch, from The Connecticut Academy of Arts and Sciences, appointing Prof. E. Hershey Sneath, from The Washington Academy of Sciences, appointing Dr. L. O. Howard, and from The American Institute of Electrical Engineers, appointing Mr. Harry Archer Hornor, to represent them respectively at the General Meeting of the Society.

The decease was announced of the following members:

Rear Admiral George W. Melville, U. S. N., at Philadelphia on March 17, 1912, æt. 71.

Professor Thomas H. Montgomery, Jr., at Philadelphia on March 19, 1912, æt. 39.

Prof. A. Lawrence Rotch, at Boston on April 7, 1912, æt. 51.

The following papers were read:

"The Roentgen Rays—Principles underlying Production, Development of Apparatus and Usefulness in Medicine and Surgery," by Dr. Willis F. Manges (introduced by Dr. W. W. Keen). Discussed by Doctors Goodspeed, Tyson, Coplin, and Keen.

"The Japanese Verb So-Called," by Mr. Benjamin Smith Lyman.

General Meeting, April 18, 19, and 20.

Thursday, April 19th. Opening Session, 2 o'clock.

William W. Keen, M.D., LL.D., President, in the Chair.

Letters were received from The American Oriental Society, appointing Prof. A. V. Williams Jackson, The American Philological Society, appointing Prof. John Carew Rolfe, The Archæological Institute of America, appointing Prof. Harry Langford Wilson, to represent them respectively at the General Meeting.

The decease was announced of Rev. Charles G. Ames, at Boston, April 15, 1912, æt. 83.

The following papers were read:

"Some Former Members of the American Philosophical Society," by Thomas Willing Balch, Philadelphia. Discussed by Mr. Harrison Morris.

"The Diary of a Voyage to the United States, by Moreau de Saint Méry," by Stewart L. Mims, B.A., Instructor in History, Yale University. (Introduced by Mr. J. G. Rosengarten.) Discussed by Mr. Rosengarten.

"The Legendary and Myth-Making Process in Histories of the American Revolution," by Sydney George Fisher, A.B., LL.D., Philadelphia.

"Bardaisan and the Odes of Solomon," by William Romaine Newbold, Ph.D., Professor of Philosophy, University of Pennsylvania.

"Sumerian Bookkeeping Five Thousand Years Ago" (illustrated), by George A. Barton, Ph.D., Professor of Semitic Languages, Bryn Mawr College.

"The Political Ideals of Ulrich von Hutten," by Kuno Francke, Ph.D., LL.D., Professor of History of German Culture, Harvard University.

"Some Anthropological Aspects of the Brain with Reference to Race, Sex and Intellect," by Edward A. Spitzka, M.D., Professor of Anatomy, Jefferson Medical College, Philadelphia. Discussed by Professor Haupt and Mr. Fisher.

"Waterway Conservation" (illustrated), by Louis M. Haupt, Philadelphia. Discussed by Mr. Sidney George Fisher.

Thursday Evening, April 18, 8 o'clock.

Celebration of the Centenary of the Introduction of Gas as an Illuminant.

Under the auspices of The American Philosophical Society, The Franklin Institute, The American Chemical Society, The American Gas Institute.

William W. Keen, M.D., LL.D., in the Chair.

"By-Products in Gas Manufacture," by Charles E. Munroe, Professor of Chemistry, George Washington University, Washington.

For the titles of the addresses on Friday, April 19, see the special programme.

Friday Morning, April 19.

William W. Keen, M.D., LL.D., President, in the Chair.

Morning Session—10.05 o'clock.

The following papers were read:

"Heredity of Feeble-mindedness," by Henry H. Goddard, Director of Research, The Training School, Vineland, N. J. (Introduced by Dr. Henry H. Donaldson.)

"The Inheritable Factors of Epilepsy," by David F. Weeks, M.D., Superintendent of the New Jersey State Village for Epileptics at Skillman. (Introduced by Dr. Henry H. Donaldson.)

"Is the Control of Embryonic Development a Practical Problem?" by Charles R. Stockard, Ph.D., Professor of Anatomy, Cornell University Medical College. (Introduced by Dr. Henry H. Donaldson.) Discussed by Doctors Donaldson, A. C. Abbott, Goddard, Weeks, Stockard, and Bogert.

"An Avian Tumor in Its Relation to the Tumor Problem," by Peyton Rous, M.D., of the Rockefeller Institute, New York.

(Introduced by Dr. Alexander C. Abbott.) Discussed by Doctors Keen and Bogert.

"Protein Poison: Its Preparation and Its Nature," by Victor C. Vaughan, M.D., LL.D., Professor of Hygiene and Physiological Chemistry, University of Michigan.

"Bacterial Vaccines, with Special Reference to Typhoid Prophylaxis," by Frederick F. Russell, M.D., Major, U. S. A., Curator of Army Medical Museum, Washington, D. C. (Introduced by Dr. Alexander C. Abbott.) Discussed by Doctors Abbott, Bogert and Vaughan.

"Prolonged Active Life," by Alexis Carrell, M.D., of The Rockefeller Institute, New York. Discussed by Dr. Keen.

"Dynamical Theory of the Globular Clusters and of the Clustering Power Inferred by Herschel from the Observed Figures of Sidereal Systems of High Order," by T. J. J. See, Ph.D., of the U. S. Naval Observatory, Mare Island, California.

"Some Notes on Persian Mystic Poetry," by A. V. Williams Jackson, Ph.D., LL.D., Professor of Indo-Iranian Languages, Columbia University, New York.

Afternoon Session—2 o'clock.

William B. Scott, Ph.D., LL.D., Vice-President, in the Chair.

Exhibition of Volumes of Illustrations of North American Vegetation, by John W. Harshberger, Ph.D., Professor of Botany, University of Pennsylvania. Discussed by Professor Haupt.

"History of the Fungus of the Chestnut Tree Disease," by William G. Farlow, Ph.D., LL.D., Professor of Cryptogamic Botany, Harvard University.

"The Classification of the Black Oaks" (illustrated), by William Trelease, Sc.D., LL.D., Director of Missouri Botanical Garden, St. Louis.

"The Mammals of the Patagonian Miocene" (illustrated), by William B. Scott, Ph.D., LL.D., Professor of Geology and Paleontology, Princeton University.

"Illustrations of Remarkable Cambrian Fossils from British Columbia" (illustrated), by Charles D. Walcott, Sc.D., LL.D., Secretary of the Smithsonian Institution, Washington.

"Some Considerations Bearing Upon the Origin of Lava" (illustrated), by William H. Hobbs, Ph.D., Professor of Geology, University of Michigan. Discussed by Professor Scott and Dr. Clarke.

"Recent Archæological Discoveries in Peru" (illustrated), by Hiram Bingham, M.A., Ph.D., Curator of Latin American Collections of Yale University. (Introduced Mr. Henry G. Bryant.) Discussed by Professor Scott and Mr. Bingham.

"The Discovery of the Continent of Antarctica by Americans: An Historical Vindication," by General Adolphus W. Greely, U. S. A., of Washington. Discussed by Mr. E. S. Balch, Professor Hobbs, and General Greely.

"The Interrelations of Eight Fundamental Properties of Classes of Functions," by Arthur D. Pitcher, Assistant Professor of Mathematics, Dartmouth College. (Introduced by Prof. Eliakim H. Moore.)

Evening Session, 8 o'clock.

Robert Williams Wood, LL.D., Professor of Experimental Physics at Johns Hopkins University, Baltimore, gave an illustrated lecture on "The Study of Nature by Invisible Light, with Especial Reference to Astronomy and Physics."

Saturday, April 20.

Executive Session—9.30 o'clock.

William W. Keen, M.D., LL.D., President, in the Chair.

Pending nominations for membership were read and the polls opened.

Secretary Keller and Dr. Holland, tellers, subsequently reported that the following nominees had been elected to membership:

Residents of the United States.

Albert T. Clay, B.A., Ph.D., New Haven,
George W. Crile, M.D., Ph.D., Cleveland,
Arthur Louis Day, Ph.D., Washington,
Edward Curtis Franklin, Ph.D., Washington,
John Grier Hibben, Ph.D., LL.D., Princeton,
G. Carl Huber, M.D., Ann Arbor,
James Furman Kemp, Sc.D., New York,
Arthur Henry Lea, B.A., Philadelphia,
John Matthews Manly, Ph.D., Chicago,
Edward Bennett Rosa, Sc.D., Ph.D., Washington,
Frank Schlesinger, A.M., Ph.D., Allegheny, Pa.,
George E. de Schweintiz, M.D., Philadelphia,
Frederick Winslow Taylor, M.E., Philadelphia,
Roland Thaxter, A.M., Ph.D., Cambridge, Mass.,
Oswald Veblen, Princeton.

Foreign Residents.

George Friedrich Julius Arthur Auwers, Ph.D., Berlin,
Wilhelm Ostwald, Sc.D., LL.D., Leipzig,
Magnus Gustaf Retzius, Stockholm.

The following papers were read:

"Some Geochemical Statistics," by Frank W. Clarke, Sc.D., LL.D., U. S. Geological Survey. Discussed by Professor Hobbs and Dr. Clarke.

"Some General Results of the Work of a Century on the Atomic Weights of the Chemical Elements," by Gustavus D. Hinrichs, of St. Louis.

"Absorption Spectra and the Solvate Theory of Solution" (illustrated), by Harry C. Jones, Ph.D., Professor of Physical Chemistry, Johns Hopkins University.

"The Classification of Carbon Compounds," by Marston T. Bogert, Ph.B., LL.D., Prof. of Chemistry, Columbia Univ.

"An Autocollimating Mounting for a Concave Grating" (illustrated), by Horace Clark Richards, Ph.D., Professor of Mathematical Physics, University of Pennsylvania..

"Thermal Relations of Solutions," by William F. Magie, M.A., Ph.D., Professor of Physics, Princeton University.

"The Measurement of Temperature up to 1750° C." (illustrated), by Arthur L. Day, B.A., Ph.D., Director of the Geophysical Laboratory of the Carnegie Institution.

"Selective Scattering Reflection and Absorption by Resonating Gas Molecules" (illustrated), by Robert Williams Wood, LL.D., Prof. of Experimental Physics, Johns Hopkins Univ.

"Some Observations on the Transmission of Sound through Walls," by Arthur Gordon Webster, Ph.D., LL.D., Professor of Physics, Clark University, Worcester, Mass.

"New Magnetic Charts of the Indian Ocean" (illustrated), by Louis A. Bauer, C.E., Ph.D., Director of the Department of Terrestrial Magnetism of the Carnegie Institution.

"The Treaty-Making Power of the United States and the Methods of its Enforcement as Affecting the Police Powers of the States," by Charles H. Burr, of Philadelphia, the Essay to which the Henry M. Phillips Prize was awarded.

Afternoon Session—2 o'clock.

EDWARD C. PICKERING, Sc.D., LL.D., F.R.S., Vice-President, in the Chair.

Prof. B. Osgood Pierce, a recently elected member, and Dr. Arthur Louis Day and Prof. Frank Schlesinger, newly elected members, signed the Laws and were admitted into the Society.

The following papers were read:

"Symposium on Stellar Spectroscopy":

"Radial Velocity" (illustrated), by William W. Campbell, Sc.D., LL.D., Professor of Astronomy, Lick Observatory, University of California.

"Objective Prism Spectra," by Edward C. Pickering, Sc.D., LL.D., Professor of Astronomy, Harvard University.

"The New Star in Gemini," by Storrs B. Barrett, of the Yerkes Observatory, Williams Bay, Wisconsin. (Introduced by Edward B. Frost, D.Sc.)

"On the Prospect of Obtaining Radial Velocities by Means of the Objective Prism," by Frank Schlesinger, M.A., Ph.D., Professor of Astronomy, University of Pittsburgh.

"Relations Between the Spectra and Other Characteristics of the Stars" (illustrated), by Henry N. Russell, Ph.D., Professor of Astronomy, Princeton University.

Stated Meeting, May 3, 1912.

William W. Keen, M.D., LL.D., President, in the Chair.

Dr. William T. Sedgwick, a recently elected member, and Mr. Arthur H. Lea and Dr. George E. de Schweinitz, newly elected members, signed the Laws and were admitted into the Society.

Letters accepting membership were received from

Arthur Louis Day, Ph.D., Washington,
John Grier Hibben, Ph.D., LL.D., Princeton,
James Furman Kemp, Sc.D., New York,
Arthur Henry Lea, A.B., Philadelphia,
Frank Schlesinger, M.A., Ph.D., Allegheny, Pa.,
George E. de Schweinitz, M.D., Philadelphia,
Roland Thaxter, A.M., Ph.D., Cambridge, Mass.,
Oswald Veblen, Princeton.

From the III Congresso Archæologico Internazionale, Rome, October, 1912, inviting the Society to be represented thereat by a delegate.

From the Assoçiation des Ingenieurs Electriciens, announcing the conditions of the Triennial Prize for 1914, under the Fondation George Montefiore.

A paper entitled "Is Typhoid Fever a Rural Disease?" was read by Dr. W. T. Sedgwick, of Boston, Mr. G. R. Taylor, of Scranton, and Mr. J. S. MacNutt, of Orange, N. J., and was discussed by Doctors Abbott, Mr. John F. Lewis, Doctors Tyson, Smith and Stengel and Professor Sedgwick.

Stated Meeting October 4th, 1912.

William W. Keen, M.D., LL.D., President, in the Chair.

Letters accepting membership were received from:

Alfred T. Clay, B.A., Ph.D., New Haven.
George W. Crile, M.D., Ph.D., Cleveland.
Edward Curtis Franklin, Ph.D., Washington, D. C.
G. Carl Huber, M.D., Ann Arbor, Michigan.
John Matthews Manly, Ph.D., Chicago, Ill.
Edward Bennett Rosa, Sc.D., Ph.D., Washington.
Frederick Winslow Taylor, M.E., Philadelphia.
George Friedrich Julius Arthur Auwers, Ph.D., Berlin.
Wilhelm Ostwald, Sc.D., LL.D., Leipzig.
Magnus Gustaf Retzius, Stockholm.

Invitations were received:

From the organizing committee of the First International Eugenics Congress, to be represented by a delegate at the Congress to be held on July 24–30, in London.

From the American Antiquarian Society, to be represented at the celebration of the one hundredth anniversary of its foundation, to be held at Worcester on October 15, 16, 1912.

From the Naturwissenschaftliche Verein für Steiermark, to be represented at the celebration of the fiftieth anniversary of its foundation on November 10, 1912.

From the Rice Institute, to be represented at its inauguration at Houston, Texas, on October 10–12, 1912.

From the Fifteenth International Congress of Hygiene and Demography, to participate in the Congress to be held at Washington on September 27–28, 1912.

From the State of New York, through the Education Department, to attend the dedication of the State Education Building, at Albany, on November 15 to 17, 1912.

From the Academy of Natural Sciences of Philadelphia, expressing its gratitude for the Society's congratulations on the occasion of its Centenary Celebration.

From Sir George Otto Trevelyan:

WALLINGTON, CAMBO, Northumberland,
August 16, 1912.

Dear Sirs: I always read, with interest and admiration, everything in the *Proceedings of the American Philosophical Society* the technical form of which is not beyond me; and I fully appreciate the deserved and wide-spread influence of that publication. In your number of April to June, 1912, there is an article on American history in which it is stated, three several times over, that Charles James Fox was my "relative"; and it is implied, not obscurely, that I wrote with a family partiality about him, and about the public events of his period in England and America. I do not suppose that your readers concern themselves much about the personal question in relation to me; but it must be remembered that the statement of a fact, made with emphasis and circumstance, in the pages of the American Philosophical Society's journal, bears the stamp of authority; and what is written there remains written. I therefore feel bound to say that Charles Fox is in no sense my "relative" and that between his family and mine (I am sorry for it) there never existed any connection by blood or marriage, however remote. Indeed my progenitors on my father's side, voted sturdily against him in Parliament, beat his supporters at election, perfectly abominated him in his character of a friend of liberty and humanity, and held, at the time, the same view of his policy and attitude towards America which the author of your article holds to-day.

I remain, Sirs,

Yours very faithfully,
GEORGE OTTO TREVELYAN.

To the Secretaries of the American Philosophical Society.

The decease of the following members was announced:

William W. Goodwin, Ph.D., LL.D., D.C.L., at Cambridge, Mass., on June 15, 1912, æt. 81.

Thomas Hewson Bache, M.D., at Philadelphia, on July 8, 1912, æt. 86.

Jules Henri Poincaré, Sc.D., at Paris, France, on July 17, 1912, æt. 58.

Horace Howard Furness, Ph.D., Litt.D., LL.D., at Wallingford, Pa., on August 13, 1912, æt. 79.

Archibald Loudon Snowden, LL.D., at Philadelphia, on September 7, 1912, æt. 75.

The following papers were read:

"Restoration of North and South American Mammals," by Prof. W. B. Scott.

"Some Tic-transmitted Diseases," by Prof. G. H. F. Nuttall, of Cambridge, England (introduced by Dr. A. C. Abbott).

"Acceleration of Development in Fossil Cephalapoda," by Prof. James Perrin Smith, Ph.D. (introduced by Prof. John C. Branner).

Stated Meeting November 1, 1912.

William W. Keen, M.D., LL.D., President, in the Chair.

Sir William Ramsay, elected to membership in 1899, and Mr. Frederick W. Taylor, a newly elected member, having subscribed the Laws, were admitted into the Society.

The decease was announced of Lewis Boss, A.M., LL.D., at Albany, N. Y., on October 5, 1912, æt. 66.

The following papers were read:

"Electrons," by Sir William Ramsay, K.C.B., LL.D., F.R.S.

"The Formation of Coal Beds," by John J. Stevenson, A.M., LL.D.

Stated Meeting December 6, 1912.

I. Minis Hays, A.M., M.D., in the Chair.

Professor Oswald Veblen, a newly elected member, having subscribed the Laws, was admitted into the Society.

Decease of the following members was announced:

John William Mallett, M.D., LL.D., at Charlottesville, Va., on November 7, 1912, æt. 80.

Richard Alsop Cleemann, at Philadelphia, on November 19, 1912, æt. 72.

Inman Horner, at Philadelphia, on November 28, 1912, æt. 66.

Professor Oswald Veblen read an obituary notice of Professor Henri Poincaré.

Professor Felix E. Schelling read a paper on the "Elizabethan Playhouse."

INDEX

Normal Rabbit: Cerebrum.

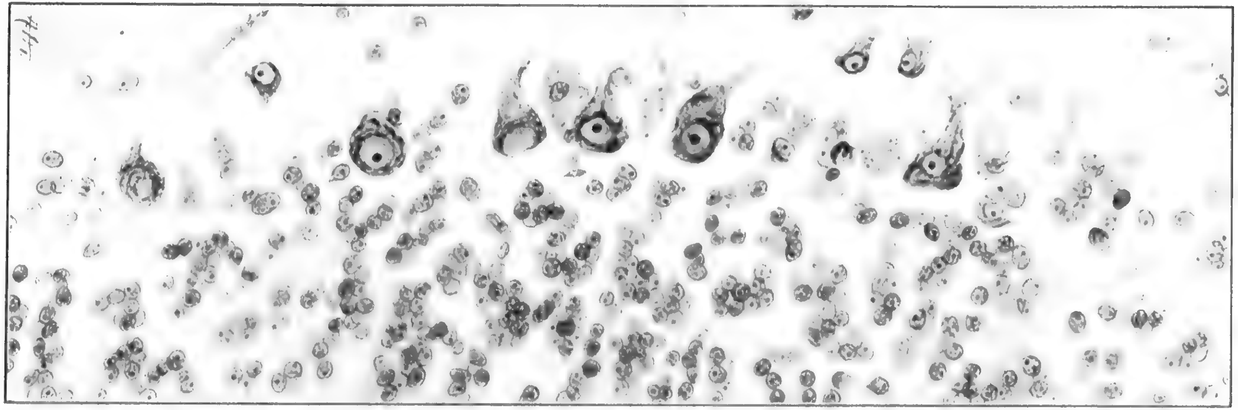
Frightened Rabbit: Cerebrum. The rabbit was frightened once and *immediately killed.* Note the hyperchromatism.

Frightened Rabbit: Cerebrum. The rabbit was frightened once and killed at the end of six hours. The cells are more swollen than in the normal.

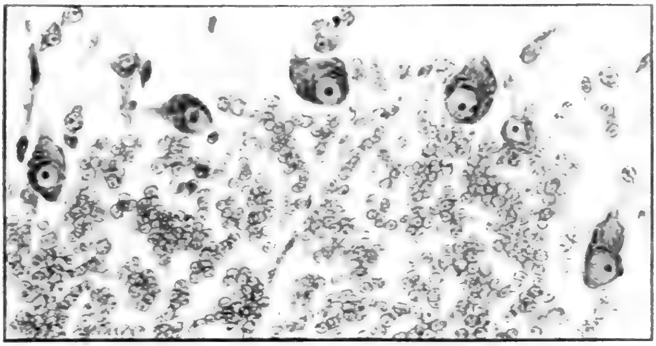
Fear in Rabbits.

These and the following cuts are intended to show that fear and exophthalmic goitre cause demonstrable morphologic changes in the nerve cells of different parts of the brain which vary in degree [rather than in specificity] according to the part of the brain.

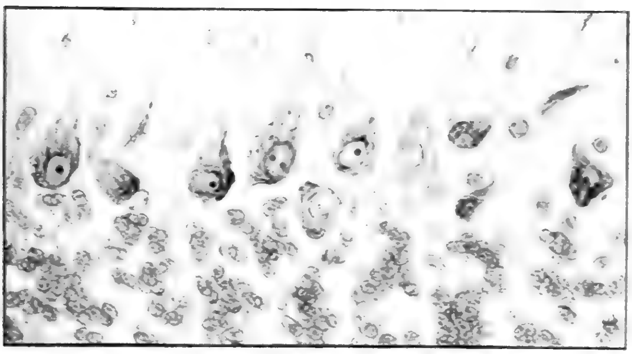
The rabbits used in the fear experiments were frightened by dogs *without being injured* or without making muscular efforts of any consequence.



Normal rabbit: Cerebellum. The average of ten differential Purkinje cell counts from ten rabbits was: Active cells, 64.8 per cent.; fatigued cells, 34.5 per cent.; exhausted cells, 0.7 per cent. [For comparison with cuts on Plate III.]



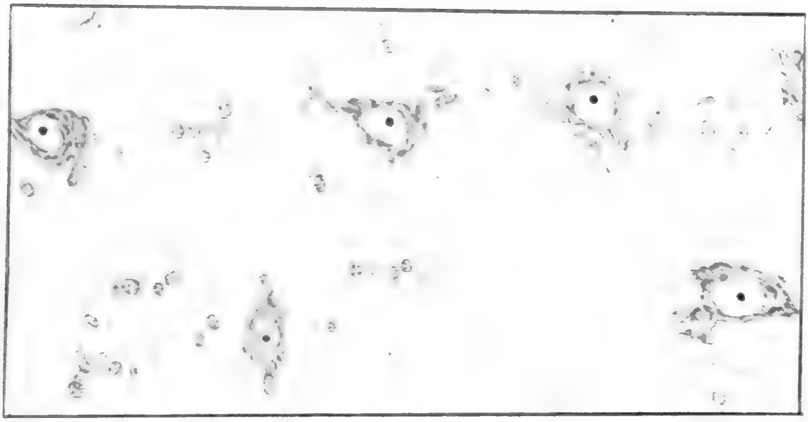
Frightened rabbit: Cerebellum. The rabbit was frightened once and *killed immediately*. The average of ten differential Purkinje cell counts from ten such experiments was: Active cells, 83.4 per cent.; fatigued cells 15.7 per cent.; exhausted cells, 0.9 per cent.



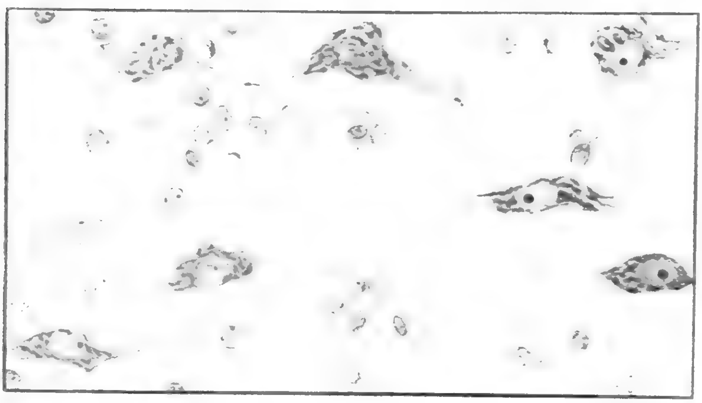
Frightened rabbit: Cerebellum. The rabbit was frightened once and *killed at the end of two and one half hours*. The average of five differential Purkinje cell counts from five such experiments was: Active cells, 55.6 per cent.; fatigued cells, 35.4 per cent.; exhausted cells, 9.0 per cent.

FEAR IN RABBITS.

These cuts and the cell counts as given above illustrate several important points, viz., that cerebral stimulation by fear causes, first, demonstrable morphologic changes in brain cells, second, a marked early increase in the number of active [and hence also hyperchromatic] cells, and, third, that this stimulation is followed by later and more serious morphologic changes in the cells which do not attain a maximum until from 2½ to 6 hours have elapsed after the period of fright.

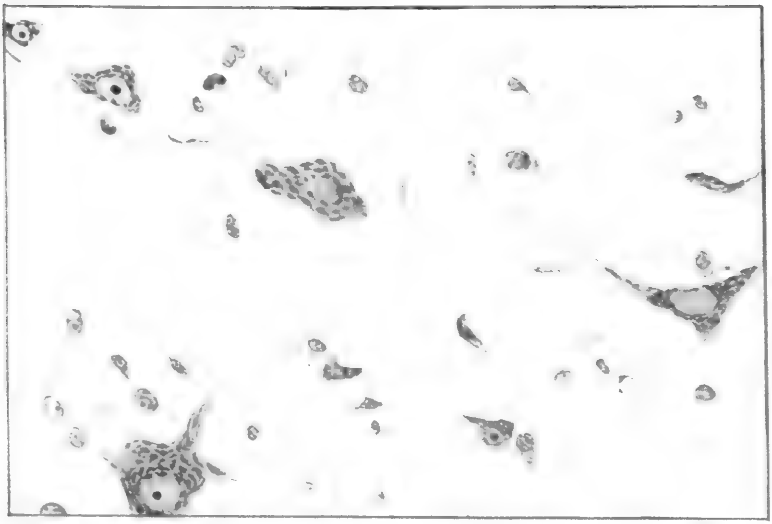


Normal rabbit: Medulla.

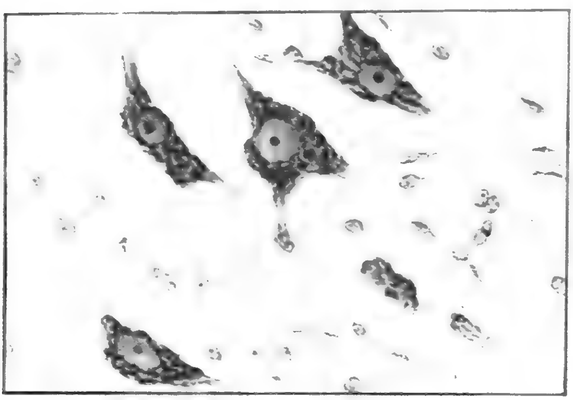


Frighteued rabbit: Medulla. The rabbit was frightened once *and immediately killed.*

FEAR IN RABBITS.



Normal rabbit: Cervical cord, anterior horn.



Frightened rabbit: Cervical cord, anterior horn. The rabbit was frightened once and *immediately killed.* Note the marked hyperchromatism.

FEAR IN RABBITS.

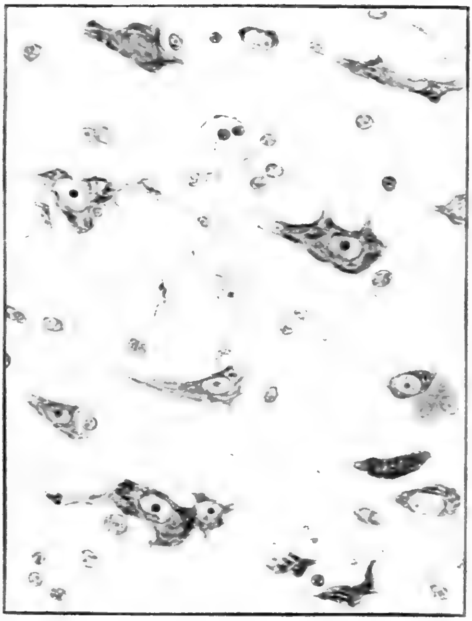
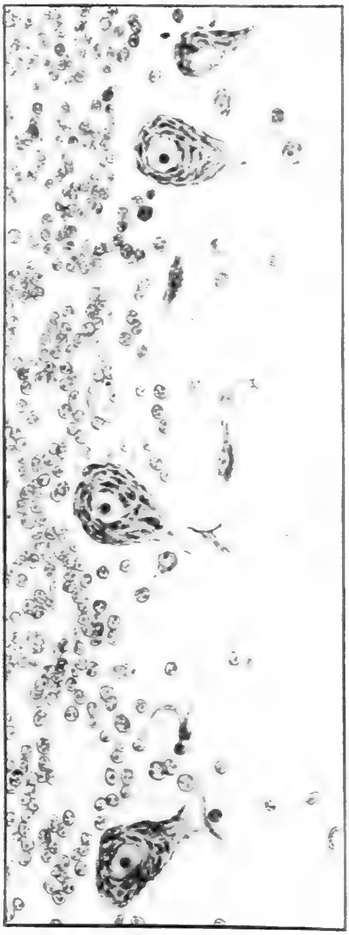


FIG. 1. "Normal" Human Cerebrum.

FIG. 2. Exophthalmic Goitre Cerebrum

Exophthalmic Goitre. The contrast between the normal and exophthalmic goitre cerebrum sections is more marked than between the medulla sections. As a rough general rule it may be said that the lower the portion of the central nervous system affected the slighter the degree of injury.



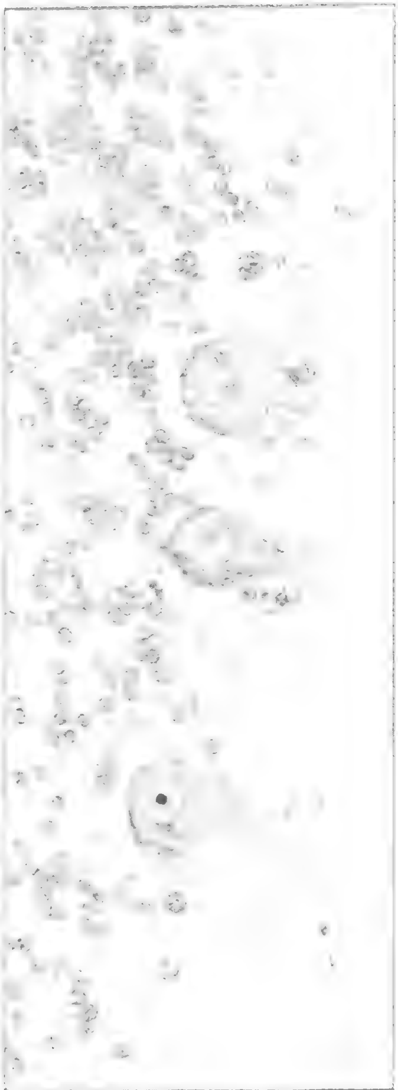


FIG. 1. "Normal" Human Cerebellum. FIG. 2. Exophthalmic Goitre Cerebellum.

Exophthalmic Goitre. Note the marked injury of the Purkinje cells, and the striking contrast between the general appearance of the two cuts. The average differential Purkinje cell count from five cases of exophthalmic goitre was: Active cells, 34.2 per cent.; fatigued cells, 37.6 per cent.; exhausted cells, 28.2 per cent.

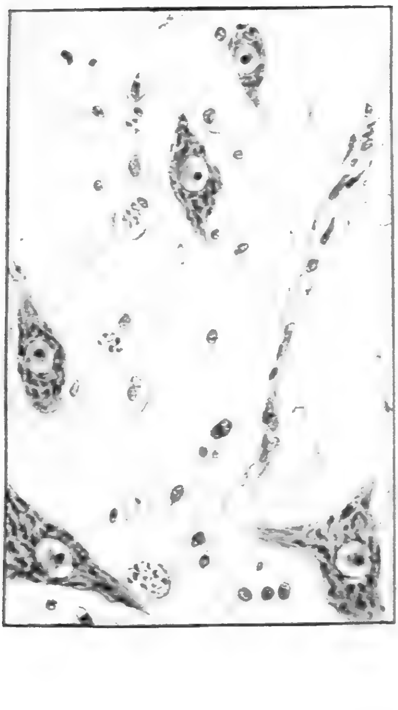
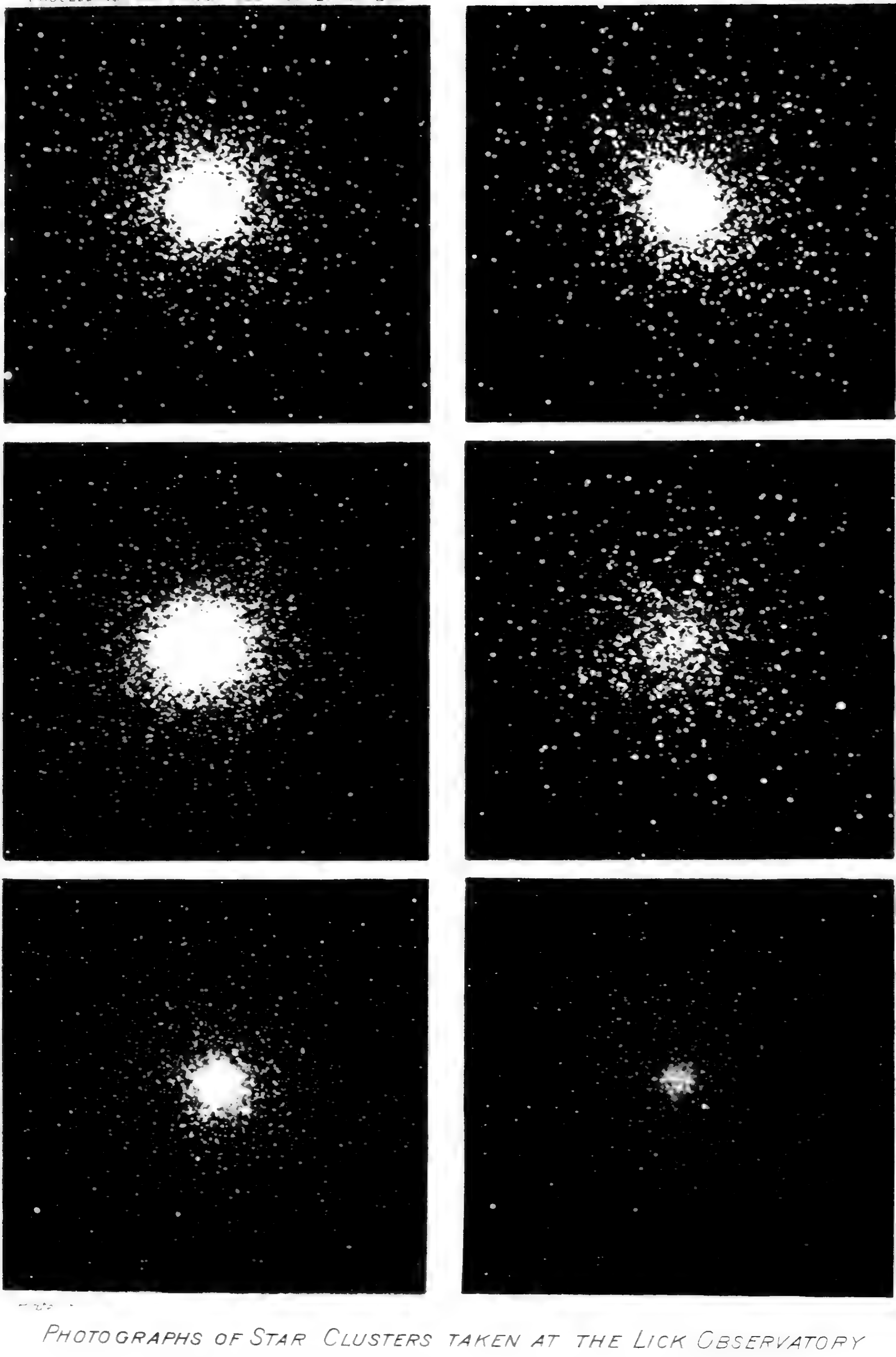


FIG. 1. "Normal" Human Medulla.

FIG. 2. Exophthalmic Goitre Medulla.

EXOPHTHALMIC GOITRE.



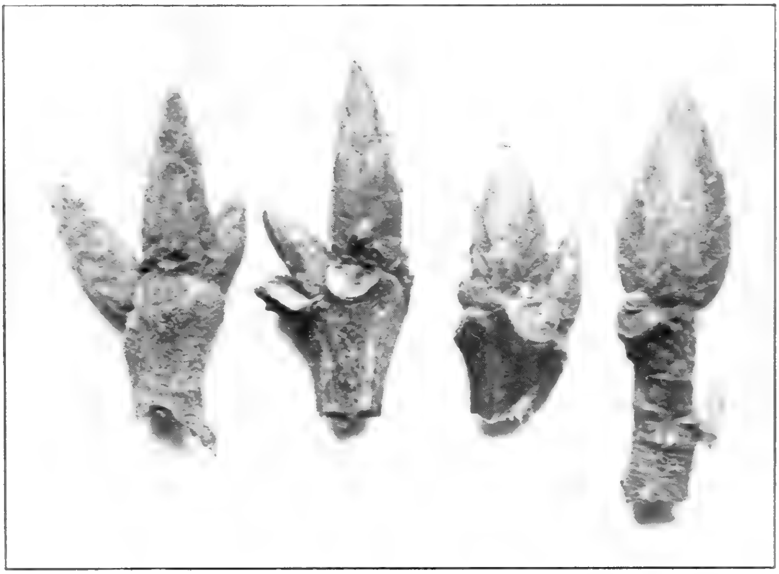
PHOTOGRAPHS OF STAR CLUSTERS TAKEN AT THE LICK OBSERVATORY AND THE ROYAL OBSERVATORY. CAPE OF GOOD HOPE

M 3, Canum Venaticorum. — M 5, [illegible]brae,

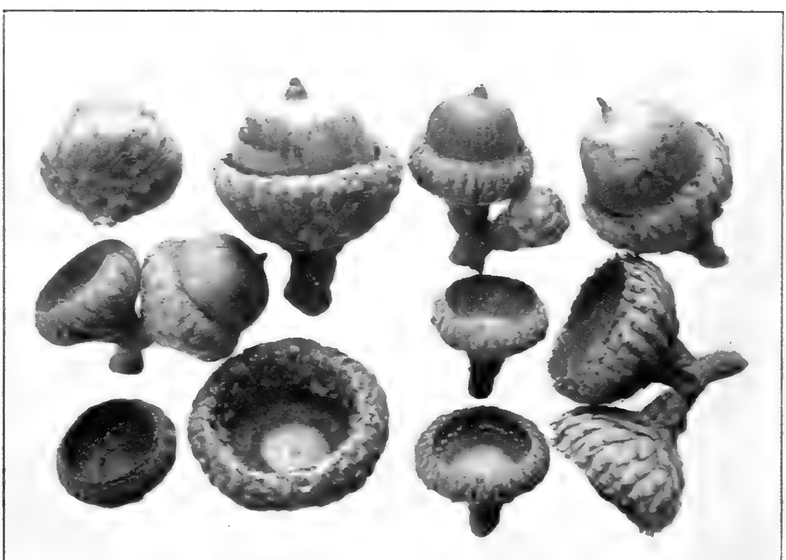
M [illegible]3, Herculis. — M [illegible] [illegible]

47 Toucan, general view [illegible] — [illegible]

PHOTOGRAPH OF THE GREAT STAR CLUSTER OMEGA CENTAURI
TAKEN AT THE D. O. MILLS EXPEDITION OF LICK OBSERVATORY SANTIAGO DE CHILE.



1 2 3 4



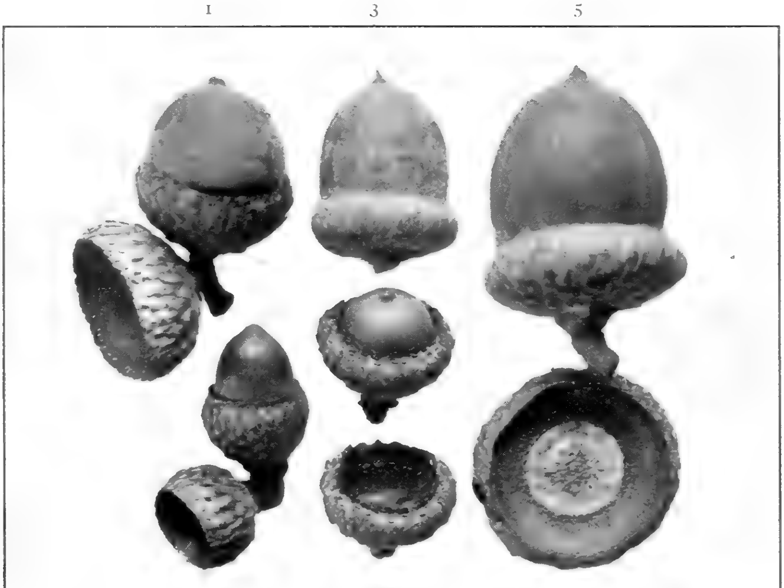
1 2 3 4

BLACK OAKS

1 2 3 5

4 6

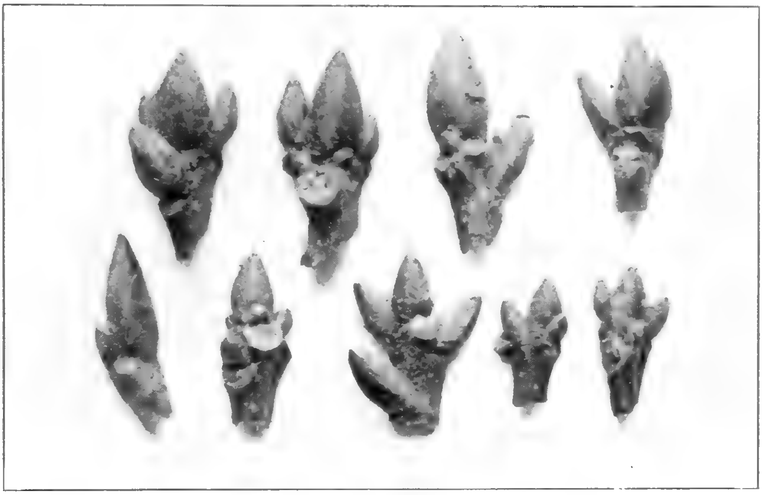
1 3 5



4 2 6

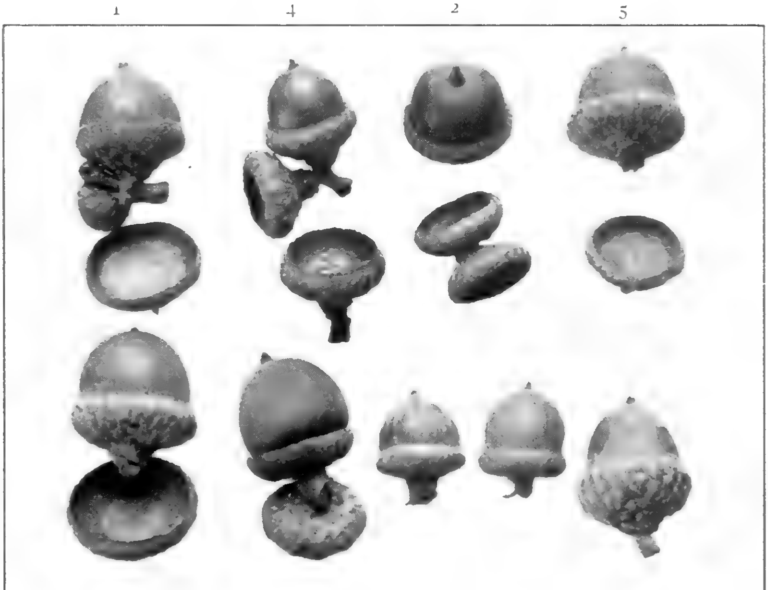
SCARLET OAKS

1 4 2 5



8 6 9 3 7

1 4 2 5



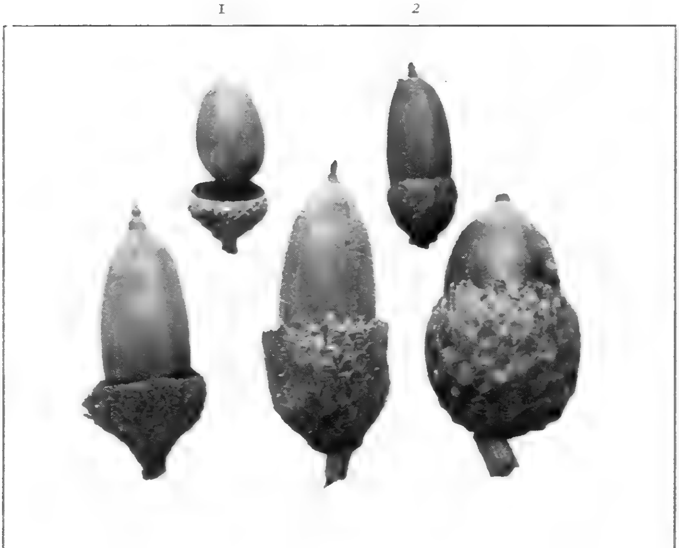
8 6 9 3 7

SWAMP OAKS

1 2

3 4 5

1 2



3 4 5

OLIVE AND HOLLY OAKS