

may accomplish much, if he can avoid a precipitate. We hope that when he finds his discoveries are being used, 'the true scientific spirit' will yet allow him to continue his experiments and his philosophy.

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#### RELATIONS OF SALARY TO TITLE IN AMERICAN UNIVERSITIES

HAVING just read the interesting discussion in *SCIENCE* of February 15, under the above title, I venture to suggest that there is yet more to be said.

University men possess different kinds of value, *e. g.*: (1) Some are principally of value to the student body in attendance on their classes. (2) Some are valuable more particularly to picked individuals in the university and out of it. Such may be said in a certain sense to have as many students as those whose classes are thronged, but they are in many places. (3) Some will be exceedingly valuable to posterity, but their work is comparatively useless to the present generation, because it has not learned to value or use it, or because it will only reach its greatest significance and utility after it has been carried on for two or three generations.

From the standpoint of the state, all these classes of men are of value and should be supported. If there is any difference in their value, no doubt the pioneers, those of the third class, are the most valuable; but it requires very little reflection to see that these, from a psychological necessity, will be the *least* valued by presidents, trustees and the community at large. To properly estimate the value and importance of an 'infant industry' in the intellectual field requires imagination of such quality that those doing the work do not always possess it, and outsiders almost never.

It is quite possible to argue that the concern of the university is only with the students in attendance, so that all values must be determined by the standard applicable to the first of the above classes. This notion, however, is surely passing away, and with it the possibility of correctly estimating the money value

of university men. The larger outlook also serves to convince us that the actual worth of certain professors, having in view their total influence upon contemporaries and posterity, exceeds any sum that can be thought of as payment. On the other hand, the *needs* of the great and the small are not so very diverse.

There is one kind of payment which should no doubt differ greatly according to the character of the man and his work. This is for the support of the work itself. One man may need expensive apparatus, or journeys to distant lands, while others may have no use for these things. This is not necessarily dependent in any way on the eminence of the man himself, but rather on the character of his labors; only, of course, he should be able enough to use well the means provided.

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#### SPECIAL ARTICLES

##### RIVER CAPTURE IN THE TALLULAH DISTRICT, GEORGIA

THE head-waters of the Savannah River have been frequently referred to as an example of drainage transferred from the gulf system to the Atlantic through the process of stream capture. Dr. C. Willard Hayes, in his paper on 'The Southern Appalachians,' published as a National Geographic Monograph, cited this case as an instance of recent capture and ascribed the falls on the Tallulah River (one of the head-waters of the Savannah) to the fact that the newly acquired drainage had not been in possession of the captor sufficiently long for the falls to be worn down to grade. In a paper entitled 'Drainage Modifications' (*Jour. Geol.*, 1896) Mr. M. R. Campbell notes this capture under the heading 'remote changes shown in the streams of the Atlantic slope.' Mr. Chas. T. Simpson (*SCIENCE*, 1900), in discussing 'The Evidence of the Unionidae regarding the Former Courses of the Tennessee and other Southern Rivers,' reports the finding of mollusks similar to the Tennessee and Coosa River forms in the

Chattahoochee and Savannah Rivers, and molusks of the Savannah drainage in the Chattahoochee River. From this he was led to support the theory of a capture of the upper Chattahoochee drainage by the Savannah River, since the diversion in question would effect the transference of fresh-water faunas from one stream to the other. A paper on 'The Geology of the Tallulah Gorge' (*Am. Geol.*, 1901), by Mr. S. P. Jones, discusses the general geology of the region, mentions the possibility of capture already suggested by Hayes and Campbell, but reaches no conclusion in regard to the matter. Other references to this capture are found in the literature, but need not be repeated here.

Believing that the upper Savannah would probably show evidence of river capture, and desiring to make a test of certain principles which had been applied in the case of the supposed capture of the upper Tennessee River with only negative results, the writer spent a month in the Tallulah district during the spring of 1905, studying the geologic and physiographic features of the district with special reference to the supposed changes in drainage. The evidence in favor of capture appeared to be quite conclusive. A detailed discussion of the various elements of the problem will be found in the *Proceedings* of the Boston Society of Natural History, Vol. 33, No. 5, but it is desired to outline certain phases of the subject here.

The results of this study appear to justify the following conclusions:

1. The upper Savannah (Chattooga) River formerly flowed southwest through the Chattahoochee River into the Gulf of Mexico, but was diverted to the Atlantic drainage by a process of stream capture, as already announced by Hayes and Campbell.

2. The capture furnishes an example of what may be termed 'remote capture,' having occurred so long ago that much of the direct evidence has been obliterated.

3. The capture seems to have resulted from the advantage gained by the Atlantic drainage over the gulf drainage, owing to the shorter course to the sea which streams of the former

system enjoyed, although the process may have been aided by crustal warping.

4. The place of the capture was near the junction of the Tallulah River with the Chattooga, and probably just below that junction.

5. The falls of the Tallulah River, while initially caused by the capture, exist to-day because of a hard rock barrier crossed by the river, but not yet worn down by it.

6. The similar falls which must have existed on the Chattooga River have been obliterated by that stream, since the great lapse of time since the capture has been ample for it to grade its course in the less resistant rock over which it runs.

The Tallulah district is crossed from northeast to southwest by the southwestern extension of the Blue Ridge escarpment, which is from 500 to 600 feet high at this point. The escarpment connects a higher with a lower peneplain, both of which are eroded on folded crystallines, the higher one sloping gently toward the west, the lower one gently toward the southeast. The streams on the higher level flow in fairly mature valleys cut but slightly below the general surface. In like manner the streams on the lower level flow in broad shallow valleys; but their upper branches are working actively headward into the higher level, thus pushing the escarpment backward to the northwest, and capturing additional drainage areas from the rivers flowing on the surface well above them.

In striking contrast to these two classes of streams, on the lower and upper levels, respectively, is a drainage system cut down *into* the upper level. This is the upper Tugaloo-Chattooga River, which flows in a deep gorge cut 500 feet or more below the upper level, until it breaks from its gorge at the face of the escarpment and flows out over the lower level in a fairly mature valley. Nothing could be more striking than the contrast between this young stream with its picturesque, steep-sided chasm, cut *in* the upper level, and the mature streams in broad open valleys flowing *on* the upper and lower levels. The Tallulah River first flows through low mountains on the upper level, but when near its junction with the Chattooga suddenly plunges down into a gorge

known locally as the 'grand chasm,' and so joins the drainage system, which is cut so deeply into the upper level. The rapid descent into the chasm is made by a series of falls and rapids, known collectively as the Tallulah Falls.

In connection with this peculiar feature of the drainage, is a striking drainage pattern. The Chattooga River flows almost due southwest until it is joined by the Tallulah, and then turns abruptly at a right angle and under the names Tugaloo and Savannah Rivers flows almost due southeast into the Atlantic. Near the point where this sharp bend or elbow occurs, a stream on the upper level, Deep Creek, takes its rise and continues the southwest line begun by the Chattooga, until, under the names Soque and Chattahoochee Rivers, it reaches the gulf.

It is this assemblage of features which has suggested that the Chattooga River formerly flowed southwest into the gulf drainage, being continuous with and forming the upper part of the Chattahoochee; that one of the head-water branches of the Tugaloo-Savannah system succeeded in eating headward into the escarpment so far that it undermined the valley of the Chattooga-Chattahoochee some 500 or 600 feet above, thus diverting the upper part of that system into the Atlantic drainage, and causing it to flow down to the lower level and so on southeast to the ocean. As a result of this capture falls and rapids would be established where the descent from the higher, older course down to the lower, new course was made. These falls would be gradually worn back, leaving a young valley or gorge below them, in the vicinity of the sharp bend or 'elbow of capture' where the stream changed from the southwest to the southeast course. From the elbow of capture the remaining portion of the beheaded stream would continue its southwest course, flowing in a more mature valley on the upper level.

The features in the Tallulah district are so striking and so typical that it seems difficult to account for them on any other basis than the theory of capture. Certainly the conditions are eminently favorable for capture; and when one sees the streams on the lower

level actively engaged in gnawing headward into the steep escarpment and thus undermining the upper level, he feels a growing conviction that the streams on the upper level are in imminent danger of diversion. So when he witnesses those features which must necessarily follow capture, he is not at all surprised, but adopts the theory of capture as a matter of course. There are certain features of the Tallulah district which have caused some doubt as to the efficiency of river capture, and which, therefore, deserve special attention. It would appear that if the capture is so recent that the stream has not yet had time to wear back the falls and rapids produced by capture, then there should be falls in the Chattooga River as well as in the Tallulah. The former is no larger a stream than the latter, and so far as volume goes, no better fitted to grade its course. Recency of capture, therefore, does not seem competent to explain the falls in the Tallulah, when there are no corresponding falls in the Chattooga. Mr. Jones concluded that there was no difference in the resistance of the rocks over which the two streams ran, and was, therefore, led to doubt the fact of capture, and to suggest some other alternative. Professor Davis believed that the topographic features indicated capture, and in order to account for the falls in the Tallulah and their absence in the Chattooga, suggested that the former courses of the rivers might have been such that the Chattooga was captured first, and the Tallulah not until a later period, thus giving more time for the reducing of the falls in one case than in the other.

After careful investigation it appears that the difficulty lies in the interpretation of the character of the rocks over which the two streams run. Instead of sameness of character, there is seen to be the most significant difference in composition and ability to withstand erosion and weathering. The Chattooga River flows over a mica schist, which in all parts of the region is seen to offer little opposition to stream erosion. Occasional more quartzose bands have determined the location of minor falls or rapids along the smaller branch streams, but even these small

branches of the deeply incised drainage (except in the case of the very smallest examples), have eroded deep valleys in the mica schist. On the other hand, the Tallulah River is found to cross a resistant barrier of dense, hard quartzite near its junction with the Chattooga. This rock is wholly distinct from the mica schist, contains little else than fine quartz grains firmly cemented into a massive bluish-gray quartzite. It is less apt to be sheared than the other rocks of the region, having to a great degree withstood the crushing incident to regional metamorphism; it weathers with difficulty, and wherever present forms a serious obstacle to stream erosion, even a small layer of it determining the site of falls on some of the branch streams. A great thickness of this resistant rock is crossed by the lower course of the Tallulah. A traverse of several miles along the lower course of the Chattooga resulted in the finding of nothing but mica schist in the ledges and in the boulders in the stream bed, so it seems apparent that this stream has not encountered any of this hard rock in its down-cutting, but is located wholly on the weaker mica schist.

The presence of the falls in the Tallulah River and their absence in the Chattooga now become perfectly intelligible. When the capture occurred falls were produced which at once began to be worn back. After retreating to the junction of the Tallulah and Chattooga Rivers two series of falls were formed, one retreating up the course of the former river, and one up the course of the latter. The falls in the Chattooga were worn back to grade during the long period of time which has elapsed since the capture, for the weak mica schist offered no great obstacle to the river's attempt to grade its course. The falls in the Tallulah have not been thus worn back, since the hard-rock barrier with which that stream had to contend has made the process of grading a very slow one, a retreat of but a few miles having been accomplished thus far, and the work still continuing very slowly under the extremely unfavorable conditions which prevail.

There are many direct evidences of river capture which have been obliterated during

the long period of erosion since the capture occurred. The former channel of the Chattooga across the divide to the southwest cannot be seen; stream dissection has been extensive and all traces of that channel itself have been removed. The valley of the Chattooga has been so widened that no bench or terrace remains to indicate the abrupt change from the former mature upland valley to the deeply incised gorge. The lack of adjustment between the shrunken beheaded stream and the broad valley made to accommodate the former larger river, has given place to a newly established adjustment. The evidences of *recent* capture are lacking, and everything points to a great lapse of time since the capture, permitting the effacement of the more temporary effects of capture, and a considerable degree of adjustment to the new order of things. The evidences of remote capture, however, are none the less conclusive.

The theory of capture has been supported on the basis of certain facts in the distribution of the fresh-water faunas. It appears that a few shells from the Chattahoochee and more western drainage basins are found in the Savannah River, while a number of forms from the Savannah system are found in the Chattahoochee system. It is argued that these forms must have passed between the two systems at the time of capture.

That the fauna of the upper Chattahoochee (the Chattooga River) might be transferred into the Savannah River by the capture would appear quite possible. It is much more difficult to account for the transfer in the opposite direction, however, if we limit ourselves to river capture as the means. Yet the main transfer is supposed to have been in that direction. That shells could have passed from the lower level of the Tugaloo up 500 or 600 feet over falls and rapids to the higher level of the Chattahoochee, does not seem probable. It is possible, of course, that the headwater portion of the capturing stream may have been a more even slope instead of a series of falls, but the evidence of other streams working headward into the escarpment suggests that the capture was most probably initiated by a series of more or less prominent cata-

racts. These would effectually prevent transfer through the water itself. Furthermore, there is reason to believe that the transfer of water may have been nearly or quite completed before an actual surface valley connection was formed, since (as Lane has pointed out) leakage through the rocks from the higher to the lower level will go on for a long time, possibly increasing until all of the water from the higher level passes underground to the lower stream, leaving a dry channel for some distance below the point of capture in the upper valley. Under these circumstances it would be difficult to conceive of any transfer of faunas from the lower to the higher stream which was dependent upon direct fresh-water communication. On the other hand, there are so many means for the dispersal of fresh-water shells, and the evidence in other localities is so conclusive that they have been dispersed by such means, that we may reasonably suppose shells from either of the two systems might be transferred to the other independently of the capture. For this reason I do not believe that the distribution of the shells can be urged as a proof of capture, although the fact of capture is well attested by other lines of evidence.

The conclusion in favor of the theory of capture is further confirmed by the presence of old river gravels along the former southwestward course of the Chattooga. In view of the fact that the capture occurred at a remote period, we should not expect to find the former channel preserved, nor to find the gravels deposited by the river along that channel in their proper place. The stream dissection which we have already seen destroyed all traces of the former channel, would also wash the gravels down the slopes of the growing ravines and valleys, in many cases removing them altogether, but possibly leaving remnants in specially favored spots on the slopes and in the valleys. A careful search revealed the presence of these gravels, usually as scattered pebbles and boulders on the hillsides, but occasionally as considerable patches in the bottoms of small branch valleys. There was no mistaking their character. The present stream-borne material,

even in the largest of these branches, is quite angular and evidently of local origin. The gravels are beautifully rounded quartz pebbles, cobbles, and boulders, somewhat roughened where exposed to the weather for a long time, but perfectly smooth where recently unearthed. In one place they were so abundant that a farmer had made numerous large piles of them in an ineffectual attempt to clear a small plot of ground for agricultural purposes. Their occurrence, together with the unequivocal topographic evidence, would seem to remove the question of capture from the realm of theory, and place it definitely in the realm of known facts.

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#### REASONS FOR BELIEVING IN AN ETHER

MANY scientific men who are not physicists feel an ill-defined distrust of some of the more or less complex conceptions of modern physics. They feel that the physicist has, perhaps, allowed his imagination to carry him too far and has not stopped often enough to re-examine the foundations of his faith.

Perhaps the most fundamental conception exciting some such distrust from the outside is that of the æther which is assumed to fill all space. The non-physicist who has read of the oft-repeated but entirely unsuccessful attempts to detect the 'ether wind' due to the earth's movement through space, and of the negative results of all 'direct' experiments on the æther, begins to feel that the builders of physical theory are perhaps unreasonably tenacious of an idea which could, perhaps, best be dispensed with.

It may not be out of place, therefore, to state as briefly and clearly as possible several reasons for belief in an ether, reasons sufficient because based directly on observation or experiment.

The most important evidence is the simple fact that *the velocity of light does not depend on the velocity of the source*. This is shown by the normal apparent shape of the orbits of binary stars, which, it is easy to see, would otherwise appear distorted. For, if the orbital velocity of one member of a binary star