fully. The greatest need, and likewise the greatest demand, among even highly educated persons, is for *information* rather than *training* in science. All workers and students require training in their specialty, but in other fields they want knowledge in simple form and by the most direct method.

Natural science has moved from a position of great worth as a school subject to one of minor importance. Science teachers everywhere are beginning to regard it a high duty to bring it back to its rightful place and value. Attention has been too sharply focused on teaching "subjects" as against teaching students those things that are important for them to know. The schools reached the lowest point in real science instruction when, under the stress of preparing for higher institutions, they narrowed their work to "the forty quantitative experiments." It was desultory, scrappy, unorganized, unscientific. At best the teaching was confined to vocabularies of technical words, definitions of scientific terms, statements of "fundamental principles," etc. The natural and effective order is not principles followed by applications, but the reverse. From a multitude of experiences, facts and observations, arranged so as to illuminate one another, some few principles may be derived; if these principles can be shown to be fundamental and can be brought into immediate use. The trouble with most of the so-called "fundamental principles" is that they are never again met either in school or life, and the majority even of enlightened men get on very well without having ever heard of them, or, having heard, they have forgotten them because they did not prove to be fundamental to anything. A principle which occurs, or is likely to occur, so often that one can not forget it, is fundamental, and few others need be considered.

Principles are not to be taught merely for discipline and training, nor for use only in a remote future.

The study of "projects" in science will necessitate the breaking down of boundary fences that have been erected between highly specialized sciences.

General science should be adapted to local conditions and may not be universalized. Many projects elaborated by ingenious and skilled teachers should be published in a series of small books or pamphlets for the use of pupils. Teachers may select from these as time, place and other circumstances require. Enough of this material may easily be prepared to occupy many years of study on the part of pupils. What it is worth while to know from the fields of astronomy, botany, chemistry, geology, meteorology, physics, physiology, zoology, etc., may be thus acquired.

Correspondence is invited.

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INDIANA UNIVERSITY EXPEDITIONS TO NORTHWESTERN SOUTH AMERICA

In these columns in 1905, Dr. C. H. Eigenmann gave a discussion of the fresh-water fishes known from both slopes of Panama,[1] and suggested the advisability of a biological survey to record their distribution before the completion of the canal should furnish a waterway and allow the intermingling of the two faunas. His conclusions were, in the main, that the Pacific slope fauna was derived from the Atlantic slope fauna in times more recent than the obliteration of the interoceanic connection, and that this fauna crossed the divide somewhere near Panama. At his suggestion, resolutions were adopted by various scientific bodies, including the International Zoological Congress and the American Association for the Advancement of Science, calling upon the president and congress to provide means for a survey of the regions about the canal. In 1910, under the auspices of the Smithsonian Institution, the survey was organized from among the various scientific departments at Washington. The collection of fishes was intrusted to Dr. S. E. Meek, of the Field Museum of Natural History, and Mr. S. F. Hildebrand,

[1] Science, N. S., Vol. XXII., No. 549, 1905, p. 18.

of the U. S. Bureau of Fisheries. They spent the winters of 1910 and 1911 in the field, but their results remain largely unpublished.

In December, 1911, Professor Eigenmann left for Colombia with the principal object of investigating the faunas of the Atrato and San Juan Rivers, south of Panama. These rivers flow in opposite directions in a longitudinal trough west of the Western Cordilleras and the height of the divide between them does not much exceed 300 feet. Other points were the relation of the faunas of the Atrato and the Magdalena, which seemingly possess no obstacles to inter-migration, and the relationship existing between the faunas of the upper Cauca and the upper Magdalena, separated as they are by the high Central Cordilleras. Dr. Eigenmann landed at Cartagena and proceeded thence by river steamer and rail up the Magdalena, collecting en route at Puerto Wilches, Peñas Blancas, Honda and Girardot, thence to the high plateau of Bogota, where a large collection was made of all fishes occurring there, including the supposedly mutating "capitan" (*Eremophilus mutisii*). He then proceeded by pack-train from Girardot through Ibagué and Toche, crossing the Central Cordilleras over the Quindío pass, descending thence to the Cauca at Cartago, from which point he continued by pack-train to Cali, collecting on the way. With more pack mules the Western Cordilleras were crossed to Caldas; from here collections were made at successively lower elevations on the River Dagua to the coast at Buenaventura. From this point a steamer carried the expedition up the San Juan to the head of navigation at Puerto Negria, thence a dugout continued on to Istmina. The low continental divide was crossed here to the Atrato; he went then by steamer to Cartagena. Collections were made at various points along these rivers. Dr. Eigenmann returned to the university in the middle of April, 1912. The expenses of this expedition were assumed by the Carnegie Museum of Pittsburgh, to which belongs the first series of the fishes collected; the second series remains at Indiana University.

Since his return, Mr. Manuel Gonzalez, a Colombian, who accompanied him on part of the trip, has been employed by the university to continue collecting about Bogota and to the eastward in the headwaters of the Orinoco.

Mr. Charles E. Wilson, an Indiana University student, left in December, 1912, for Tumaco, the most southerly port of Colombia on the Pacific. He spent about a month collecting in coastal streams and above Barbacoas in the Telembi, a tributary of the Patia. He then continued northward to Buenaventura, returning over the San Juan-Atrato route, collecting at various points in both of these rivers and in the Truando, one of the principal tributaries of the Atrato. He returned to the university in April, 1913. His expenses were paid by Mr. H. McK. Landon and Mr. Carl G. Fisher, both of Indianapolis.

Mr. Arthur W. Henn, another student of the university, had been with Mr. Wilson on the Telembi when both were forced to return to Tumaco with fever. When recovered Mr. Henn returned to Barbacoas by small steamer and then went by pack-train to Tuquerres, situated in the Western Cordilleras at an elevation of over 10,000 feet. From here, after some delay, he continued northward with another specially engaged pack-train to the gorge of the Patia, where this mighty stream has cloven a majestic canyon through the Western Cordilleras. The route followed here was in general that followed by the geologist A. Stübel through Ancuya, Tambo and Peñol. The gorge was reached at the mouth of the Guaitara. The expedition continued back through Pasto and Tuquerres to Barbacoas and Tumaco. Mr. Henn sailed then for Buenaventura, continued to Puerto Negria by small steamer, and returned by canoe to the lower San Juan, especially for work in the Calima, which he ascended for three days, returning overland to Buenaventura. Instructions had meanwhile been received from Dean Eigenmann directing the work to Ecuador.

Mr. Henn sailed southward to Guayaquil, where he arrived in May. A short trip was taken to Naranjito, where collecting was done in the River Chan Chan. He then went to Manabi, entering at Bahia, fishing at Chone

and Portoviejo and returning to Guayaquil by way of Manta. Several more weeks were spent in the rivers Daule and Vinces. He then ascended into the high Andean plateau over the Guayaquil and Quito Railway, collecting at various points. From Quito he descended again into the subtropical forest region at Mindo on the western slopes of Mt. Pichincha. The expedition then continued northward to El Angel, where several weeks were employed excavating old Inca tombs. Nearly 300 pieces of Inca pottery were obtained; these are now in the John Herron Art Institute of Indianapolis and the Carnegie Museum. Mr. Henn went from here down the valley of the Chota to a point below the hacienda Paramba.

Revolutionary developments and the presence of roving bands of "montoneros" made necessary a return to Quito, where the month of January was spent. Here a small collection of birds, aggregating about 65 species, was obtained, chiefly from Pichincha and the surrounding region. When quiet again prevailed, Mr. Henn returned to El Angel to secure the stored collections, continued on through Tulcan to the Colombian frontier and thence to Barbacoas, reached after twelve days of continuous travel by mule from Quito. He arrived in New York at the end of March of this year after fifteen months in the field. Aside from the collections of fishes, the collection of batrachians comprises probably 400 specimens, representing all ranges of altitude and climate. The collection of mammals is insignificant, of note is the acquisition of four skulls and one skin of the rare spectacled bear (*Tremarctos ornatus*). This expedition was made possible by the generosity of Mr. Hugh McK. Landon, of Indianapolis.

The general result of these expeditions is the definition of two geographical sub-provinces, of more or less equal value, differing somewhat in their constitution, but more so in their origin. The Pacific Province of continental South America may be divided into two sub-provinces, (1) the Colombian, extending from the Chepo basin of Panama south to the river of Esmeraldas and (2) the Ecuadorian, extending from the Guayas system south until lost, probably in the desert of Atacames. The fishes of the Pacific slope are in general widely distributed Amazonian types; none of them would cause surprise if taken at Manaos.

The Colombian sub-province is characterized by its extreme humidity. None of its rivers are large, the San Juan and Patia are the largest, but all carry a relatively immense amount of water. The few fishes which have come into them have undergone much adaptive radiation. Its fauna is much richer than that of the Ecuadorian sub-province. Its types are mostly Amazonian and among the oldest found on the continent. This fauna has certainly entered over the Atrato-San Juan route. The fishes of these two rivers are very similar and many species are common to both. The channel-fishes of the Atrato, however, have not succeeded in crossing over to the San Juan. They have spread thence to all the rivers south to Esmeraldas. Those of the Chepo and Tuyra basins of Panama have evidently also come from the Atrato. Dr. Meek says:[2]

> . . . it is quite evident that strictly South American migrants in comparatively recent times did not go far beyond the Canal Zone, and that most of these are lowland forms which came from the streams on the Atlantic side of Colombia to the Pacific side after the last gap (Atrato-Tuyra) here between the two oceans was closed. We find *Curimatus*, *Ctenolucius* and *Gasteropelecus* and other Colombian Atlantic forms in streams opposite the Rio Chagres but not in it. Some Loricarids occur in these streams and also in the Rio Chagres, but these appear to us to have probably crossed from the Pacific side streams to the Chagres and not to have migrated from the rivers of Colombia to the Chagres direct.

The Ecuadorian sub-province is characterized by its increasing aridity, which begins immediately south of the cross-ridge of Esmeraldas, is intensified below Guayaquil as shown by the Desert of Tumbez, and culminates in the desert regions of Peru. In the long dry season all of the rivers dwindle to mere puddles. Under these unfavorable conditions

[2] Publications, Field Museum of Natural History, Zoological Series, Vol. X., No. 10, 1914, p. 134.

but little evolution has taken place. The difference from the fauna to the north is the difference in species; the genera are in most cases of wide distribution.

Few species occur in both faunas, and these are such widely distributed barrier-surmounting fishes as *Rhamdia, Hoplias* and *Lebiasina.* For them the Esmeraldas ridge has not been a barrier. *Sternopygus macrurus* may have come from the north; it is the only Gymnotid found south of Esmeraldas. Sub-andine forms also occur indiscriminately in both regions. The four distinctive Pacific-slope genera are confined to this region. It is a very old fauna and an extremely meager one. *Astyanax festæ, Astyanax* or *Bryconamericus brevirostris* and *Bryconamericus peruanus,* all lowland forms, confined to this area are more intimately related among themselves than they are to the nearest geographical members of their respective genera. Either long isolation in a region offering few environmental units has caused them to converge or they have only recently arisen.

This fauna has evidently come from the east coincident with the first stages in the rise of the Andes. This possibility was suggested by Dr. Eigenmann[3] in 1909, chiefly to account for the presence of *Cetopsis occidentalis* which has near relatives in the Upper Amazon. A ridge or spur of the Andes forms the watershed between the systems of the Esmeraldas and the Guayas. On it is situated Santo Domingo de los Colorados at an elevation of 1,500 feet, but its height nearer the sea is further decreased. This seems to separate the two faunas. It is, according to Wolf,[4] of early tertiary formation and probably arose but slightly later than the beginning of the upheaval of the great western chain. The trough in which now flow the Guayas and the Daule is of subsequent alluvial formation. Deposits showing tertiary depression occur at Loja and in the headwaters of the Catamayo. Through this route possibly have entered the fishes. This point now raised more than seven thousand feet above the sea is, however, the only break in the majestic wall of the Andes.

"The distribution of the *Glandulicaudinæ* shows a strange relationship between the faunas of Transandean Colombia and southeastern Brazil. This relationship is confirmed by the distribution of *Salminus* and other fishes. The similarity is not confined to positive resemblances, but a number of types absent from northwestern Colombia are also absent from southeastern Brazil and Uruguay.

"The few genera of small fishes which succeeded in crossing or circumventing the Eastern Cordilleras of Venezuela and Colombia have undergone a remarkable radiation in Colombia. These Cordilleras very probably become a barrier before the evolution of the electric-eel, the Serrasalmoninæ and many others of the common Amazonian sub-families which are absent from Colombia. This makes very desirable a knowledge of the fauna of the region about Lake Maracaibo, where the university later plans to send an expedition."

The factors of vertical distribution are to be considered in a region so mountainous as that contiguous to the Andes. Of interest here is the *recurrence* of the same species at similar altitudes, in widely separated localities, a fact pointed out by Sir Edward Whymper among insects. The same species of *Hemibrycon* was taken at Sandoná, in the Pacific slope of the Western Cordilleras; at Ibagué in the Central Cordilleras and at Guadual, in the Atlantic slope of the Cordilleras east of Bogota, in each case at an elevation of some four thousand feet. *Bryconamericus caucanus* occurs in the Upper Cauca and at a similar altitude in the Upper Patia. *Arges cyclopium* occurs in all the high inter-andean valleys of Ecuador and is represented at Toche in the Central Cordilleras nearly four hundred miles to the north by a very similar if not identical form. This species, known as "Humboldt's fireproof fish" is the only true andean fish; in the great Andes of Ecuador it ranges as high as eleven thousand feet.

At elevations not greater than five thousand feet, a subandine fauna is encountered containing fishes such as *Pygidium, Arges, Hemibrycon, Rhoadsia* and *Piabucina.* The number

[3] Reports of the Princeton University Expeditions to Patagonia, Vol. III., 1909, p. 361.

[4] "Geografia y Geologia del Ecuador," Leipzig, 1892.

of species here is in direct proportion to the amount of rainfall. The stream gradient at this altitude is very high, but great humidity permits standing pools of water outside of the rivers themselves. Full tables of the distribution of the fishes of Colombia and Ecuador will be given in the final complete reports.

ARTHUR HENN

SPECIAL ARTICLES

POSSIBLE FACTORS IN THE VARIATIONS OF THE EARTH'S MAGNETIC FIELD

NEWALL[1] has described a very interesting experiment in which "a lamp flame held under an iron or steel wire (which is in circuit with a galvanometer), so that a short portion of the wire becomes red hot, is made to travel slowly under the wire, and it is found that a current appears in the galvanometer, the direction of the current depending on the direction in which the flame travels. Tomlinson[2] described a similar experiment at an earlier date than Newall. While this current is described as due to difference in thermo-electric quality between the iron or steel in the magnetic and non-magnetic state, yet it is suggestive of what might happen in the crust of the earth as the sun's rays fall upon its surface and warm it.

The following simple experiments were carried out with a view to getting more light on the phenomenon of earth currents and their relation to the earth's magnetic field. A board, seventy-five centimeters long and four centimeters wide, Fig. 1, had a shallow rim fastened around it so as to form a tray. At either end was fastened a zinc strip, both of which were in turn soldered to copper wires leading to a galvanometer. In this tray and covering the zinc terminals, a fairly homogeneous paste of mud was placed about one half centimeter thick. The water used in making up the mud paste was slightly acidulated with sulphuric acid to make it a better conductor. When a Bunsen flame was allowed to play on this strip of mud for some little time and then slowly moved in one or the other direction lengthwise of the tray, a current was set up in the galvanometer, depending upon the direction of the motion of the flame.

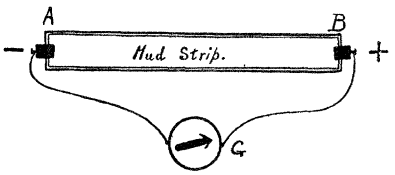

FIG. 1

If the electrode marked *B*, Fig. 1, was made positive by applying the positive pole of a dry cell to it and the negative pole to *A*, then the galvanometer gave a deflection to the left. When the flame was slowly moved from *A* toward *B*, the deflection of the galvanometer was to the right, and when the motion of the flame was reversed the current was also. This indicated that the direction of the current was opposite to that of the burner.

Suppose now this condition exists in the surface of the rotating earth as the heat rays of the sun falling upon it move from east to west. A current will be set up in the opposite direction, *i. e.*, from west to east, which will locally complete itself on the earth's surface somewhat as shown in Fig. 2.

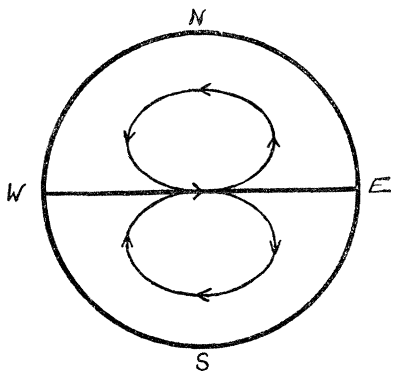

FIG. 2

It was found that the hotter the Bunsen flame for a given rate of moving, the greater

[1] Newall, *Philosophical Magazine*, June, 1888. See also Ewing's "Magnetic Induction," p. 184, 3d ed.

[2] Tomlinson, *Philosophical Magazine*, January, 1888, p. 50.