eral reading. It is also frequently stated that the vocabulary of certain miners consisted of but one hundred words. Whether this was an actual count or merely an estimate I do not know, but should think that it must be the latter. In order to determine the size of an ordinary vocabulary I could think of no better means than to find out the number of words used in some standard work that is easily read and understood by everybody. Nor could I think of any book better suited for the purpose in view than that great English classic, "Robinson Crusoe." The copy of that work in my possession contains 460 pages, and I first noted down all of the different words found on every tenth page (counting as a separate word what is given as such in the dictionary). This probably gave more different words than forty-six consecutive pages would have done, because a greater number of subjects and incidents are discussed and described. I then noted the new words on the remaining nine of a section of ten pages in the front part of the book, and then of a section in the latter part, in order to get a basis for estimating the new words in the rest of the book. The number of words on the sixty-four pages counted was thirty-one hundred, and if the percentage of decrease for each section of nine pages from the section counted just before it should be the same as for the two sections counted, there would be on the remaining 396 pages about three thousand words. It may be, as would seem probable, that the percentage of decrease would increase after awhile, but so far as counted there was no sign of an increased rate of falling off. The falling off was very rapid for the first five pages, less rapid for the next twenty, and after that not enough to be evident unless the average of a number of pages was taken. It seems quite certain, then, that De Foe, in writing his account of the adventures of Robinson Crusoe, used not less than five or six thousand words. Children of ten or twelve years read the book with pleasure, and probably have a pretty clear idea of the meaning of nine out of ten of the words they find in it. The work probably contains most of the verbs and a large proportion of the adjectives and adverbs in common use, but there is a large number of nouns, both common and proper, familiar to every child, which De Foe had no occasion to use in this work. It is probable then that to read ordinary general reading in English understandingly one needs to be familiar with from six to ten thousand words. The same must be true for other languages equally rich in synonymes. Grimm's "Märchen" contains a vocabulary of between four and five thousand words, yet any one who can readily read those stories needs a dictionary constantly by his side when reading ordinary German.

From the data at hand I should estimate the vocabulary of a citizen of the United States with a common-school education and of ordinary intelligence and reading at about ten thousand words, and that of a well-read college graduate, and of those who have pursued a university course, at from twenty thousand upwards to perhaps one hundred thousand. One's vocabulary is usually nearly complete at thirty years of age. If but two words are learned each day the vocabulary at that age would be only twenty thousand. My records show that young children acquire new words more rapidly than that.

As to the composition of a vocabulary, I find that in the dictionary about 60 per cent of the words are nouns, a little over 22 per cent adjectives, and a half that per cent verbs, and a fourth adverbs. Pronouns, prepositions, and conjunctions, though used in every sentence, constitute a very small part of a general vocabulary — none were found in examining fifteen pages, or one in every hundred, in the dictionary. Of the thirty-one hundred words obtained from "Robinson Crusoe," a little over 45 per cent were nouns, 24 per cent verbs, a little over 17 per cent adjectives, and 7 per cent adverbs. Probably nearly every one is familiar with a larger proportion of the verbs than of the nouns in the dictionary, but "Robinson Crusoe" is particularly rich in verbs. Many of them are used only as participles, the form in many cases being the same as for the adjectives, but they only counted as verbs unless distinctively used as adjectives. As already suggested, the ordinary vocabulary contains a larger proportion of nouns than are found in "Robinson Crusoe," and many that are not found in the dictionary, although the proportion is probably not greatly different from what it is in the latter. In small vocabularies the proportion for the different parts of speech is quite different. Of the 215 words on the first page of "Crusoe" that I counted, 5 per cent were prepositions, 10 per cent adverbs, 10 per cent pronouns, 6 per cent conjunctions, and but 24 per cent nouns. This must be borne in mind in considering small vocabularies like those of children.

As a matter of some general interest, and a point of considerable importance, in considering the question of the pronouncing vocabulary of children, it is worth while to notice with what letters of the alphabet the greatest number of words begins. The letters s, p, and c begin nearly one-third of the words in the English language. The following is the order for the letters most frequently used in the dictionary: s, p, c, a, t, b, r, m, d, f, e, h, l, g, w, o, v, n, u; in "Robinson Crusoe," s, c, p, a, f, b, r, m, e, t, w, h, l, i, g, o, n, u, v.

Further data are needed in order to confirm or correct the estimates given in this article.

E. A. KIRKPATRICK.

Rhodes, Iowa, Aug. 14.

Climatic Changes in the Southern Hemisphere.

HAVING had occasion to cruise a considerable time over the Southern Ocean, I have had my attention directed to its prevailing winds and currents, and the way in which they affect its temperature, and also to the ice-worn appearance of its isolated lands.

It is now generally conceded that the lands situated in the high latitudes of the southern hemisphere have in the remote past been covered with ice-sheets, similar to the lands which lie within the antarctic circle. The shores of southern Chili, from latitude 40° to Cape Horn, show convincing evidence of having been overrun by heavy glaciers, which scoured out the numerous deep channels that separate the Patagonian coast from its islands. The Falkland Islands and South Georgia abound with deep friths; New Zealand and Kerguelen Land also exhibit the same evidence of having been ice-laden regions; and it is said that the southern lands of Africa and Australia show that ice accumulated at one time to a considerable extent on their shores. At this date we find the southern ice-sheets mostly confined to regions within the antarctic circle; still the lands of Chili, South Georgia, and New Zealand possess glaciers reaching the low lands, which are probably growing in bulk; for it appears that the antarctic cold is slowly on the increase, and the reasons for its increase are the same as the causes which brought about the frigid period which overran with ice all lands situated in the high southern latitudes.

Why there should be a slow increase of cold on this portion of the globe is because of the independent circulation of the waters of the Southern Ocean. The strong westerly winds of the southern latitudes are constantly blowing the surface waters of the sea from west to east around the globe. This causes an effectual barrier, which the warm tropical currents cannot penetrate to any great extent. For instance, the tropical waters of the high ocean levels, which lie abreast Brazil in the Atlantic and the east coast of Africa in the Indian Ocean, are not attracted far into the southern sea, because the surface waters of the latter sea are blown by the westerly winds from west to east around the globe. Consequently the tropical waters moving southward are turned away by the prevailing winds and currents from entering the Southern Ocean. Thus the ice is accumulating on its lands, and the temperature of its waters slowly falling through their contact with the increasing ice; and such conditions will continue until the lands of the high southern latitudes are again covered with glaciers, and a southern ice period perfected. But while this gathering of ice is being brought about, the antarctic continent, now nearly covered with an ice-sheet, will, through the extension of glaciers out into its shallow waters, cover a larger area than now; for where the waters are shoal the growing glaciers, resting on a firm bottom, will advance into the sea, and this advancement will continue wherever the shallow waters extend. Especially will this be the case where the snowfall is great.

Under such conditions, it appears that the only extensive body of shallow water extending from the ice-clad southern continent

is the shoal channel which separates the South Shetlands from Cape Horn, which is a region of great snowfall. Therefore should the antarctic ice gain sufficient thickness to rest on the bottom of this shallow sea it would move into the Cape Horn channel and eventually close it. The ice growth would not be entirely from the southern continent, but also from lands in the region of Cape Horn. Thus the antarctic continent and South America would be connected by an isthmus of ice, and consequently the independent circulation of the Southern Ocean arrested. Hence it will be seen that the westerly winds, instead of blowing the surface waters of the Southern Ocean constantly around the globe, as they are known to do to-day, would instead blow the surface waters away from the easterly side of the ice-formed isthmus, which would cause a low sea-level along its Atlantic side, and this low sea-level would attract the tropical waters from their high level against Brazil well into the southern seas, and so wash the antarctic continent to the eastward of the South Shetlands.

The tropical waters thus attracted southward would be cooler than the tropical waters of to-day, owing to the great extension of cold in the southern latitudes. Still they would begin the slow process of raising the temperature of the Southern Ocean, and would in time melt the ice in all southern lands. Not only the Brazil currents would penetrate the southern seas, as we have shown, but also the waters from the high level of the tropical Indian Ocean which now pass down the Mozambique Channel would reach a much higher latitude than now.

The ice-made isthmus uniting South America to the antarctic continent would, on account of its location, be the last body of ice to melt from the southern hemisphere, it being situated to the windward of the tropical currents and also in a region where the fall of snow is great; yet it would eventually melt away, and the independent circulation of the Southern Ocean again be established. But it would require a long time for ice-sheets to again form on southern lands, because of the lack of icebergs to cool the southern waters. Still, their temperature would gradually lower with the exclusion of the tropical waters, and consequently ice would slowly gather on the antarctic lands.

The above theory thus briefly presented to account for the climatic changes of the high southern latitudes is in full accord with the simple workings of nature as carried on to-day; and it is probable that the formation of continents and oceans, as well as the earth's motions in its path around the sun, have met with little change since the cold era iced the lands of the high latitudes.

At an early age, previous to the appearance of frigid periods, the ocean waters of the high latitudes probably did not possess an independent circulation sufficient to lower the temperature so that glaciers could form. This may have been owing to the shallow sea-bottom south of Cape Horn having been above the surface of the water, the channel having since been formed by a comparatively small change in the ocean's level. For, while considering this subject, it is well to keep in mind that whenever the western continent extended to the antarctic circle it prevented the independent circulation of the Southern Ocean waters, consequently during such times ice periods could not have occurred in the southern hemisphere.

It will be noticed that according to the views given above, the several theories which have been published to account for great climatic changes neglect to set forth the only efficacious methods through which nature works for conveying and withdrawing tropical heat sufficient to cause temperate and frigid periods in the high latitudes. While lack of space forbids an explanation of the causes which would perfect an ice period in the northern hemisphere, I will say that it could be mainly brought about through the independent circulation of the arctic waters, which now largely prevent the tropical waters of the North Atlantic from entering the arctic seas, thus causing the accumulation of ice sheets on Greenland. But before a northern ice period can be perfected, it seems that it will need to co-operate with a cold period in the southern hemisphere; and in order to have the ice of a northern frigid period melt away, it would require the assistance of a mild climate in the high southern latitudes.

C. A. M. TABER.

Wakefield, Mass., Aug. 14.

BOOK-REVIEWS.

The Journal of the College of Science, Imperial University of Japan. Vol. IV., Part I.

THIS volume forms a fitting complement to the numbers already issued, and indicates the advanced position of the college and the high standing of its teachers and special students. If any thing would commend an institution to the generous attention of the government it is the admirable work which has been embodied in the various memoirs of the series. The present number opens with a memoir by Professor K. Mitsukuri on the "Fœtal Membranes of Chelonia." It is one of a series on the embryology of *Reptilia*. The first one, in which Mr. Ishikawa was joint author, was on the germinal layers of Chelonia. The fœtal membranes of *Reptilia* have been supposed to bear a close resemblance to those of birds. Mr. Mitsukuri has found many notable features which have, hitherto, been overlooked, and these appeared so remarkable that he has made them the subject of his memoir. Ten beautiful plates accompany the text.

Mr. Kamakichi Kishinouye gives the results of his researches on the "Development of the Araneina," illustrated by four plates. The material for study was obtained on the grounds of the university, and this included *Lycosa*, *Agalina*, and other genera of spiders. His method of treating the eggs is given in full, and will be found of great value to the student. His discussion of the formation of the pulmonary lamellæ or lung-book is very interesting. He thinks it probable that the lung-book was derived from the gills of some aquatic arthropodous animal, such as Limulus, comparing it with the lamellar branchia of Limulus sunk beneath the body surface. He shows that an invagination of the first abdominal appendage gives rise to the lung-book, and a similar invagination at the base of the second gives rise to a tube—abortive trachea. Many other interesting points are developed or sustained in this memoir.

Mr. Oka has a memoir on a new species of fresh-water polyzoa, *Pectinatella gelatinosa*. His methods of preparation will be found valuable to students of this group. His allusions to the views of Hyatt and Morse as to the anterior region of the polypidæ refer to views uttered over twenty-five years ago, when the polyzoa and brachiopods, with the tunicates, were supposed to be molluscan. These views are antiquated, and have long since been abandoned by the authors in question. Circulation is showed by Oka to be by ciliary action. He confirms Verworn in showing ciliary action on the external wall of the alimentary canal. Important observations are made on a pair of excretory organs which are ciliated and communicate with the epigastric cavity by wide openings. Their external openings have not been found, but the relation these bear to the segmental organs of brachiopods and worms seems unquestionable. An exhaustive discussion is given to the development of the statoblast, and the longitudinal sections depicted are of great value. The memoir is a solid contribution to the literature of this interesting group of animals. Four plates illustrate the details of anatomy and development.

Mr. Seitaro Goto has a memoir, with three plates, on a new form of Diplozoon, to which he gives the specific name of "nipponicum." He gives reasons for separating it from the single species known as paradoxum. The curious creature is described in detail, and interesting points are added to what has already been known.

A new species of hymenomycetous fungus injurious to the mulberry tree, illustrated by four plates, is described by Mr. Nobujiro Tanaka, with a discussion of this fungus, which has caused much destruction of the mulberry tree in Japan.

Notes on the irritability of the stigma, by Mr. Miyoshi, are illustrated by two plates. The author shows conclusively that this irritability, as Hermann Müller first suggested, has to do with the cross-fertilization of the flower, and is not for protection against wind and rain. Irritability is excited by an insect or a bristle, and not by a drop of water or by blowing against it.

Notes on the development of the suprarenal bodies in the mouse, with two plates, are by Mr. Masamaro Inaba. In this paper is discussed the mode of origin of the two substances which go to make up the suprarenal bodies. He comes to the conclusion that