a wide range of variability we have two or three species each with a slight range of variability. In the particular case in hand, however, it is not certain that the lower Jack's Bank form-unit (named *Pecten eboreus* by some one) has given rise to any other form than something of which *Pecten 'irradians'* of Morehead is a near representative. The evidence indicates that the reduced variability is solely the effect of the skewing factors.

The upshot of this whole investigation into the biological significance of skew variation is then this: Skewness is sometimes reminiscent and sometimes prophetic. In our present state of knowledge it is not possible by inspecting a single skew curve to say which of the two interpretations is correct in the given case. But by a comparison of the frequency curves of allied form-units the state of affairs can usually, as in the examples given, be inferred. A method of interpreting the single skew curve is a discovery for the future.

ASTRONOMICAL OBSERVATIONS IN GEOGRAPHY.

BY JOHN M. HOLZINGER.

State Normal School, Winona, Minn.

Efforts to improve the teaching of geography in the elementary public school have been numerous and varied among us. Nor does the present exhibit any abatement of them. The present tendency, however, seems to be setting strongly in the direction of physical geography. This paper is confessedly an effort to show that more observational work should be done in the teaching of what may be termed astronomical geography.

Probably the strongest argument for such work is to be drawn from the almost uniformly unsatisfactory answers given by high-school graduates to geographical questions involving a concrete knowledge, as opposed to a verbal knowledge, of such easily demonstrable facts as the earth's daily motion on its axis. Correct mental images of the earth as a sphere, and of the position

of the plane of the observer's horizon in all latitudes, are not derivable from the committing of the formal phrases and diagrams of a book. Certainly not one student in a hundred who has been taught geography according to present methods is able to imagine for himself with any degree of adequacy the dependence of daily phenomena upon the observer's latitude—and is this not quite as valuable to him as the commonly current dallying with the papooses of the Esquimaux? It would seem that the connection of such facts as the latter typifies with the latitude, although real enough, are too accidental, not to say silly, to justify the time commonly spent upon them.

Of course we teach how to compute the position of the sun relative to the horizon in different latitudes. Perhaps we even draw diagrams showing the decrease in the daily total of calories as we pass northward in latitude. But the proof that all this remains mere words, wholly inconvertible by the pupil into anything like a panorama, is found in the well-nigh uniformly incorrect answers to questions concerning phenomena within the arctic circle. Let the problem be set. In a place having three months of consecutive daylight and three months of consecutive night, what circumstances as to light and darkness prevail during the remaining six months? The common answer will be, "The remaining six months are twilight" Generally, though not always, these six months of twilight are said to occur in two periods of three months each, one previous to, and the other subsequent to, the "long night." The palpable ignorance here shown of the most fundamental and regular daily occurrence, or perhaps better, the absolute inability to apply what every child must know full well as a verbal statement; viz., the earth's rotation, is incredible to any one not familiar with the facts.

How can this and similar evidences of ignorance be at least measurably remedied? In the writer's opinion the only way out of the difficulty lies through simply observing for a period of years during the later grades and high school the more obvious phenomena of the daily and nightly sky.

To carry this out it is quite unnecessary that the pupils should do their star-gazing in groups. The better plan is to draw upon the board, a few at a time, some twelve or fifteen simple diagrams

of star-groups to be used by the pupils as a guide in their surveys of the heavens. Pupils copy these diagrams and identify and verify them from their homes. The objective point of this work is to familiarize the pupil with the star-groups which mark the constellations of the zodiacal belt. And within certain limits it may almost be said that the fewer stars selected in each constellation the better. For elementary pupils the names of the individual stars is a matter of no consequence. The writer requires his pupils to learn the names of the first and a few second magnitude stars; not over twenty in the entire heavens visible in latitude approximately 40° N.

Thus, "three stars" mark Arias, Pleiades and Aldebaran, Taurus, Castor and Pollux, and Tejot (the only third magnitude star learned by name), Gemini; "four faint stars and a cluster," Cancer; "the Sickle, and the right-angled "Triangle with Denebola," Leo; "Spica," Virgo; "four stars," Libra; "Antares and its two companions," Scorpio; "the five stars of the inverted dipper," Sagittarius; "two stars, the upper apparently double," Capricornus; "the four stars of the Y," Aquarius; "the Pentagon," Pisces.

Of the constellations north of the belt, only the following are really valuable as guides to the zodiacal groups: 1. Polaris; 2. The Great Dipper; 3. Cassiopeia; 4. Vega in the Lyre; 5. The Northern Cross in the Swan; 6. "Altair and its two companions" in the Eagle; 7. Arcturus in Boötes; 8. "Capella and the Kids" in Auriga; 9. The Square of Pegasus; 10. "Two stars" in Andromeda; 11. Algenib and Algol in Perseus.

In the space south of the zodiacal belt we learn only the following: 1. Orion, by noting Betelguese, Bellatrix, Rigel, Saiph and the yard stick, or Belt; 2. Sirius; 3. Procyon.

With these objects definitely known in relation to each other, after a year of *occasional lessons*—one or two a month are sufficient—the mapping of the place of the moon and of the visible planets with reference to the nearest zodiacal star group or groups, from night to night, becomes a delightfully interesting and profitable exercise. The discussion of the observations, of course, falls always on a morning after a cloudless evening, and should constitute a part of the geography recitation.

The result of these observations is a fairly good, because a *concrete*, understanding of the following points: 1. The line of the moon's path among the stars; 2. The dates of its nodes, determining two points in the sun's apparent path, and so the earth's real path; 3. The rising and setting, and constant westering of *all* fixed stars every twenty-four hours; 4. The *eastward* course of the moon at the rate of 13° (about), and of the sun at the rate of 1° , every twenty-four hours; 5. The determination of the point of the winter solstice a few degrees west of the handle of the Little Dipper in Sagittarius, 28° west of the *constellation* Capricornus, and of the point of the summer solstice, at Tejat, 28° west of the constellation Cancer, showing the *fact* of the discrepancy between signs and constellations (the *fact* of precision, not the *theory*, at first); 6. The determination of the angles which the sun's rays make at midday with our horizon on the cardinal dates of the year.

After a few lunations have been observed and mapped by nights (each map, of course, is to be accompanied by data; *hour*, *day* and *month* of observation), the pupil has for the first time a concrete illustration of the *way* and *direction* of the sun in its apparent annual path among the stars. Never mind, at first, the problem of the nodes, and the 5° of inclination of the planes of the orbits of the earth and moon. It is quite enough, to begin with, that the student learn, by *his own observation*, that the moon travels *eastward* from night to night, in spite of its regular setting beneath our western horizon. That it travels at the rate of about 13° daily, he may be taught to deduce from his observations. And this fact, of having in addition to the "yard stick" a measure of *angular* distance across the heavens, becomes gradually a very helpful element in the observations. The apex of the angles in geometry is *objective*, so to speak, on paper; the apex of the angles, or degrees which we say lie between two celestial objects, is *subjective*, that is, in the eye, of the observer. And here also lies a much neglected opportunity, both in geometry and geography, that of cultivating the habit of correct imaging of angles. The ability to estimate the values of angles in terms of degrees is very necessary in expressing distances between the stars.

It seems quite superfluous to point out the obvious fact that the stars, by observing which we are helped to think rightly the phenomena of the earth's rotation and revolution, are always spread out before us at the time of greatest leisure, and may with little effort be satisfactorily observed and understood by young and old alike, from one's very doorsteps; while the data of physical geography, possessing also unquestioned educational value, are acquired effectively at best by a comparatively small number, and with considerable labor and exertion in studying the absolutely insignificant area in their vicinity, as a preparation for the elementary appreciation of the laws and forces that have fashioned the whole of the earth's surface. In both cases, it is generally admitted that effective thinking is possible for the majority only on the basis of observation. But whereas in physical geography only the most insignificant portion of the earth's surface is readily studied, in astronomical geography the great panorama of the heavens may be taken in almost entire with little physical effort. And it seems almost useless to think out the earth's two motions and the resultant phenomena without such observations.

There is also another class of observations which the children and teachers of every school should make each year with scrupulous regularity, viz.: of the *sunrise point*, and the *sunset point* at the cardinal dates. Let this be done, watch in hand, on the first cloudless morning and evening nearest each date; if done a day or two before, repeat it on or right after the date. For this it is best to agree upon some common spot, preferably the school house grounds, or a second story recitation room from which sunrise and sunset can be observed. The actual determination of the angle made at the place of the observer by the shifting of this point from December to March, and to June, in degrees, is as simple as the measuring of a line; we use a Prang triangle (10 cts.), which should be possessed by every student and teacher of geography. This, as much as any exercise, will aid in the right imaging of the actual space relations of the observer, standing on the arctic circle, and of the sun, during the twenty-four hours of June 21, and as well farther north.

Some of the most important facts of geographical knowledge are the cardinal dates, the cardinal points, the lines of latitude and

of longitude, the decrease pole-ward of the sun's heat, and the effect of this changing condition upon human existence in high as well as low latitudes. An effective understanding of them by the verbal textbook method, if not quite impossible, is yet exceedingly difficult with the great majority of young minds. And the removal of this difficulty lies, according to the conviction of the writer, in the direction of the simple observations suggested.

TRAINING FOR THE STUDY OF CHEMISTRY.

H. R. CARVETH.

Instructor in Physical Chemistry, Cornell University.

Alchemy was the old study; chemistry is the new science. Before the latter could develop, experimentation was necessary. Experiments gave rise to facts. As the facts in the field of knowledge accumulated, it became necessary to classify and correlate them. The systematic arrangement and the development of relationships led to exact theory, the basis on which this science, as all others, now rests.

In experimental work there appears the general tendency for a great number of workers to be satisfied with a very restricted view of the subject, while the general perspective presents itself only to the few who by dint of genius and hard work have refused to be satisfied with the ordinary point of view. The latter in looking around should be able to discover the general position of the science, the points open to successful attack, or the positions which must be abandoned at the first severe onslaught of opponents. In a world and an age where lack of aggressive attack shows weakness of position or a feeble initiative, no leader of men can stand at ease, for the younger, more active and more restless elements are always eager to move and to feel that they are mov-