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ARCHETYPES AND SYMBOLISM[1]

It has been a custom in this association to grant an incoming president three great privileges: he is allowed to address you for more than twelve minutes; he is allowed to speak on any topic he chooses, and, thirdly, what he says is allowed to go without immediate contradiction and embarrassing discussion. Most of your preceding presidents have utilized this attractive opportunity for departing from the troublesome humdrum problems of the day and gaily sailing forth on a sea of generalities where there are no limiting shores or submerged rocks in the way of facts to annoy one. This precedent allures me and I propose to indulge just this once. The particular speculative cruise on which I would have you join me is indicated in the title, and it involves a discussion of a characteristic prevalent among writers and teachers—including teachers of anatomy. As I see it, teachers have a shameless yearning for the diagrammatic; the tendency to state things in a simple way, even when the things themselves are not simple; the tendency to supply sharp contours or classifications where the real margins are indistinct or the parts intimately blended. Apparently the impression is prevalent that there are simple laws and ground plans underlying all that we see about us, and for many years the investigator has been in hot pursuit after them. Our great heroes are those who succeed in cleverly expressing the complex phenomena of nature in the form of precisely stated laws, or archetypal patterns and we grade our heroes according to the length of time their laws or patterns endure. Let us consider the nature of this situation and see what is to be done about it.

If we stop and picture to ourselves some of the circumstances of the beginnings of our guild, the original utility of diagram and symbolism is plainly evident. It is difficult to see how civilization could have developed without them. As you all know, the origins of the medical and biological sciences are to be found in the ancient priestcrafts. Among the earliest civilizations, it was the priests who were the possessors of the truth. They fostered what there was of learning. Much of their information came to them through direct revelation—by virtue of their peculiar and magical understanding of the desires

[1] Presidential address, read before the American Association of Anatomists, at the Nashville meeting, April 14, 1927.

and purposes of the Governor of the Universe. But they also acquired and handed down a considerable amount of information obtained through observation and experiment. They were the first professional teachers. In addition to ministering at the sanctuary they taught the laws of hygienic, social and ethical conduct and explained the nature of the universe as they understood it. The training of new recruits in the craft and more especially the expounding of doctrinal matters to a laity incapable of comprehending the higher ranges of ecclesiastical wisdom involved the pedagogical device of simplification. We thus find in that remarkable heritage of ours, the chronicles of the primitive Jewish tribes, evidence of the great extent to which they relied on analogy, parable and diagrammatic representation. Likewise we find the Egyptian, Oriental and early Christian civilizations rich in symbolism, of which we still have many persistent relics. From those days to this the practice has continued. The chosen ones, those to whom all is revealed, talk down to their benighted contemporaries, in simplified edition.

As time has gone on, however, many things have happened. Oral and written languages have been perfected. Mutation and specialization has occurred among the priests. Various groups have budded off to devote themselves to special intellectual and scientific pursuits and thus a medical profession has come about and finally among the latter we recognize our own group, the anatomists. With this there has been a great increase in observed fact in proportion to revelation and a corresponding gradual decrease in the necessity for symbolic thinking and pedagogy. As observed facts increased better ways of discovering facts were devised and greater zeal shown in the search of them. The curve of the rate of their accumulation bent sharply upward and a new technique was required for their adequate recording and teaching; thus classification came into existence. This resulted in a relative recession of symbolism but not in its complete disappearance. The mass of new facts explained many of the old problems, but they also introduced new riddles of their own. There was still opportunity for revelation. There was still occasion for those gifted with lively vision to talk down, though not so far down as in primitive times, to the less gifted ones.

Coming to modern times one finds more facts than ever before. Our systems of record and classification have steadily advanced. We have invented new techniques of fact-analysis and fact-prediction. We are bristling all over with facts and our craving for them is insatiable.

In the meantime the position of revelation in its raw form has become precarious. It has to go around under cover and we deal with it, as with bootleggers, only as a matter of expediency and where facts fail us. Even its more refined cousin, transcendentalism, has become taboo. It is not until we come to its second cousins—concept, theory, idea and schema—that the family is allowed in good company, and they are only allowed pending good behavior. We require that they remember their place.

The situation remains that a complicated world is to be explained. The explanations must be formulated in terms sufficiently simple for our comprehension, just as was true with primitive man. We, however, can deal with more complicated propositions than he could. The child starts with simple numbers, he then masters fractions and decimals, but it is not until he has advanced to applied mathematics that he can successfully deal with variable and approximate quantities. In the present state of our development, amidst facts there remain many yawning chasms of uncertainty—too great for us to reckon with directly. We require the help of a certain amount of definiteness, simplification and a little touch of revelation. So it comes about that slogans appeal to us as they did to our predecessors. The world is still largely ruled by phrases, oracular utterances and sweeping generalizations. The popular professor talks glibly of archetypes and underlying principles and draws marvellous diagrams of nature's mysteries. The audience cries, "Give us clarity or give us death."

One of the devices commonly employed for securing convincing simplicity is the adoption of numerical headings or subdivisions. In that way a proposition is more easily presented and also more easily grasped. It appeals to our sense of authority and exactness. Moses understood that and our most successful lecturers and textbook writers understand it to-day. We have firstlys, secondlys and thirdlys. We divide objects and phenomena into parts, periods and stages, knowing oftentimes there are no interruptions like those inferred. Every schoolboy learns that "All Gaul is divided into three parts." The great master of descriptive writing who was authority for this failed to mention the province which was, in fact, a very lively part of Gaul and he also completely disregarded Cisalpine Gaul. Furthermore, he subsequently informs the reader that a great many different tribes inhabited Gaul. In spite of our realization of its artificiality and misleading nature the concept of a tripartite Gaul stays with most of us throughout life.

Philosophers differ as to the most perfect number. Various numbers have had their advocates. Some numbers find particular favor with certain objects. If the digits of an animal do not occur in fives we feel that something is wrong and we seek to explain it. The number four has never acquired any particular sanctity—it nevertheless has proved very useful. We divide many things in quarters, for instance, the moon. We say there are four points to the compass and that has helped matters considerably, though it doesn't meet the requirements of those who are most dependent on that instrument. Sailors commonly reckon with eight points and surveyors with many more. There is only one magnetic direction and there are as many other directions as there are possible divisions of the circle.

As for the greatest popularity I rather think the threes have it. There is something irresistible about three. "Alle gute Dingen sind drei." It seems to meet all artistic, physical and intellectual requirements. It can be recommended to any one contemplating classification in any field. We say that substances are either animal, vegetable or mineral. Things are good, bad or indifferent. Our education is based on the three R's. Our flag is red, white and blue. Liberty, equality and fraternity won a revolution. Rum, Romanism and rebellion defeated Blaine. There are just exactly three graces and no one has dared spoil the charm by adding a fourth. There are three great desiderata, the Good, the True and the Beautiful. There are three germ layers—and so on. You can easily recall hundreds of such trilogies that have enjoyed successful careers.

All this concerns us, for we have often been influenced in our scientific reasoning, and even still are, by such factors as revelation and transcendentalism, our proneness to clever dicta and our great craving for the simple and diagrammatic and especially for "threes." We forget that these things are merely temporary fallible expedients and confuse their products with verifiable truths. I should like to illustrate this by referring to three typical concepts as instances in which anatomical thought has been influenced and misled in this manner. The first horrible example that I am laying before you was savagely guillotined by our fathers, the second is already in the electric chair of the present and the third remains to be mercifully chloroformed in the future.

One could scarcely select a more classical illustration of the kind of speculation with which this paper is concerned than the *archetype vertebra* of Owen. The concept of the vertebral nature of the head did not originate with him but had been touched on by a number of his predecessors. Chief of these was the German naturalist, Lorenz Oken. The analogy between the skull and vertebral column was utilized by Oken as an illustration of the mystical system of the "all-in-all" and "all-in-every-part." According to him, "The head is a repetition of the whole trunk with all its systems; the brain is the spinal cord; the cranium is the vertebral column; the mouth is intestine and abdomen; the nose is the lungs and thorax; the jaws are the limbs; and the teeth the claws or nails." With regard to the origin of this grand idea, Oken narrates that while walking one autumn day in 1806 in the Harz forest he stumbled upon the blanched skull of a deer, picked up the partially disarticulated bones and on contemplating them the truth flashed across his mind, and he exclaimed, "it is a vertebral column." It is to be observed that Oken had higher aims than to busy himself with detailed homologies—he preferred bigger and more general concepts. He writes:

> A vesicle ossifies and it is a vertebra. A vesicle elongates into a tube, becomes jointed, ossifies, and it is a vertebral column. The tube gives off (according to laws) blind lateral canals; they ossify, and it is a trunk skeleton. This skeleton repeats itself at the two poles, each pole repeats itself in the other, and they are head and pelvis. The skeleton is only a developed, ramified, repeated vertebra; and a vertebra is the pre-formed germ of the skeleton. The entire man is only a vertebra.

This way of looking at things might simplify the task of the teacher of anatomy, but, unfortunately, none of the statements is true. A vertebra is not an ossified vesicle, as Huxley in his time pointed out, and the vertebral column is not derived from a tube, nor are the head and pelvis repetitions of one another. Furthermore, to say that the human body is a vertebra is, of course, ridiculous. It behooves us to remember, however, that intellectual people of the rank of Oken and Goethe at one time discussed this matter seriously, just as intellectual people at an earlier period discussed the question as to how many angels can stand on the tip of a needle—and it may well happen that things we now take seriously, such as genes and recessives, at some future time may in their turn prove ridiculous.

In spite of its extravagant metaphorical speculations Oken's vertebral theory of the skull obtained a considerable credence among the ikonophiles. Its vogue might have been more extensive had it not been for the counteracting influence of Cuvier, who attacked it bitterly with facts and sarcasm and who is credited with having driven it out of scientific circles. But hardly had it been thus disposed of when back it came dressed in new raiment by no other than the British Cuvier, Richard Owen, a comparative anatomist and paleontologist of the first rank. In Owen's "Archetype and Homologies of the Vertebrate Skeleton" we find the idea elaborated in its perfected and completed form.

Owen conceived an ideal typical vertebra, or archetype, having elements and parts from which all bony structures could be derived—similar to the electric signs which have bulbs so arranged that illumination of the various combinations can produce any desired letter. He defined a vertebra as one of those segments of the endo-skeleton which constitute the axis of the body, and the protecting canals of the nervous and vascular trunks. The vertebrate frame, in turn, consists of a series of fundamentally identical segments, each being modified to a greater or less degree according to its position and function. The bones of the head compose a series of four vertebrae, essentially similar to those of which the rest of the skeleton is constituted. They are, namely, the occipital, parietal, frontal and nasal, and they each have a neural and a haemal arch, and may or may not have diverging appendages. The arms are appendages of the haemal arch of the occipital vertebra and thus are parts of the head. In a similar way the pterygoid and zygoma are appendages of the most oral of the cranial vertebrae.

In the repetition of similar segments in a vertebral column and in the repetition of similar elements in a vertebral segment Owen saw an analogy to the growth of crystals. He points out that the principle of vegetative repetition prevails more and more as we descend in the scale of animal life, and at the same time the forms of the repeated parts of the skeleton approach more and more to geometrical figures. Furthermore, the calcifying salt in low-organized skeletons assumes the same crystalline figures which characterize it when deposited outside of the organized body. From this he argues that in the development of the animal body there is the concurrence of a general and all-pervading polarizing force like that which produces crystals along with an adaptive or special organizing force.

To Owen the archetype vertebra was a very real thing—an all-pervading polarizing force; to us it is mostly a product of his imagination. Even in Owen's time embryology was already revealing that segmentation of the body is not its primary condition, and it was soon found that when segmentation occurs it does not extend throughout the whole head, and, furthermore, that bones are not all similar in their mode of origin, nor, in this respect, are they the same in the skull as in the spinal column. After Owen's archetypal concept had been given decent burial its executioners, with due piety, granted that there was a grain of truth in it—that it did serve to call attention to the continuity in structural design beween the occipital and upper cervical regions.

The second concept that I would bring to your attention took form and became universally accepted during the golden age of anatomy in Germany. It is chiefly associated with the names of Rathke and v. Baer. Both of these investigators became very much excited when they found the presence of gills (as they first called them) in mammalian embryos—even human. On studying the blood vessels coursing through them, they found a series of aortic arches on each side, similar to what had already been observed in the chick. All this seemed to signify the existence of a transitory branchial apparatus throughout the mammals, and, pyramiding theory upon theory, it later came to be one of the favorite arguments for the recapitulation theory.

In his 1827 paper on the origin and fate of the aortic arches v. Baer gives a surprisingly accurate and discerning account of their development, not being handicapped by the rigid symbolic concept that was to take form and dominate his followers. He notes the gradual appearance of the vascular arches from the front toward the back and correctly states that at no time are they simultaneously active. In another place he points out that migration of the heart results in changes in the direction of the blood stream, and these in turn lead to changes in form of the arches. Some of the arches are obliterated early, some last longer and some remain as permanent vessels. Though realizing the difficulty of expressing the various phases of this phenomenon in a single sketch, he nevertheless attempted it, just as any good teacher would do, and that sketch, appearing in Burdach's curious six-volume work on physiology, is the underlying diagram for all the schemata of the aortic arches which have since appeared in numberless modifications. The first one to be dissatisfied with it was v. Baer himself. So he modified it a little and reprinted it in his comparative embryology. The next improver was his amiable competitor, Rathke, who showed, in a beautifully executed series of drawings, the real ground plan of the aortic arches—the familiar symmetrical gridiron schema, all smooth and uniform and completely stripped of environmental structures. Along beside the type-gridiron are other gridirons representing the plan for reptiles, birds and mammals with various parts colored in red indicating the portions that are permanently retained.

The influence of Rathke's diagram can be seen in most of the diagrams of the long list of improvers that have followed him. Every writer dealing with the subject seems to have had a personal opinion as to how the red should be allocated in the framework, and there has been much uncertainty as to whether six or five is the perfect number of arches. In them all, however, there is the concept of a ground plan for all air-breathing vertebrates, a common fish-like aortic arch pattern, supposed to exist more or less perfectly in the embryo, but surviving only in a fragmentary manner in the adult. The inference is that blood vessels have a definite individuality in pattern, over and above environmental circumstances, that, of their own initiative, the various vessels strive to attain a particular form. One could imagine, for instance, that if the tiny bit of embryonic endothelium, constituting the primordium of the brachial artery, were transplanted to some perfect culture medium it would result in a main trunk growing out and branches and communications would be given off, one after another, until the usual pattern for the arm and hand became elaborated, and there in plain view would be our old friend, the dorsal interosseous, and all the rest of them. I can imagine the experiment but I do not imagine it would come out that way—and you probably do not, either.

We have learned that of all the structures of the body the vascular system is one of the most adaptive. No organ in its development and maintenance is altogether independent of its environment, but some are more so than others. Some are individualistic and domineering, others are subservient and plastic. Endothelium belongs in the latter group. It is highly responsive to its environment. Thus, when one studies the development of the blood vessels of the brain it is found that they do not independently unfold into the adult pattern but react continuously in a most sensitive way to the factors of their environment. Arteries change to veins, veins to arteries, capillaries to large vessels and large vessels to capillaries with a constant surrender of old channels for new ones. The apparatus is continuously adequate and complete for the growing brain as it exists at any particular stage; as the environmental structures progressively change, the vascular apparatus also changes and thereby is always adapted to the new conditions. The final pattern is the result of the sum of the environmental influences experienced. In short, embryonic blood vessels have no ground plan of their own, independent of the structures around them.

As for the aortic arches, we have learned in recent years that they are and behave much like other blood vessels. To say that they are a transitory set of symmetrical and uniform tubes, a symbol of a phase in ancestral history is no longer an adequate description of them. It has been shown by F. T. Lewis, Bremer and Evans that they are not simple tubes but possess many interesting irregularities in conformance to the structures around them, and that they develop from capillary nets, and revert to capillary nets, and are continuously associated with capillary nets, just like other embryonic vessels and quite apart from any specific gill characteristic.

With this better knowledge of the exact anatomy of the aortic arches it has become apparent that at no time does Rathke's embryonic type really exist in the embryo—any more than does the Owen archetype vertebra. Apparently von Baer appreciated this, but his followers did not. They accepted irregular capillary vessels as vestiges of the arches, therefore virtually arches, and so constructed in their imagination and embryonic type, which at the best was only a composite of several stages.

Nor are the arches or parts of them eradicated bodily, as with a pair of tinner's snips, as indicated in the diagrams. The studies of Heuser in the pig and of Congdon in man have shown us that in the transformation of the vessels of this region probably no endothelium is lost. It all appears to be negotiated through the remarkable capacity of the endothelial apparatus for reshaping itself. By means of their improved technique these investigators were able to trace the development step by step from the formation of the first arch to stages where the mature pattern could be recognized. They demonstrated that, just as in other parts of the body, there is a sensitive vascular response to environmental needs and conditions, in this case the shifting heart, the changing pharyngeal pouches and branchial bar tissues and the acquisition of arm buds. As these change, the endothelial pattern changes and thereby provides at all times an adequate service.

The entire vascular equipment of the aortic arch region can be explained in terms of this service, and there is nothing left over to be accounted for. There is no endothelium left over with which to make vestigial gill vessels, and one can not base a ground plan on things that do not exist. If we start with a diagram of something that does not exist, an infinite number of improvements can not make it correct. That appears to be the situation in which Rathke's diagram now finds itself.

This brings us to the third illustration of a man-made concept to which I would now direct your attention, the theory of the three brain vesicles.

The battle of Waterloo was not the only thing that happened in 1815. In that year Jacob Henle, Charles Darwin and our own Oliver Wendell Holmes became six years old and presumably started off to their respective schools with their mothers' blessings and unexpressed apprehensions. In the autumn of that year a young Dr. Baer from Dorpat matriculated under Professor Döllinger in Würzburg and there received the divine spark that was to make him one of our greatest embryologists. This is the same Dr. Baer to whom I have already had occasion to refer. It was during this same year that Johann Friedrich Meckel, the younger, inaugurated Meckel's Archiv. This latter event immediately concerns us. The first paper of Meckel's Archiv is by Meckel himself and contains an account of the development of the central nervous system of mammals. He describes, and pictures, the brain of a 6 mm rabbit embryo as consisting of a series of vesicles. Concerning the significance of these vesicles he cautiously states that the most caudal one probably becomes the medulla oblongata; the next, the brain peduncles; the third the corpora quadrigemina; and the irregularly shaped anterior end of the neural tube he ascribes to the brain ganglion and hemispheres.

Malpighi long before had portrayed in his beautiful plates vesicles in the neural tube of the chick, and various observers had referred to the widened portions of the neural tube as brain cells or brain vesicles. But before Meckel no one had studied them particularly nor had traced them to adult structures in mammals as well as birds. The vesicular origin of the brain is formulated by Meckel in a crude but in a sufficiently definite way to be recognized as the forerunner of the concept.

If it is conceded that Meckel was the precursor in the establishment of the three brain-vesicle idea, then we must honor von Baer as the one who some ten years later shaped it into its present form. In his masterly presentation of the development of the chick one finds a detailed description of the widenings and constrictions of the forward end of the neural tube and the consequent formation of three primary brain vesicles; the anterior becoming the cerebrum; the posterior, the cerebellum with medulla oblongata; and the middle vesicle, the quadrigeminal mass with the corresponding part of the brain stem. He further describes that this trinity is a transitory state due to the fact that some of the boundaries are a little slower in making their appearance. Very soon the anterior and posterior vesicles become subdivided each into two parts, making five vesicles in all. These he names: forebrain, twixtbrain, midbrain, hindbrain and afterbrain. It is from these five morphological elements that the brain is finally built—just as we have all been taught and just as we are commonly teaching to-day.

The finishing touch to the conception of three brain vesicles was added later by von Baer's ardent admirer, Theodor L. W. von Bischoff, who illustrated them in his drawings of rabbit embryos. Here we find the source of the precise and diagrammatic interpretation that has predominated in most of the subsequent descriptions of the developing central nervous system.

Since these great pioneers conceived the idea of the vesicular origin of the brain much has happened in the way of method, material and experience, and it is well to stop and inquire: Are the facts bearing out the original conception? Is it all so beautifully simple? Does our brain really develop from three vesicles? Does it pass through a preliminary geometrical state, a fundamental pattern common to all vertebrates, and from which the various parts of the brain are separately derived, in forms characteristic for the species concerned?

We can better understand how the brain-vesicle idea has become so thoroughly intrenched if we recall to what a large extent embryological studies have been based on chick embryos. Now it happens that the chick has one good feature, namely, the availability of the material. The eggs are easily procured, all the year round, and the living embryos can be freely observed at any desired stage of development. It has another feature that is not so good. From the viewpoint of those primarily concerned with mammals, the chick is a very special and peculiar animal and its developmental processes can be interpreted in mammalian terms only with careful reservations. It has been the misfortune of embryology that the embryo most easily obtained, and the one that has been most studied, is, because of its remoteness from the mammalian stem, about the poorest one that could have been selected. Our minds have been saturated with impressions obtained from chick material and many of our embryological troubles are to be attributed to interpretations based on this eccentric form.

It is so with the brain vesicles. It happens that the bird has huge paired optic lobes as a visual center and terminal nucleus for its large optic nerves. They overlie the entire midbrain region as a prominent rounded eminence, entirely concealing the acoustic centers and the other tegmental structures. There is presented an entirely different picture from what is seen in mammals, where the optic colliculi are scarcely larger than the acoustic colliculi. Knowing this, one is prepared for the prominent widening of the neural tube in the midbrain region of the chick embryo. What one actually sees is the large vesicular primordium of the optic lobes, the other tegmental structures being lost in the adjoining parts of the neural tube. The so-called midbrain vesicle of the chick should not be considered as an indifferent segment of the neural tube, resembling, but diagrammatically set off from, the brain segments in front and back of it. Instead, what one sees are the definitive optic lobes, characteristic from the outset and evidently predetermined in structure long before the closure of the neural tube. These optic lobes are not identical with what is ordinarily included under the term "midbrain," although in the chick they form a large part of it. If we are to be accurate, it is therefore incorrect to speak of them as the midbrain vesicle. This point was not appreciated by the early embryologists.

So long as the chick appeared to have such a handsome midbrain vesicle, their scientific conscience did not prevent embryologists from accepting the irregular portion of the neural tube in front as the forebrain vesicle, even though it scarcely conformed to the term "vesicle." Nor could the hindbrain vesicle have obtained recognition except through the prestige of its midbrain neighbor. Moreover, the general concept appealed to them. The simplicity and diagrammatic possibility of three rather equivalent symmetrical brain vesicles—a temporary fundamental archetypal state shared by all vertebrates, like a well-rhymed proverb, argued strongly for its truth. It seemed to be a golden key that could unlock the secrets of that bewildering structure—the brain. Is it any wonder that the idea made such a deep impression on those who based their embryology on the chick and who studied at a time when the detailed anatomy of the central nervous system was none too well known?

Coming to mammalian embryos where there are no large optic lobes to masquerade as a midbrain vesicle, it became necessary for the embryologists to find a new one and this was not an easy thing to do, because there does not appear to be any. Characteristic of such dilemmas there came to be several opinions as to just where the midbrain vesicle was located. The number of opinions was about the same as the number of investigators. Bischoff solved the difficulty by putting a bird-like nervous system in a rabbit embryo. He was so deeply imbued with the concept that he could see nothing else. It should be said, however, that the investigators of the preceding generation had very little early mammalian material at their disposal. Their acquaintance with the brain did not become intimate until after the closure of the anterior neuropore, by which time the supposed three brain-vesicle period is over and the permanent nuclear masses are already defined. They realized that what they saw were not the vesicles but traces left by the vesicles, that is, they so interpreted them. It was a relatively easy matter to select certain constrictions of the brain lumen, subdividing it into the desired three parts. The more convincing of these was the constriction that eventually becomes the Sylvian aqueduct. The one separating the anterior and middle vesicle was not so good, but it answered the purpose of seeming to substantiate the idea. The real jolt came when we began to get embryos of still earlier stages and these constrictions disappeared without our being able to trace them back as boundaries of the original vesicles, proving that they are not primary but secondary growth phenomena belonging to the older stages. Before going any further I hasten to say that I can see no harm in dividing the brain into a forebrain, midbrain and hindbrain, even if the brain vesicles do not exist—at least until we find some better way of disjointing it.

It is only in very recent times that we have obtained and learned the technique of handling embryos sufficiently young to reveal these early steps in development. With this advance the name of Bartelmez is to be associated. In identifying the precocious début of the primordium of the equilibration apparatus he has given us a landmark of the greatest possible value. He has shown us that this primitive special sense organ is laid down, and the corresponding portion of the brain wall definitely determined before the lips of the neural groove have come together, before there could be any possibility of a brain vesicle.

In other words the brain begins to build its definitive parts before the closure of the neural tube—without going through a preliminary archetypal indifferent three-vesicle stage. With further experience and additional material this has been abundantly substantiated in the pig as well as in man. There seems to be no evidence that the brain wastes any empty gestures toward the past. With no false moves it proceeds directly with the building of an organ appropriate in all its parts for the respective species. It has taken us a long time to find this out. It probably would not have taken so long if we had not been so well satisfied with the diagrammatic concept of three brain vesicles.

Is it to be understood from what has thus far been said that the author of these lines believes that simplification and diagram have done us more harm than good and should be cast ruthlessly overboard? Bless me, no! Quite the contrary! One could write just as well outlining the great services they have performed. We all know very well that advance in knowledge has come about, first of all, through separating the known facts from the surrounding haze of ignorance. These known facts then have been made more significant through classification and coordination, and finally it is through the device of schemata, types and hypotheses that we have been guided in the acquisition of still more facts. The point I am making is not a new one, but it bears frequent repetition. Facts are desirable possessions, so are theories, but the two should not be confused. Facts should be kept in one pocket and theories in another. One should never forget that diagram, classification, symbolism, and hypothesis are but temporary expedients. They are good servants but poor masters. Like all man-made things they are imperfect, and as new facts come into view they must be revised or discarded. Moreover, those of us who are prudent will be particularly wary of the quick and simple explanation of the processes of living matter. In his classical monograph on comparative embryology von Baer places on the back of his title page the Latin slogan: "simplex est sigillum veritatis!"—simplicity is the seal of truth. That may have been a good working hypothesis at the time; but in view of our new knowledge of the remarkable intricacy of nature should we not change it to read:

Complex est sigillum veritatis!

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HOW THE TAXONOMISTS MAY UTILIZE THE INTERNATIONAL COMMITTEE ON NOMENCLATURE[1]

STABILITY in botanical nomenclature has been sought sporadically ever since there have been recognized systems for naming plants. At Paris in 1867 an international congress of botanists formulated a code called the "Laws of Botanical Nomenclature." About forty years later another international congress drew up another code, the "International Rules of Botanical Nomenclature," based in part on the Paris code, but introducing many alterations. A third congress held at Brussels in 1910 amended and enlarged these rules somewhat but did not materially modify them. It was proposed to hold these international congresses at five-year intervals, the succeeding one to be at London in 1915, but the World War interfered and the London congress did not meet. A fourth congress was interpolated at Ithaca in 1926, but no regulatory legislation was adopted; and the fifth congress was authorized to be held at London in 1930 at which the international rules will be again considered.

The Ithaca congress made an important contribution to the history of botanical nomenclature by appointing an international interim committee on nomenclature[2] to consider proposals for amending the international rules. Botanists now have a method by which amendments may be brought before a large committee for adequate study in advance of the congress. It is important that legislation adopted at a congress should be based on facts and should represent a real consensus of the botanical opinion of the world. If taxonomists take sufficient interest in nomenclature to present their ideas to this committee and to support their opinions with carefully prepared arguments and with sufficient evidence, the congress can legislate upon the basis of a fairly accurate knowledge of the actual taxonomic opinion.

During the last decade of the last century, and several years before the Vienna Congress, a group of American botanists formulated a carefully thought-out series of rules of botanical nomenclature, which has been known as the American code. It was felt by these botanists that the nomenclature then in use, based in part on the old Paris code, was in many respects illogical, and gave little promise of ultimate stability. In the American code all compromises, exceptions and concessions were thrust aside and a series of rules was built upon a foundation of principles, the chief of which were the type concept for the application of names and the strict acceptance of the principles of priority (dating from 1753) in establishing the validity of names.

It was thought that the advantages of such a code would be so evident that it would be accepted by the botanical world as soon as the rules were understood. The application of the American code to nomenclature of the day would result in the replacement of many well-known generic names, but it was thought that, the initial changes having been made, the names would not be subject to further change. I accepted the American code with enthusiasm and I have followed its provisions for thirty years. My experience during these years leads me to state that the American code is a good code, easy to apply and definite in its application. If we had built our nomenclature on such a code from the beginning it would now be as stable as any nomenclature could be. If all the world would adopt the American code we would reach ultimate stability in the same degree. In 1918 and the following years a committee of the Botanical Society of America prepared the "Type-basis Code of Botanical Nomenclature.[3] This is a modification of the American code in which the rules for typification are amplified and made more flexible, and certain provisions eliminated which experience had shown to be inexpedient.

At present the botanical world is divided in its support of the two codes, the international rules and the American code. With few exceptions the botanists outside of the United States support the international rules. In the United States approximately half the taxonomists are following the American code. The supporters of the international rules do not all follow the detailed provisions of these rules, but

[1] Read at the Philadelphia meeting of the Botanical Society of America.

[2] See SCIENCE 64: 290–291, 1926.

[3] SCIENCE 49: 333–336, 1919; 53: 312–314, 1921; the complete code is found in Hitchcock, "Methods of Descriptive Systematic Botany," 201–206, 1925.