SCIENCE

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*SPECIALIZATION IN EDUCATION.**

THE past few years have witnessed profound changes in the industrial conditions of our people, changes which, to many, are of deep portent. The concentration of wealth, the centralization of power, the development of monopolies, all have seemed to menace the equilibrium of our nation, and dire have been the prophecies of evil. But, with all these changes, with oil trusts and steel trusts and other trusts innumerable, have also come national supremacy in commerce, the creation of vast wealth, and an advancement in well-being. The industrial world, like the rest of the great world of nature, is never at rest. Every new invention of labor-saving machinery, every new discovery of importance, brings unhappiness and misery to some, but increased happiness and pleasure to many others. So too, who shall doubt but that the present monopolistic movements, the trusts and the mergers, when we shall have learned to guard that which is good and prevent that which is bad, will result in greater benefits to mankind and a higher civilization? To check the greed of trusts there are labor unions, to check the lawlessness of labor unions there will be consumers' unions, and over all there will be social laws to harmonize dissonance. Man,

* Read before the Society of Sigma Xi, Ohio State University, June 22, 1903.

more than any other animal, is social and gregarious, and the evolution of laws for the best interests of the race is as certain as the evolution of the organic world.

The concentration of forces in the industrial world, by whatsoever name we call them, is an expression of a definite social law. Many of my hearers will remember when every village had its own shoemaker, its butcher and baker and candlestick maker, all laboriously and with wasted energy doing those things which are now being done by scores of producers. The trusts or combinations may and will do things cheaper and better, because they concentrate in labor and material and time, all of which are possible because of increased specialization.

But it is a grave problem to all of us how far such specialization and concentration shall be permitted to go, that they may not outrun control, that they may not result in the subjugation of the weaker and their undue dependency upon the greed of the leaders of the industrial forces. When wealth and power have become perpetual, and poverty insurmountable, then would trusts and monopolies be intolerable and dissolution imminent.

Of such results, however, there is less probability than ever before in the world's history. The fountain of civilization is constantly bubbling up afresh to replace that which is foul and effete. Never before has there been less danger of stratification in our social organism. In the past history of life upon our earth it has been a law that the highest organisms of one epoch have developed, not from the dominant organisms of a preceding epoch, but from the middle classes, if I may apply such a term to them. From the farm and the work shop will come the leaders of the next generation, even as those of the present generation are, for the most part, of similar origin.

With every succeeding generation of men, as of other animals, the summit of evolution is gradually becoming higher. The way toward success is longer, but our strides are greater. Specialization is an inviolable law of nature, to which man is no exception, physically or psychically. How shall we recognize this in education? How shall we determine that which is real and avoid that which is unreal?

It must be apparent to all that our modern industrial activities are having a profound influence upon our systems of education. Or is it largely because of our improved methods in education that America is attaining its great commercial importance at the present time? A new generation has grown up since technical schools of agriculture have been established throughout our land, and technical and professional schools of all kinds have improved in a most extraordinary way during the past twenty years. The engineer is no longer a country surveyor; the physician is no longer one who turns from the plow or anvil to pills and powders with a few months' interim of perfunctory lectures; the lawyer is no longer graduated from the village law office. President Draper has recently deplored the passing of the family doctor and the coming in his stead of the specialist. He regrets that the man, the counselor and friend is merging into the cold, unsympathetic scientist. But who is there of us, when danger is imminent, that would not rather choose that same unsympathetic scientist, skilled and skilful in all that goes toward success? Who would choose the village-educated lawyer to fight a powerful trust? Special knowledge and special skill the world must have and the world will have wherever possible, and special skill is possible for every one, even though it be in nothing more than the sharpening of a jack-knife. Is there any one who doubts this? Is there

any one who prefers inferiority in a multitude of things rather than eminence in a few things or in one thing? It is not, then, a question of the desirability of special skill, but rather of how that special skill may be best attained.

I have no patience with those who think, because a student prefers to spend months or years of study in the bacteriological laboratory when he might have been devoting his attention to Greek mythology, that he is actuated by a commercial spirit, that, because he is doing something well which he will afterwards find useful, he is mercenary. Thirty years ago, however, the average college professor would have been shocked by the bare suggestion that his pupils desired to make any practical use of the knowledge he imparted, or that the single inelastic college course of those days was not the best preparation for any vocation in life.

There is still a prevalent belief, even though much modified from that of former days, that the general training of the intellectual powers should continue through at least three, if not four, years of college life —that specialization should not begin early, if one wishes to accomplish the most in life. That late specialization is not the best in all professions the world has long conceded. What eminent musician has there been who did not begin his musical training while yet a child? What great artist has there been who first decided upon his life's work after graduation from a college course? How many novelists of wide reputation are there who have been college graduates even? How few, indeed, are the great leaders in commerce, science or the arts who did not begin their distinctive pursuits early in life. Ask an Agassiz, a Darwin or a Huxley, or any one of our able naturalists, when he first began the study of nature, and he will reply that he was always a naturalist. Is it probable that such men would have been greater men had they devoted four years of their life to the humanities alone? Is the great musician less successful because his training may have been at the expense of Greek, mathematics or chemistry? It is true, indeed, that such men are often one-sided, cranky, as the world calls them, and that undue specialization has robbed them of much of the sweeter part of life, has put them out of joint with the world, has often left them, as Agassiz has said, with no time to make money, but I believe that it is better to have cranky specialists than not to have them at all. Away with the idea that such men are always born great; if early specialization is good for men with great powers, it is better for those with small powers. Precocity may be a sign of greatness, but I believe more often greatness is the result of precocity, the result of early concentration before the plasticity of youth is irrevocably gone. We cheerfully admit that the violinist *must* begin his special training while yet his muscles are plastic. Is the mind less plastic than the muscles, and is there not as great need that it should be molded early? You can not teach old dogs new tricks, nor is it often possible to teach a man new tricks after he has become matured.

Very recently a Chicago author has published a book in which he endeavors to prove, from the testimony of many prominent men of business, that a general college course is detrimental to success in a business career, and it is well known that such successful men as is Carnegie have given assent to such views. Like all such generalizations there may be both truth and falsity in this one. For many men, and by no means the poorer men, I firmly believe that a general college course is detrimental as preparation for a business career, while to all a special education and a fixed motive in their education are of

benefit. We clearly recognize to-day that the object of higher education is less the acquisition of knowledge than the acquisition of power to use knowledge, and any education which neglects those powers most necessary in a given vocation is sure to be of harm, either negatively or positively.

As a rule, I believe that the college education materially helps towards the largest success in life only when that education is to a greater or less degree a special education. Some will benefit by a wide cultural training, others will not. A broad man may benefit by a broad training; the narrow man must be content with a narrower preparation to fit him for a narrower path in life. A four years' course in Greek or paleontology will not enable the apprentice to wipe a joint nearly as well as would a four weeks' laboratory course under a master plumber. But a too broad training is, I believe, better than a too narrow one. One so trained is more apt to make a better citizen though he makes fewer dollars. A more rational system, and one towards which the educational world seems rapidly tending, is to neglect neither the general nor the special. The one fundamental principle in the teaching of science at the present day is the laboratory, the cultivation of skill in doing things rather than in knowing about things. In all the technical professions this is assumed, even though it may be carried to an undue extent. At least we are all agreed that the one chief object of education is to make the student think, and then do. How much does the general college education do this for many pursuits in life?

Professor Thorndike, in a recent number of the *Century Magazine*, has given an interesting analysis of the careers of the Phi Beta Kappa scholars during the past sixty years. He has shown that during these years the proportion of those who have followed the so-called learned professions of law, the ministry, medicine and teaching has remained nearly uniform at about sixty-five per cent., but that in some of these vocations the proportions have increased at the expense of those in others. The percentage of those scholars following the legal profession has advanced materially, while there has been a marked falling off in the proportion of those who have become clergymen. In the percentage of teachers there has been a striking increase, while that of physicians has increased from five to about seven per cent. Membership in this society in the past has been conferred upon those students who have attained a high stand in the so-called cultural studies especially, professional students being excluded even yet. What is more reasonable to suppose than that such students would of choice seek those pursuits for which their training has more especially fitted them, and in which they have attained scholarly success? The decrease in the number of those seeking the ministerial calling has been dependent upon entirely different causes, though I will venture to say that the percentage of Phi Beta scholars following this profession is larger than among other graduates with similar training. While there are so many more such scholars among our teachers than formerly in the profession of medicone, I doubt not there are proportionally fewer than there were fifty years ago. The increase of but two or three per cent. for this profession is very suggestive, and even this increase is more apparent than real. In recent years the requirements for the Bachelor of Arts degree have everywhere been much liberalized, and the Phi Beta Kappa scholar is apt to be far more varied in his training than he was formerly. In other words Mahomet has not gone far toward the mountains, but the mountains are coming to Mahomet. Professor Thorndike deplores this lack of high-

grade scholars in the medical profession, and hopes for better things in the future. But I have little sympathy with either his hopes or his desires.

In his analysis of the careers which these scholars have followed in the past sixty years, Professor Thorndike makes no mention of the profession of engineering. It is to be inferred that there have been no Phi Beta Kappa scholars who have become engineers, or at least that the number is so small as to be negligible. The fact is startling, as it also is pregnant with meaning. Has the educational concept of scholarship been such that two of the chief learned professions have been almost excluded therefrom? Or would it be more reasonable to suppose that the Phi Beta Kappa, like the Sigma Xi, is really a broad society of specialists? The reason so few Phi Beta Kappas have chosen the engineering profession is not difficult to understand. It has happened that the education of engineers has for years been more nearly in line with modern educational progress than that of any other of the learned professions. It really has been the one profession in America which has served as a model for all others in education, a model toward which all others are rapidly approaching. The profession early recognized the fact, possibly because it was not dignified with the appellation of learned, and did not, therefore, see the need of the so-called learned culture, that the most successful results must come, without neglecting other useful and cultural studies, from an early, consistent and rational specialization. Can any one believe that the profession would stand where it does to-day, richly meriting the title of learned, that it would have accomplished the tremendous results it has, had it followed the methods so long in vogue in the medical and legal professions, the adding of a year or two of purely didactic professional instruction upon any sort of a foundation? Because the engineering profession stood so far in advance of all other professions in its systems of education seventeen years ago, and because Phi Beta Kappa would not admit that any other system than its own could produce scholars, we have to-day the Society of the Sigma Xi, now firmly established in nearly all of our best universities. The medical profession tried too long and tried in vain to polish off the general scholar or the no scholar into the special scholar. But it is recognizing its error, recognizing that the best success means not so much more years of study as an earlier and rational specialization.

It is a fact, pretty well recognized by the science teacher, that the average college graduate, who has had no special scientific training, has no advantage in the laboratory over the average graduate of the high school. The latter has not so much to forget and he has not forgotten so much, his youthful plasticity is less impaired, his observational powers less dulled. Indeed, I have no hesitation in saying, and in saying it I draw from many years' experience, that a four years' college course in the languages, literature and mathematics is of positive injury to the modern student of medicine. He has lost valuable years, even as the musician has lost them who begins his special studies at twenty-two or twenty-three years of age, lost them irrecoverably. Such a student might make the good family doctor, whose loss Dr. Draper deplores, but the chances for the highest success in his profession have been impaired.

In some of the better medical colleges the course of the would-be physician is now marked out with more or less precision through six years from the high school to the hospital, and it needs no prophet to say that what these schools are

doing will soon be the rule in medical education. And not only will the course from the high school to the doctor of medicine degree be a fixed one, with only such variations as may lead to diverse ends in the profession, but I believe that the course will reach back into the high school, even as the engineering course already does to some extent. Furthermore, not only will such methods be accepted as most fitting in these professions, but similar methods will eventually become the rule for all the more important professions and vocations in life. Is there not, then, a grain of reason in the protest of the business man that the college education does not prepare for business life? How, too, can Professor Thorndike expect to see any material increase in the proportion of Phi Beta Kappa scholars in such professions unless the mountains come quite to Mahomet by the admission that the professional scholar may be the equal of the cultural scholar?

I would not for a moment have it inferred that I have aught to say in deprecation of that general cultural education of which Phi Beta Kappa has been for so long the honored exponent, but I do say that such an education is in large part a special education, and not to be desired for all men. Though such men as Professor Peck may still continue to assert that the graduate of the liberal arts course is a 'gentleman and scholar,' while the scientific man is only a 'sublimated tinker,' the world in general is ceasing to look upon the scientist as being only half educated, and the sooner the last vestige of such pedantry has disappeared the better it will be for American higher education.

I do insist that for either the literary or the scientific student the education should widen his sympathies and broaden his outlook. A few cranks may be endured, but a world of cranks would be a dreary place to live in. But one may have broad sympathies without being a jack of all trades, and the intermingling of many men of many minds does more to teach us tolerance than all the book education that can be compressed into the cranium of the pedant. The best remedy for intolerance is the habit of thinking accurately.

I urge only that every lad or every lass should be early guided into the pathway along which his future lies, that he should have a motive for all he does. A motive, indeed, is more important than much knowledge, for it brings zeal, ambition and earnestness, so often, so deplorably often, lacking in the college undergraduate. Indeed, I care less for the kind of a preparation a student has if he clearly knows what he wants—he will remedy his faults in the course of time. As college men I firmly believe that we are too careful as to the kind and amount of preparation a student has when he enters college and too careless of the work he does while in college. Some of the best and most successful students I have ever known have been those whom the college rules would have excluded, while many a one who fulfills all technical requirements is a dismal failure.

It was but six years ago that President Dwight of Yale University said: 'In any future development of the college system, the chief purpose of general culture should not give way or be subordinated to any purpose of special culture, with a view of some special work in future years.' It has been but a few weeks since the educational world has been startled by the announcement that Greek would no longer be required of the Bachelor of Arts graduate of Yale. Nor is this all. Whereas to-day Yale College requires eight or ten years' study of the ancient languages as a prerequisite for the B.A. degree, next year it will require not more than four, and none of them in the college. Such con-

cessions, coming from so conservative an institution as is Yale, are of the deepest significance. They mean that the movement toward special education can not be ignored by any institution. The demand for special education is imperative. Like the trusts, it has come to stay.

It is reported that this change in the Yale requirements was opposed by the language teachers of the faculty, who deplored the debasement of the time-honored degree of Bachelor of Arts. In many of our larger universities, as well as smaller ones, three baccalaureate degrees are given in the school of liberal arts—Bachelor of Arts, Bachelor of Philosophy and Bachelor of Science. If one will examine the lists of graduates of such institutions he will be struck with the proportionally greater frequency with which the Bachelor of Science degree is given in recent years. Usually the graduates receiving this degree outnumber those receiving both of the other degrees. In fact one can only be surprised at the rapid diminution in the number of those striving for the old simon-pure badge of a liberal culture. Indeed, those who seek the indeterminate, betwixt and between, hybrid degree of Bachelor of Philosophy are never very numerous. I dare venture the assertion that any college which persists in the old cultural course of thirty years ago to the exclusion of others, will soon be teaching empty benches for the most part. A few institutions like the University of Michigan, the University of Minnesota and Leland Stanford have abandoned the Bachelor of Philosophy and Bachelor of Science degrees, giving to all alike in the non-professional courses the one degree of Bachelor of Arts.

To those who believe with me that an earlier specialization or an earlier motive in education is to be desired, such continued rending of the bonds of liberal culture offers much of encouragement, though only the outcome of methods long ago introduced by Harvard University, the system of electives or optionals.

No one can doubt now but that this system has been of benefit. It permitted for the first time the student who was not content with an elementary training, to widen to some extent his preparation for special pursuits in life. So grudgingly bestowed at first upon the senior, it has now become the privilege of the freshman. But I can not believe that the optional system has been altogether a blessing. It has done much to encourage the ambitious, but it has also done much to stultify the lazy. We all know how many students there are who seek a degree rather than an education. And many of us also know that the average non-professional college student can not be favorably compared with the professional student of like age for zeal and ambition. There is too often a tendency for a college teacher to be lax in discipline, that he may not diminish the attendance upon his classes. The student's choice is far too often decided by trivial circumstances—the advice of a classmate, the reputation of a teacher, the ease of certain studies, or often indeed by the toss of a penny. It is only the minority who deliberately plan their work, because it is only the minority who know what they desire to do in life, and it is seldom that the student gets advice from those whose duty it should be to advise him. But the optional system is resolving itself as rapidly as circumstances permit into special courses, either recommended or required, and the student who now goes through the senior year without some notion of what he is striving after is becoming less and less frequent.

It was but a short time ago that President Butler of Columbia University shocked the world of higher education by suggesting that the college course should

terminate with the sophomore year, that the junior and senior years should be distinctively years of professional education, as in reality they are becoming in most of the better universities of the United States. He would have it that every student should orient himself, should decide what he expects to do in life by the beginning of his junior year.

On the other hand, it seems also apparent that the freshman and sophomore years are gradually being eliminated from the college and relegated to the so-called schools of secondary education. There are many high schools which would willingly, and could with advantage, take over the work of the first one or two years of the college. The average college instructors of the first and second years do not compare over favorably with those in the upper classes of the high schools, and the cost of instruction is not much greater. By thus distributing the work of these two years in many more institutions a far greater number of young men and women would receive the benefits of higher education. We all know how much the propinquity of the college has to do in influencing the average high school graduate. Every college town sends a much larger proportion of its youth to college than do towns less favorably situated. I doubt not that if the universities of our country, and especially the state universities, should encourage such an extension of the high-school course we soon would have students entering the junior year from nearly every city of fifteen or twenty thousand inhabitants, and that too in larger number than now complete the sophomore year in our colleges. And I have no doubt, were President Butler's suggestion to become a reality, that hundreds of our high schools would soon become colleges, colleges moreover that would do better work than does the average college of the present time.

Moreover, I believe that such a plan is the only one which will preserve the bachelor degree from extinction. When it becomes the rule that the medical diploma is given only after a six years' course of work from the present high school graduation, who is there that will care for the bachelor degree midway? Twenty years hence there will be fewer bachelors of science or arts among medical graduates than there are at the present time, and not more than one in ten of our physicians now possess the degree. When the engineer is required to have the professional degree of C.E. or M.E. there will be very few students who will strive after the bachelor degree. In other words, it seems to me that the tendency of American higher education is toward the German system. When our high schools become Gymnasia and Realschulen our universities will begin where theirs do, at the beginning of the junior year.

At a recent meeting of college educators of prominence at Evanston the subject of the abridgment of the college course was discussed, with but little approbation. The literary student, the student of the so-called cultural courses, almost unanimously opposes any suggestion of the elimination of the college. Fortunately or unfortunately, however, college educators do not control college education, and he is a wise man who keeps closely in pace with the world. If the world demands that special education shall begin with the junior year or earlier, that the college shall end with the sophomore year, aught we may do or say will avail little; the controlling causes are social, not educational.

Within the past few years there has been an extraordinary increase, both relatively and absolutely, as regards men, in the attendance of women in the college and uni-

versity, as well as the high school. The cause, apparently unaffected by national conditions of prosperity or distress, has not been satisfactorily explained. Doubtless a partial explanation is that fewer vocations in life are open to woman and she, therefore, seeks that higher training afforded by the college of arts which will fit her for her more peculiar vocation, that of teaching in the secondary schools. On the other hand, it is equally certain that a larger proportion than ever before of young men are seeking professional and technical education, notwithstanding the greatly increased requirements.

By every teacher of wide experience in higher education certain fundamental differences in the mental characteristics of men and women students are, I think, acknowledged. Whether these differences are inherent or whether they are acquired is by no means certain, and does not concern us here. But that there are such differences, I believe every teacher of the natural sciences at least will admit.

The woman student is usually more faithful in attention to duty, she is less distracted by outside influences, less fitful and wayward in her work. That woman has greater fortitude than man in suffering and misfortune is universally acknowledged; the same trait is displayed in her greater conscientiousness in the performance of the routine duties of life. Her memory is better than, and her power of application as good as, are those faculties in man. As a result she averages better in all those college studies where memory and faithfulness are most conducive to excellence. In language, literature and recitative science work the larger proportion of the better students are women, where the sexes are equally divided in number. In the coeducational colleges, the proportion of women who attain the distinction of membership in Phi Beta Kappa is nearly three fifths of the whole, though those eligible for such distinction are scarcely more than those of the men. Moreover, the age of graduation of women from the college is distinctly less than that of men. Certain causes partly account for the undoubted superiority of women in the general college course, though not wholly. There are decidedly more girls than boys who graduate from the high school, and as fewer girls than boys take up college work, there is a larger selection of the more able and serious women. Family ambitions, and the mistaken idea that it is the proper social thing, send many a worthless young man to college, while most women who go do so because of some serious purpose. Furthermore, as every physiologist knows, women reach maturity earlier than do men. A girl of eighteen has the intellectual maturity of the boy of twenty.

That all women students do not excel, of course goes without saying. Indeed, the frivolous girl, she who goes to college chiefly for the social or sorority advantages she hopes to find there, is usually quite as worthless, from an educational point of view, as the young man whose chief aim is a good time or athletics. I really think that we may truthfully say of the woman student that 'When she is good, she is very good; but when she is bad, she is horrid.'

On the other hand, the woman student in the science laboratory is a comparative failure. She has less inventiveness and originality, less independence and self-reliance; she invariably needs more assistance and guidance. In the concrete, observational sciences, she is less able to draw conclusions. In other words, she is deficient in research ability, save perhaps in abstract mathematics. On the other hand, opportunities for women in scientific research are probably even greater than they are for young men; the bright scientific woman is really more certain of a

remunerative pedagogical position in many branches than is her equally apt brother.

One result of these sexual characteristics is that women more often cling to the older courses in the humanities, the so-called cultural courses. She prefers these studies, not only because there is less opportunity for her in the technical professions, not only because her more usual ambition is to follow that noblest of all vocations, that of the home-maker, but because her tastes and proclivities fit her better for the more esthetic and humanistic studies.

In the coeducational colleges the women now generally exceed the men in number. This slow relative increase of the men, or in some instances actual decrease, has often been attributed to coeducation, the dislike of young men to mingle with young women in the class-room, to be brought into competition with them where they are so often outshone. I doubt this very much. The milksop who resents the rivalry of women, who thinks himself so far superior to them that he is unwilling to be shown his mistake, ought to be tied to an apron string and smothered in his callowness. The real reason is that men are in greater numbers seeking that special training which they do not or can not get in the general college course, while women are seeking that special training which they do get in the humanities. Nor do I think that either are any more swayed by the commercial spirit which so many superficial observers deplore. There are many advantages in coeducation of the sexes, as well as certain disadvantages. The women need that stimulation in self-dependence and originality which the mingling of young men will surely give them, and the men need the greater esthetic cultivation, the broader humanizing outlook, which women fellow students will surely give them. Coeducational colleges will never become women's colleges so long as they offer anything which men want, and those courses of study which women prefer will always offer that which many, though not all, men will want.

Whatever may be the tendencies of modern higher education, whatever may be the outcome of the various movements now making, who is there that can repress the feeling of exultation and of congratulation in the great achievements, the lofty aims of our colleges and universities? Whether we are to become a nation of scholars or a nation of specialists, I know not, but that we shall become a greater nation, a wiser nation, a more prosperous nation because of the high school, the college and the university is certain.

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THE LIMITS OF SCIENCE.

In moving a vote of thanks a couple of months since, Lord Kelvin said that science positively affirmed creative power and that modern biologists were coming once more to a firm acceptance of a vital principle. These remarks have given rise to an interesting series of letters to the London *Times,* which we reproduce:

When a man of known distinction gives public expression to an opinion it is, of course, received with attention. But its validity will depend, not upon his distinction, but upon the authority which he has achieved in the field to which his opinion relates.

In the domain of physics, to the exploration of which Lord Kelvin has devoted an honored lifetime, he would be a bold man who would cross swords with him. But for dogmatic utterance on biological questions there is no reason to suppose that he is better equipped than any person of average intelligence.

In a recent speech Lord Kelvin has