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Biology

THE REVOLUTION OF SOVIET GENETICS

RUFUS P. ROBERTS, S.J.

With the adjourning of the Praesidium of the USSR Academy of Sciences on August 26, 1948, came the close of a long controversy between the followers of Michurinite Genetics and the adherents of Mendelism in the defeat of the latter. Besides being of historical importance to the scientific world, the resolutions passed by the Praesidium mark the end of the universal and autonomous character of scientific research. The autonomy of science prescribes that any theory, which experimental data supports and confirms, from which accurate scientific laws can be deduced shall not be overthrown except when proven inadequate by more advanced scientific methods and discoveries. In the Soviet state, Mendelian Genetics, which, all over the world, had grown to the full stature of a biological science, supported by volumes of experimental data, with laws whose accuracy is inviolable, has been rejected on philosophical and political grounds—not on scientific grounds.

The fight was led by Lysenko, a Soviet agriculturist and peasant, who never has had any advanced scientific training. The answer to his victory is not to be found in the data he has accrued in support of Michurinism but in the fact that he is a political giant in the USSR, one time Vice President of the Supreme Soviet.

Marxism must believe in the improvement of the environment and, therefore, it must, or would like to believe that such improvements have a permanent effect on heredity. The letter of the Praesidium to Stalin clarifies this point: "The Genetics of Michurin is progressive, is the only acceptable form of science, because it is based on Dialectical Materialism and on the revolutionary principle of changing Nature" not, note, for the benefit of humanity, but rather "for the benefit of political economy."

Because of this demand of Dialectical Materialism, Lysenko has revived the long-buried theory of Lamarck regarding the inheritance of acquired characters. This concept was first disproven by Mendel himself, and now hardly anyone supports it.

Lysenko, nevertheless, claims to have induced the inheritance of acquired characters by altering the conditions of life. It has been proven, however, that he never exercised proper scientific precautions and volumes of negative results have been gathered by American and British scientists who repeated Lysenko's "experiments", taking the necessary precautions. Dr. Ashby, an eminent British geneticist, while

on a visit to Russia saw Lysenko's experimental plots and was shocked at their "deplorable variability", because genetic purity is essential for all experiments regarding the inheritance of acquired characters; and genetic impurity may produce results which merely simulate a Lamarckian effect.

The other main point of diversion from Western genetics is the categorical denial by the Michurinists of the existence of the gene as the material basis of heredity. They assert that the somatic cell itself must be considered as the unit of heredity. By this, note, their "Progressive science" is eighty years behind the biology of the Western world. For, as early as 1870, the existence of chromosomes inside the cell was discovered and their influence on heredity was demonstrated. And more recently, the existence of the genes and their spatial arrangement on the chromosomes has been ascertained, and data is accumulating in confirmation of the Gene Theory of Heredity.

Finally, unable to find any support for his denials and assertions in experimental fact, Lysenko falls back on his political principles and power to put them across, stating that: "The inheritance of acquired characters is Materialist; . . . Mendelism is unpatriotic!" And "Heredity is inherent in any particle of the living body, . . . the Morganism of the foreign bourgeois is unpatriotic!"

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PROTOPLASMIC MOVEMENT. III.*

WILLIAM D. SULLIVAN, S.J.

MUSCULAR MOVEMENT

As the organisms step-up the so called evolutionary ladder, there is a corresponding stepping-up in the size and complexity of the locomotor mechanism. Our concepts of man, and much more so of the elephant, sending out pseudopodia or moving about by means of cilia would be strange concepts, not to mention an impossible fact. Pseudopods are efficient as well as sufficient for those organisms which possess them. For man and the elephant there is need of a greater mechanism of locomotion, both because of their size and their environmental medium of a complex physiological life. This complex locomotor apparatus of the higher animals is the muscle, and, as we have already seen, its

*Part I., Protoplasmic streaming and amoeboid movement, THIS BULLETIN, 26, 121-131 (1949); Part II., Ciliary movement, *ibid.*, 27, 4-10 (1949); this Part III. on Muscular Movement with bibliography concludes the contribution at present.

activity is a very highly developed and complex type of protoplasmic movement. Primarily its activity consists in contracting, that is setting up within the musculature system of what is known as *tension* between two points, its point of origin and point of insertion. Secondly in the case of some of the muscles, i.e. the skeletal muscles, its activity results in locomotion. These muscles make use of this tension by setting into motion the articulated joints of the skeletal system, thereby causing movement of some sort. The smooth muscles and the cardiac muscles, on the other hand, make use of the tension, as we shall see later, to exert a force of pressure on the walls of tubes and other visceral canals, of which these muscles are a constituent part.

The contraction of a muscle is the shortening and thickening of the thousands of individual fibers of which the muscle is constituted.

It was for a long time thought that the *myonenes* in the protozoa were the precursors to the complex muscle of the higher animals. And Rosele (1903), on investigating the reactions of these myonenes to electrical stimuli, considered them to be simplified modifications of the more complex muscle. Further investigations, however, by various authors have shown them to be quite distinct from the muscle, having an unknown function. The stentor and the spirostomum have contractile fibers, or myonenes, passing through the cortex of the cell. The contraction of the stalk of the Vorticella is said to be due to the contractile fibers wound about it in spiral fashion. In the Porifera there are highly modified epithelial cells surrounding the osculum, which cells behave very much like muscle cells. However, these cells are known not to be muscle cells. In the Coelenterata, e.g. the hydra, there are numerous neuro-musculoepithelial cells, performing three functions: protective, nutritive and reproductive functions. In the jelly fish, Aurelia, in the syphistoma stage, tiny muscle cells have been observed to arise from the ectoderm and wander into the spaces between the forming tentacles. These cells are said to enable the syphistoma to contract readily. Parker (1916) observed longitudinal striated bands, in the final stages of development, which are the source of pulsation in the bell of the medusa. Striated muscles are observed for the first time, as we know them in the Annelida. These muscles occasionally appear with oblique striations. They pass around the cortex of the fibers, sometimes in opposite directions, giving the appearance of crossed striations. In the Molluscs, striated muscles are developed to a great extent, especially in the cephalopods. In these animals there appear for the first time striated muscles. At times these muscles become very complex, and especially is this true in the Insecta. The wing muscles of these animals have been the material for many valuable investigations. The vertebrates possess all three types of muscles, skeletal, smooth and cardiac muscles.

The skeletal is also called voluntary muscle in man because it is under the control of the will. It is called striated muscle because of

striations appearing in the individual cells. The cells of this muscle are long and cylindrical, having many nuclei. The smooth muscle differs from the striated muscle because of the absence of cross striations and its relative slowness to react. These muscles are usually found surrounding the alimentary canal, the blood vessels, the bronchi and the genito-urinary canals. They are also called involuntary muscles in man. Some of these muscles, like the skeletal muscles, have true motor units stimulating them to contraction; others are automatic, i.e. spontaneous to response. The smooth muscles may run along the length of the canal or tube and on contraction cause the canal to shorten in length and increase in the bore of the tube; or they may encircle the canal causing it to lengthen out and become narrower on contraction. Also both of these types may be found at one and the same time in the same canal. The third type of muscle is the cardiac muscle, which also manifests spontaneous activity. It is the muscle tissue of the heart. Unlike the skeletal muscles and some of the smooth muscles which have a motor unit, the cardiac muscle does not have a true motor unit. However, it does receive a methodic and regular impulse from the vagus nerve and the sympathetic system. This type of muscle is a lacework of branched interconnecting striated fibers.

A typical skeletal muscle is composed of a bundle of fibers called *fasciculi*. Each fasciculus is surrounded by a sheet of connective tissue, the *perimysium*. The *epimysium* surrounds the entire muscle holding the numerous bundles of fasciculi together. The constituents of the fasciculus are the muscle *fibers*, surrounded by an elastic connective tissue, the *sarcolemma*, inside of which it is possible to see tiny *fibrils* separated from each other by the *sarcoplasm*, undifferentiated protoplasm. These fibrils run along the length of the fiber and are about five micra apart. Due to the fact that these fibrils have striations at right angles to the long axis of the fibers themselves, they have the appearance of being composed of alternate light and dark discs. It has been observed that during contraction, it is the dark discs which seem to shorten most.

Investigations into the chemical constituents of the muscles have been rather extensive in the past few decades. All the muscles in the one organism do not possess the same constituents, much less the muscles of different organisms. Also, the skeletal, smooth, and cardiac muscles differ in their composition and the relation between the morphological structure and the physiological behavior of these three different types of muscles is a question still open to much investigation. The inorganic salts found in every muscle are those of K, Na, Ca, and Mg. These salts are present in varying degrees. In a resting muscle the quantity of K exceeds that of Na, and the Mg present is greater in amount than the Ca. However, in a well exercised muscle, i.e. one capable of doing much work, the K content is reduced (Krutchakova, 1938). Seventy-five per cent of the muscle is water.

Of the solids, the proteins make up about four-fifths. There is also present varying concentrations of lipids, fats, carbohydrates, creatine and creatinine, purines, urea and amino acids (Embden, 1925). Four different types of proteins have been classified in the muscle: myosin, myogen, globulin X and stroma protein.

Submicroscopically, through the use of the polarized microscope, it is fairly well established that the muscle is ultimately composed of protein chains arranged in the form of micelles. Both form and intrinsic birefringence have been observed in the muscles. Therefore, the fibrils must have a structure of longitudinally oriented molecules arranged in micellular formation. Such an arrangement will manifest the intrinsic birefringence. This also must mean that the pattern of the molecules is anisotropic. The form birefringence is due to the orientation of the individual micelles lying along the long axis of the fibrils. Though it is almost impossible to measure the intrinsic birefringence, yet, by varying the refractive index of the surrounding medium of the micelles, form birefringence can be measured. This is done by immersing the muscles in solutions of formaldehyde with different refractive indices. The double refractive indices are measured and a curve may be drawn. Unless the muscle were composed of parallel longitudinal micelles, such a result would not be possible. The conclusion drawn from this, therefore, is that the muscle is ultimately composed of the protein chain and the micelles. This formation of the myosin protein chains differs in some way, not yet established, in the two regions of the fibrils, i.e. in the light and dark discs, because the birefringence of the light regions is almost completely absent. It has been known for some time that the stretching of the muscle increased its birefringence. Fischer (1936) claims that this is due to the fact that in the resting muscle there are many micelles which are out of line with the rest of the micelles and in stretching the muscle these micelles are brought into line with the others, thus increasing their birefringence.

The myosin chains are composed of polypeptide linkages, which have the property of lengthening and shortening under certain conditions. A polypeptide chain is composed of numerous amino acids linked together at the junction of the carboxyl group by a nitrogen molecule. The type of chain is determined by the number and type of amino acids which are so joined. These chains may change their length if the linked proteins slide into line so that the links of the chain are in a direct line with each other; or if the links, arranged in a straight line along the axis of the fibrils, become disorientated; or, thirdly, if the angle of the folding polypeptide linkages becomes smaller or larger. Due to the x-ray studies by Astbury (1940), it would seem that the degree of the angular fold of the chains plays the most important part in the changes of the length of the fibers. The bending and folding of the polypeptide chains takes place at the junction of the carboxyl and the amino groups of the chain. The

nature of the individual amino acids and the length of the chain will determine the degree of folding that the chain can possibly undergo.

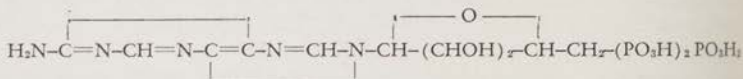
The contraction of the muscle is usually so rapid that very little, if anything, can be seen. The kymograph has demonstrated the relative timing of the different contractions in the three muscles. With every muscle contraction there is a corresponding period preceding the actual contraction in which there is no immediate response to the stimulus. This period has been described as the interval between the actual stimulation and the beginning of contraction. It is called the *latent period*. Though such a period has been doubted by some of the authors, due to the inadequacy of accurate measurements, it is almost certain that such a period exists. In the case of the *single twitch* contraction, the muscle is first stimulated by one stimulus. This is followed by the latent period and then by the actual contraction. The degree of stimulation will determine, to a great extent, the degree of contraction. The contraction period is then followed by a relaxation period in which the muscle, by a reversible reaction of some sort, returns to the status of a resting muscle. Such a complete contraction takes but one-tenth of a second in the frog's gastrocnemius muscle. In the case of repeated stimuli, following rapidly one after the other, the condition of *tetanus* is had, which is nothing more than the prolonged contraction of the muscle followed by a relaxation of the muscle. Such a prolonged contraction is an energy expending factor, while the condition of *tonus*, as well as *contracture*, also prolonged contractions, do not expend energy. Tonus is the natural result of activity of the muscle; contracture is the result of artificial stimulation. Both of these conditions of the muscle are resistances to extension and are probably due to the protoplasmic change within the muscle. This change may be from a relatively fluid protoplasm to a more solid protoplasm. *Rigor mortis* is just such a condition of the muscles, brought on by death. The condition of fatigue will have its effect on the muscle protoplasm, when the stimuli follow one another, not too closely, but unceasingly. The muscle will gradually slow down until there is finally a complete cessation of contraction. We shall see presently the chemical effect of unceasing work and its relation to fatigue. At any rate such a result brings about the tiring of the organism. There are, therefore, two physical factors which bring on fatigue: a continued stimulation of the muscle and the work done by the muscle. The product of the weight and the height to which a muscle lifts this weight determines the amount of work a muscle can do.

So far we have seen, in a summary fashion, the morphological chemistry of the muscle. The physiological chemistry of the muscle is quite different and tells how the energy is released in musculature contraction and how this energy is put to work.

Such a study is extremely complex and is by no means as clear as one would like to have it. There is still much to be done in this field.

However, it is an almost established fact that there are two cycles which take place in every contraction. There is a glycolytic cycle and a phosphate or energy cycle. It is the difficulty one has in understanding the nature of these cycles that makes the explanation of muscle contraction merely theoretical and not factual.

In the muscle there are three very important chemical compounds, glycogen, phosphocreatine and adenosine triphosphate (ATP). Glycogen is the chief source of carbohydrate in the muscle. It is composed of any number of glucose units which are linked together through the loss of water. Its formula is $(C_6H_{10}O_5)_n \cdot H_2O$. We shall see presently its relation to the muscle contraction and to the enzymes present in the muscle. Phosphocreatine is a substance which is easily hydrolyzed, forming creatine and inorganic phosphates found in the muscle. Its formula may be represented by $C=O \text{ OH } CH_2 \text{ NCH}_3 \text{ C:NH NH } PO_3H_2$. Adenosine triphosphate, or as it is sometimes called, adenylypyrophosphoric acid, was first discovered by Lohmann in 1928. This substance is found only in the resting muscle, but in the active muscle it has been found that the phosphates may be transferred to adenosine diphosphate and adenosine monophosphate. The three compounds taken together make up the adenylic acid system which are the source of the high phosphate energy-bond during the muscle contraction. ATP may be represented by the formula:



It was Lipmann (1941) who first described, to the satisfaction of most of the investigators, the phosphate linkages and their potential chemical energy as "phosphate-bond-energy". The source of this chemical energy is the ATP. The source of the energy is obtained from the two powerful terminal phosphate groups. When either one of these two bonds break there results 12,000 calories of energy. Due to the presence of enzymes in the muscles these radicles may be moved or transferred to other groups or compounds within the system. The energy derived from the splitting off the last phosphate group starts the whole cycle in its round of reactions.

Fletcher and Hopkins (1916-1917) brought to the front the importance of the lactic acid production within the muscle and from a series of experiments concluded that the most important chemical reaction within the muscle during contraction was the breakdown of glycogen to lactic acid. They were of the opinion that the breakdown of glycogen was responsible in some way for the contraction. Though this theory did not survive, the later investigations and the present knowledge of the two cycles within the muscle are certainly due to these two men. Due to their work, it was found that though the muscle requires oxygen for continued activity, it can produce a large amount of energy in the absence of oxygen for a time. The

anaerobic and the aerobic phase of the glycolytic cycle was established and may be summarized as follows:

ANAEROBIC PHASE: Glycogen to hexose phosphate to lactic acid.

- AEROBIC PHASE:
- 1) One-fifth lactic acid is oxidized and energy is released.
 - 2) Four-fifths lactic acid plus the energy from one-fifth results in the formation of the hexose phosphate, which, in turn, is converted back to glycogen.

The second cycle, the phosphate cycle, may be summarized as follows:

- 1) ATP is broken down by ATPase to form phosphoric acid and adenylic acid releasing the energy required for contraction.
- 2) Phosphocreatine is broken down to creatine and phosphoric acid, releasing the energy required for the resynthesis of ATP.

The glycolytic cycle does not produce the necessary energy for contraction; rather it produces the energy for the rewinding of the whole system of chemical reactions. It is the phosphate cycle which probably supplies the energy required for contraction, and hence the name *energy cycle*.

The metabolic processes of glycogen are very much like the processes of yeast fermentation. As a matter of fact those processes which convert grapes to wine and malt to beer are similar in many respects to those processes which produce energy required for collegiate and professional football players. The entire glycolytic cycle is the same except for the last two steps and there are approximately fourteen steps in all. The main difference between these two is that the end products of the yeast fermentation are carbon dioxide and ethyl alcohol, and those of the muscle metabolism are carbon dioxide and lactic acid ($\text{CH}_3\text{CHOHCOOH}$). This lactic acid is then taken up by the blood stream and carried to the liver where it undergoes the reversible reactions equivalent in number to the breakdown of glycogen.

There follows an attempt on the part of the author to simplify the different reactions which the chemicals within the muscle undergo during contraction. Though all the authors do not agree on the specific reactions mentioned here, all do admit of the fermentation process in general. Figure 6 is a diagrammatic picture of the anaerobic phase which is explained more fully in the following pages.

Glycogen seems to be the main source of carbohydrate in the muscle and is an ever-ready store of foodstuff for the muscle. The first step in the breakdown is an hydrolysis of glycogen resulting in the production of an hexose sugar. The enzyme responsible for this reaction is phosphorylase (Cori, 1941). This hexose sugar then combines with two molecules of phosphoric acid and the resulting

product is a hexose sugar in diphosphate form. The hexose sugar is here said to be fructose and not glucose.

Though there are many inorganic phosphates in the system which may be the source of the phosphoric acid, it is most probable that the ATP is the actual source of the phosphoric acid. The ATP is acted on by the enzyme ATPase, which splits the compound into adenylic acid and two molecules of phosphoric acid.

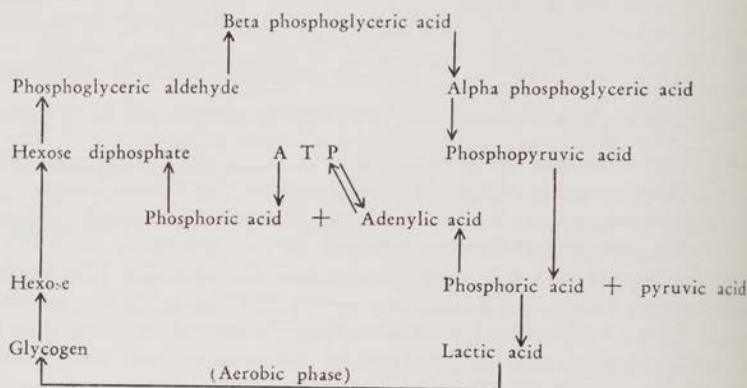
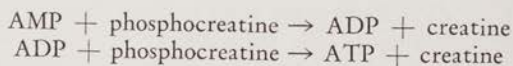


Figure 6. Anaerobic Cycle of Glycogen Fermentation to Lactic Acid.

Due to the presence of the enzyme, hexokinase, the production of fructose diphosphate is made possible from the fructose and the two molecules of phosphoric acid. The fructose diphosphate is next converted, by the enzyme adolase, to two triose monophosphates, dihydroxyacetone and beta-phosphoglyceric aldehyde, which are in equilibrium. In this reaction, one-half of the molecule is oxidized to an aldehyde, the other half, the keto form, is reduced to an alcohol. And though they are said to be in equilibrium in as much as they possess the properties required for equilibrium, it does not ordinarily take place, since the phosphoglyceric aldehyde is used up immediately in the succeeding reactions.

Though some energy has been expended in the formation of the hexose diphosphate, no appreciable amount has been obtained as yet. Hence, due to the two following reactions there is sufficient energy released for the further chemical reactions:



Parnas discovered that the chemical energy contained within the ATP thus formed, is sufficient to give the impetus to the following reactions. It must be kept in mind that the ATP is being continually used and therefore the foregoing reactions with phosphocreatine must also be continuous.

In the next step two molecules of the beta-phosphoglyceric aldehyde undergo an oxidation-reduction reaction in which one molecule is oxidized to beta-phosphoglyceric acid and the other is reduced to the alcohol, phosphoglycerol. Meyerhof claims that this is the first step in the glycolysis of glycogen in which energy is released. According to him one molecule of inorganic phosphate is taken from the medium for each molecule of phosphoglyceric aldehyde which is oxidized; also with each oxidized molecule there is formed one molecule of ATP from ADP. In the cell there is an enzyme triosephosphate dehydrogenase which removes two hydrogens from the six-carbon chain, transforming the low-energy inorganic phosphates into high-energy phosphates. These high-energy phosphates are then received by the ATP. It will not accept the low-energy phosphates.

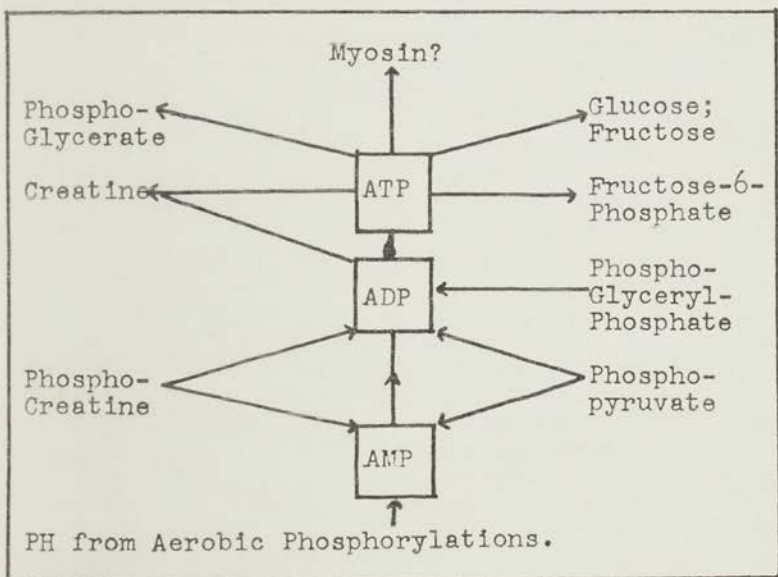


Fig. 7. The relations of the adenylic acid system as donor, acceptor, and distributor of phosphate bond energy. (From Howell's Textbook of Physiology. p. 69).

The next step consists in a shifting from the (levo-) beta- to the (dextro-) alpha- position of the phosphoric acid in the beta-phosphoglyceric acid. According to some of the authors this reaction is forced to completion by the enzyme phosphotriose mutase. By the loss of a molecule of water, the alpha-phosphoglyceric acid is converted to phosphopyruvic acid (enol form). This dehydration reaction is completed in the presence of the magnesium ion and the enzyme endolase. The phosphopyruvic acid then undergoes hydrolysis to yield pyruvic acid. Phosphoric acid is also liberated in this

last reaction from the enol compound. Uniting with the adenylic acid present, ATP is resynthesized and converts the hexose into fructose diphosphate, as previously explained, which, in turn, will begin the entire process all over again.

The pyruvic acid then reacts with the phosphoglyceraldehyde (produced in the reaction above, when fructose diphosphate was acted on by the enzyme adolase) and produces lactic acid and beta-phosphoglyceric acid. The latter compound once again changes to the enol form, hydrolyzes and eventually results in the formation of more lactic acid. The whole series of reactions, resulting in the resynthesis and breakdown of the chemical compounds present in the muscle, is continually in equilibrium.

As we have noted, the supply of energy to the contractile factor in the muscle is said to be through the compound ATP. It is known that ATPase is present in the muscle and that it is very closely associated with myosin, which, as we have also seen, is the fundamental element of contraction. It is very possible, then, that ATP is the main line of communication between the energy released in the glycolytic cycle and respiration and the energy-liberating systems in the muscle. When the muscle is undergoing a prolonged activity it is possible that the energy reserved within the ATP and the phosphocreatine may be called upon at any time.

Such a system of chemical changes is extremely complicated and just why a contraction of the muscle does take place as result of these reactions is something yet to be explained. Some of the investigators have theorized that the lactic acid formed changes in some way the pH of the proteins within the muscles. This change in pH results in a change in the surface energy of the myosin constituents, which, in turn, result in contraction. However, since lactic acid is not produced until after the contraction, such an explanation fails to explain the contraction. Other investigators, following the theory of Galvani, claim that electrical changes within the muscle will stimulate the contraction.

It was not until the turn of the century that the chemical analysis of the muscle constituents threw any light into the theory of the muscle contraction. The first of these theories is called by the general title *Lactic Acid Era*. It began in 1926, with the theory proposed by Hill. He measured the amount of heat produced and demonstrated the energy produced through purely physical experiments. Belonging to this same era is another very important name in muscle physiology, Meyerhof. Though his experiments paralleled those of Hill's, they treated more of the chemical nature of muscular activity. Both of these men merely stated their conclusions, committing themselves to no definite theory. Their prestige, however, was very great and though they did not propose that lactic acid was the causative agent of muscular activity, they did open the field for future investigations. This era did not provide for any definite theory of energy

production. The energy reactions from the production of lactic acid are too small to explain the high efficiency of musculature activity. Also the lactic acid is produced, according to this theory, by osmotic pressure; but the osmotic pressure produced is not sufficient to explain the tremendous work a muscle can do. And finally, the lactic acid is not produced until after the muscle has contracted.

The second era of the study of musculature contraction was the *Phosphate Era*. Due to the conclusions drawn from the Lactic Acid Era, which did not prove satisfactory to most of the investigators, the study shifted to the phosphates present in the muscle. The discovery of phosphocreatine in the muscle and the changes which ATP undergoes at different stages of muscle contraction introduced the biochemists to the field of muscle physiology. They brought with them a maze of enzymes and coenzymes. This era ended without any definite advance in the discovery of musculature activity. As a matter of fact, though they eventually brought to light chemical reactions heretofore unexplainable, they just seemed to cover the whole field with a complexity of reactions.

Meyer (1929) and Astbury (1940) are representative of the third era of muscle study. This era was called the *Myosin Era*. Both of these men were physiologists and they introduced the x-ray studies of the molecular structure of myosin. They studied the molecular structures of the proteins within the muscles and brought the study of muscular activity to the present stage. According to these two men the shortening of the muscle may involve a change in myosin molecules. Meyer first proposed that the molecules fold during the contraction of the muscle. Astbury postulated that the muscles contract due to a super folding of the myosin molecules.

Other theories, by way of enumeration, are the surface tension theory, proposed by Bernstein in 1909. The surfaces, proposed by Bernstein, undergoing the change in surface tension are far too few to have the ensuing results of contraction. The length of the surfaces would necessarily have to be lengthened about eight times their present length.

The colloid chemistry theory of muscle contraction was proposed by Lillie and Roaf. This theory maintains that the contraction of a muscle is due to the movement of water causing a lateral swelling and secondarily the shortening of the sacromeres. This, however, could be true only of the striated muscles, since it is only these muscles which possess sacromeres. Also, these men can account for only about 33% of the total shortening which these striated sacromeres actually do undergo.

Szent-Giorgyi, in 1940, extended the theories of musculature activity to the sub-microscopic dimensions. He did not deny the former theories, but by combining the demonstrated facts of all of them, his theory of the myosin chain is probably true. The muscle is fundamentally composed of myosin chains. In the rest-

ing muscle the chains are folded; in the contracted muscle they are superfolded. Some of the authors say that the folding is due to the production of lactic acid (no longer held). Others say that it is due to the breakdown of phosphocreatine. Szent-Giorgyi, himself, says that it is due to the breakdown of potassium compounds. Heilbrunn claims that potassium may cause the stretched condition of the muscle, but not the contracted condition. He claims that the folding is actually due to the liberation of calcium ions. According to him, it is clear that calcium ions are liberated and set free in the muscle. And like other types of protoplasm, muscle protoplasm is sensitive to these ions. It clots the protoplasm in a way similar to blood clotting. It is due to the release of the calcium ions in the region of the ATPase that ATP breaks down and makes available the energy for muscle contraction. "Clearly calcium can and does initiate shortening (as might be expected from its known behavior in the surface precipitation reaction), and it can also initiate a chemical reaction thought to be of primary importance in muscle metabolism" (Heilbrunn, 1943).

It is true that an amoeba, when stimulated, releases calcium from its cortex. This is then followed by a coagulation of the protoplasm. It is probably true that such a result will also occur in muscle protoplasm. While the two are very much alike in their reactions to electrical, mechanical and chemical stimuli (Engelmann), the amoeba will not cease moving and will contract and shorten only on stimulation. The muscle must needs be stimulated to act at all.

Whatever the cause of muscle contraction may be, the author is inclined to believe that it will not be long before the unknown factor will reveal itself, or be revealed, due to the tenacity of the modern investigators in this difficult study of musculature activity.

The following are a few of the experiments performed by the author on musculature activity.

Before beginning this first set of experiments a different frog was pithed each time and a muscle-nerve preparation was made. After the frog is pithed, it is ready for dissection. A gastrocnemius muscle is removed so that it includes a good portion of the Achille's tendon and 3 to 4 cm. of the sciatic nerve. This is what is known as a muscle-nerve preparation. The first class of stimuli used were mechanical. It was observed that when the sciatic nerve was touched lightly with the pithing needle, there was a twitch in the muscle. When pinched slightly with the forceps there was a simple twitch of the muscle. When the pinch was sharp enough to crush the nerve a greater muscle twitch was noted. When the nerve was again stimulated distal to the point where the pinch of the forceps had taken place, there was no response. When the nerve was pinched between the muscle and the former crushed point in the nerve, there was a response. The injury due to the forceps blocked any

stimulus originating further away from the muscle, but did not interfere with the stimulus originating between the muscle and the injury.

The second class of stimuli were thermal stimuli. The muscle was prepared as in the previous experiment. When the glass needle, at room temperature, touched the nerve, there was no response. When this same needle was heated, a positive response was observed. On touching the nerve distal to the last point of contact with the heated needle, there was still a positive response. Heating the needle to a greater degree and again coming in contact with the nerve, a response was noted. No response was noted when the needle contracted the nerve at a point distal to the last point of contact. The above experiments indicate that heat can be a stimulating agent in the case of an exposed muscle-nerve preparation. It also indicates that the nerve injury blocks, due to some kind of a breakdown in the protoplasm of the nerve fibers, can be of such a nature as not to allow an impulse to pass through the injured area, while the rest of the nerve may conduct normally.

In the next set of experiments the muscle-nerve preparation was allowed to dry. In this state the nerve manifests no *action potential*, as it is called, which is a current generated whenever a nerve is activated by a stimulus. When bathed in a solution of M/8 NaCl, the muscle responded to a mechanical stimuli. The M/8 NaCl is said to act as a chemical conductor.

That this same muscle-nerve preparation will respond to electrical currents or electrical stimuli, is manifested by the tremendous use today of the kymograph and its recording of such responses. Every college student in the physiology laboratory is well acquainted with these experiments. The type experiments performed in the laboratories are known as 1) the make and break currents (galvanic and faradic), 2) the minimal adequate stimulus, 3) the summation of inadequate stimuli, and 4) the submaximal and maximal stimuli.

The effect of curare on the muscle-nerve preparation was also observed. Twenty minutes after injecting the frog with curare, the frog was limp and no longer retracted the right leg when it was mechanically stimulated. Both sciatic nerves were exposed and stimulated electrically. The right leg, with unimpaired circulation, did not respond. The left leg reacted positively to the electrical stimuli. The blood was prevented from flowing freely through the vessels of this leg. The results of this experiment indicate that curare is carried through the circulatory system to the muscles. There it does not affect the muscle itself, but does block any stimuli coming through the nerve. This drug is said to block the nerve-muscle juncture.

The effect of increasing load upon the contracting muscle was observed. The muscle was prepared without the nerve in this experiment. Suspended from the muscle was a 10 gm. tray, to

which could be added other weights. The muscle was attached to the lever 1 inch from the fulcrum and the lever extended 4 inches farther (5 inches from the fulcrum). After each stimulation of the muscle more weights were added and the drum of the kymograph was turned by hand 1 to 2 cm. after each recording. The results of this experiment indicate that the muscle is capable of doing mechanical work and can lift a load against gravity. The amount of work done by the muscle, which is allowed to shorten, depends on the load. If this is so great that the muscles does not shorten at

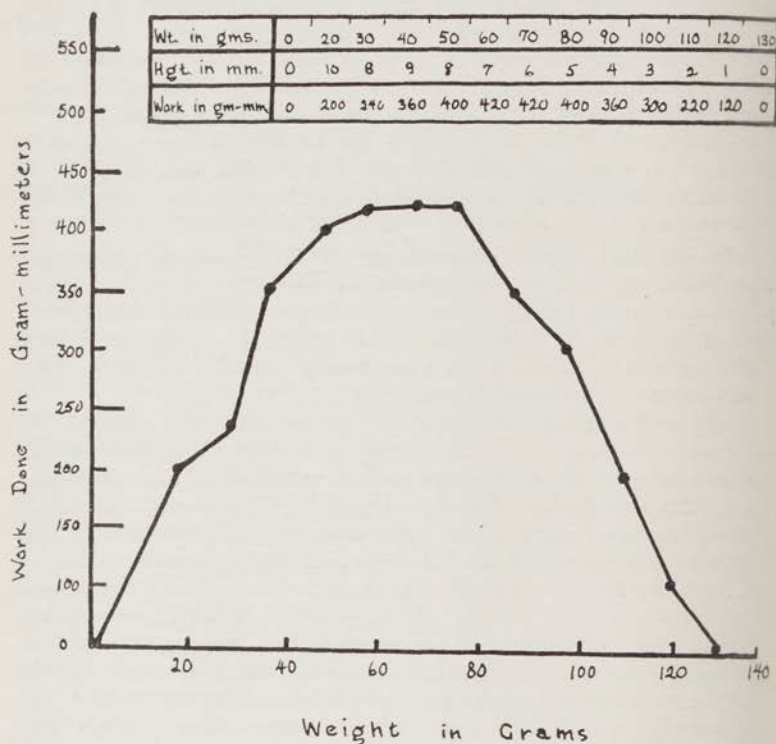


Figure 8.

all, the work done is zero. If, on the other hand, the load is removed, there is no external work done, for the force is also zero. The actual weight in grams lifted by the muscle multiplied by the height in millimeters will determine the work done in gram millimeters (fig. 8).

The absolute muscular force of the gastrocnemius muscle of the frog was observed. The absolute muscular force is measured by the number of grams attached to the muscle which just prevents it from contracting when stimulated by a tetanizing current. The

number of grams attached to the muscle which just prevented it from contracting was observed to be 570 grams. The weight of the muscle was observed to 0.700 gms; the density 1.104 and the length in centimeters was 4.

In parallel-fibered muscles a sectional area can be obtained fairly accurately by dividing the weight of the muscle by its density, giving the volume in cubic centimeters, and then dividing the volume by the length. The absolute force per square centimeter is then easily calculated. $0.7/1.104 = 0.6340$ cc; $0.6340/4 = 0.1585$ cm.²; $570/0.1585 = 3590$ g./cm² absolute force of the frog's muscle.

The absolute force of the muscle is the maximum tension which the muscle can attain without a change in its length. This force can be measured for different animals, and by way of comparison is expressed in terms of the cross area of a muscle in square centimeters. Since the amount of work that a muscle can do depends on the number of constituent fibers whose combined contraction determines the contraction of the muscle, it may be said that the force of a muscle to do work varies directly with the cross area of the muscle. Also since the greater length of the muscle will determine the greater lifting, the force of the muscle will also vary with the length of the muscle. By increasing the length of the fibers, the work done by the muscle will also increase. And there is an actual increase in the energy of contraction when the fibers are extended by a greater tension or an increase in the load.

The next set of experiments were performed on the cardiac muscles of the turtle and their purpose was to study the effect of chemicals on the heart beat. The heart was suspended in a chamber (fig. 9). A small bottle was used as the chamber. The bottom of the bottle was removed and a stopper large enough to seal off the opening was placed at the bottom. Through this stopper a rubber tube extended into the chamber. The tube was equipped with a stopcock to allow the liquids to pass from the bottle when a change of solution was required. On the inside of the stopper a wire hook was attached to hold the muscle rigid. A piece of string was first allowed to pass through the neck of the bottle and extend out through the bottom. The heart was attached to the hook at the end of this string. The opposite side of the heart was attached to the hook in the stopper. The string was then pulled upwards until the heart was inside the bottle and the stopper at the bottom was secure. This apparatus was then fixed to the kymograph and recordings made. When the Ringer's solution, lacking the Na, was poured into the chamber, the beat was observed to be very much like the normal heart beat. The repetition of beats was not as constant, however, as in the normal heart. When the Ringer's solution, minus K, was poured into the chamber, the heart beat was slowed down immeasurably. And when the Ringer's solution, lacking Ca,

was poured into the chamber, the beat was noted to return to normal, with a slightly slower repetition of the beats.

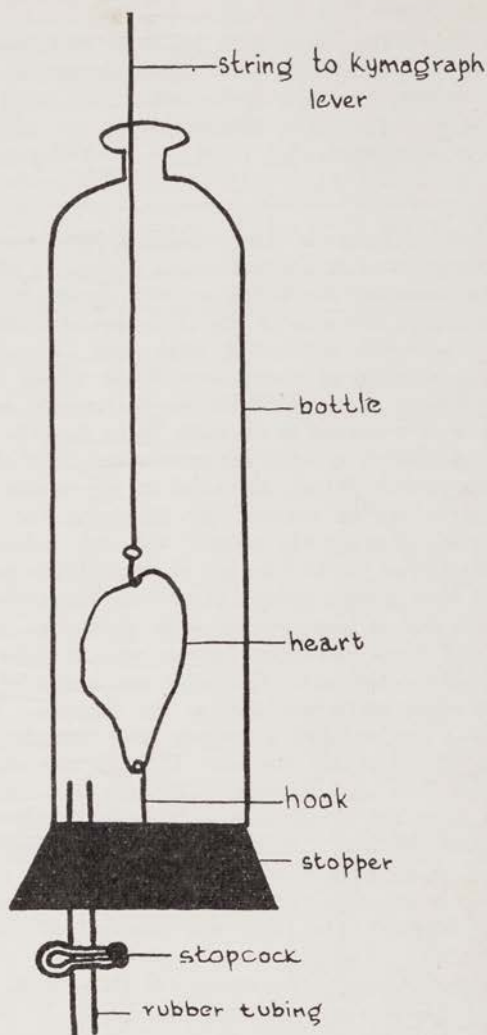


Figure 9.

The heart muscle must be supplied for its nourishment not only with organic materials, but also with inorganic salts. If the heart is immersed in a NaCl solution, it begins to beat and continues its activity for a long time. Finally the beat becomes weaker and would eventually cease unless a few drops of CaCl_2 were added.

It has been found that the heart beats best when it is being supplied with chloride solutions of Na, Ca and K. The following concentration of inorganic solutions is the best for experimental uses: 100 cc. of 0.6% NaCl; 1.0 cc. of 1.0% CaCl₂; 0.75 cc. of 1.0% KCl.

If the KCl is too concentrated the heart muscle relaxes freely and may stop in diastole. K salts favor the diastole of the heart. CaCl₂ aids the systole and an excess of it causes systolic arrest. NaCl not only supplies the necessary osmotic pressure, but may also be said to be indispensable for the origin of the heart beat.

Nicotinic acid, the antipellagra vitamin, is a necessary constituent of cellular activity in most animals. For the most part animals can synthesize their own supply of the acid, though in some cases it may be observed to be lacking and thereby necessitates the acquisition of the vitamin through foods of different types. For the normal transition of impulses from the vagus nerve to the cardiac muscle, nicotinic acid acts as mediator. In a final experiment the heart was separated from the vagus nerve and hence no impulse from the nerve was to be had. However, the direct application of the nicotinic acid served the same purpose as the impulse from the nerve. The more concentrated is the nicotinic acid, the greater is the acceleration of the heart beat.

SUMMARY

The primary activity of a muscle is contraction, secondarily its action may result in locomotion. Muscle cells are noted for the first time in the Aurelia, the common jelly fish. In all animals, on the lower rung of the evolutionary ladder, there are no muscle cells. The myonemes are not precursors to the muscle. The three types of muscle are found in the vertebrates. From the outside and working inwards the different muscle constituents of the skeletal muscle are as follows: epimysium, perimysium, fasciculi, sarcolemma, fibers, fibrils and sarcoplasm. The inorganic salts found in every muscle are those of K, Ca, Na, and Mg. Submicroscopically the muscle is composed of myosin chains with polypeptide linkages arranged in micellular formation. These chains manifest both form and intrinsic birefringence. The three stages of a single muscle twitch are the latent period, the contraction period and the relaxation period. The contraction is due in some way to the glycolytic cycle and the phosphate cycle. The energy required for contraction arises from the high phosphate energy-bond of ATP. The three important theories of muscle contraction are the Lactic Acid Era, the Phosphate Era and the Myosin Era. Other theories have also been proposed, such as the surface tension theory, the colloid chemistry theory and the myosin, folding and superfolding, theory. No one of these theories explains adequately all the reactions of a single contraction. The myosin theory is probably the most acceptable.

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Chemistry

NOTES ON PREPARATORY WORK FOR COLLEGE CHEMISTRY

REV. VINCENT F. BEATTY, S.J.
AND WILLIAM A. DAWSON, S.J.

High school science instructors and persons interested in the formation of high school curricula may perhaps be interested in the results of a nation-wide survey recently completed at Woodstock College. A miniature questionnaire, which inquired into attitudes on various phases of the problem of preparation in high schools for college chemistry, was mailed to instructors in general chemistry in colleges throughout the country. For the sake of brevity, the questions will be listed below together with the tabulation of the answers given. In all, 130 cards were returned, many of them inscribed with brief comments which proved helpful in making a hasty interpretation of the data furnished by the replies. It is hoped that the information we have gathered may shed a ray of light into some region of obscurity where it will prove useful.

The composite results of the questionnaire are as follows:

1. *Is high school chemistry required in your school for admission to the B.A. curriculum?*

Yes:	—	
No:	123	97.4%

7 colleges do not confer the degree.

to the B.S. curriculum?

Yes:	10	8%
No:	107	82%

13 colleges do not confer the degree.

2. *Do you think chemistry should be taught in college preparatory high schools?*

Yes:	117	90%
No:	10	8%
Undecided:	3	2%

3. *Would you advise a two-year course of topics taken from chemistry and physics in order to avoid overlapping and to insure a more logical sequence? e.g. matter and energy, heat, electricity, chemical reactions, metals, non-metals, optics, etc.*

Pro:	72	55%
Con:	38	29%
Undecided:	20	15%

4. *If chemistry is taught in high school, should the course stress description ----- principles ----- quantitative treatment in the form of chemical arithmetic?*

It was anticipated that in answering this question, our correspondents would restrict themselves to a single choice. However, those answering in this manner were a decided minority. Most made two choices, and many checked all three. It was therefore impossible to make a simple compilation such as was made in every other question. Nevertheless the general trend demonstrated under this heading proved valuable in the interpretation of the overall picture. In this light it will contribute to the discussion to follow.

5. *Do Latin and Greek in high school help to make better science students in college?*

Latin:

Yes:	56	43%
No:	46	35%
Undecided:	28	22%

Greek:

Yes:	46	35%
No:	47	36%
Undecided:	37	29%

6. *Should laboratory be more quantitative or more descriptive?*

Quant.:	47	36%
Descrip.:	64	49%
Undecided:	19	15%

It might conveniently be noted here that technical schools voted unanimously for a quantitative laboratory, and preferred classroom stress on principle and quantitative treatment. Which of the two they would have dominate, could not be determined on the basis of the replies received.

On consideration of the above information, and with the added help of numerous unsolicited marginal comments, we have ventured to draw several general conclusions:

1. There seems to be a universal dissatisfaction with the preparation the average student is now receiving in high school for the study of chemistry in college. We believe this dissatisfaction mani-

fects itself both in the overwhelming demand for a high school chemistry course, and in the underlying motivation of those who prefer to start from scratch. Further evidence lies in the fact that a large majority readily gave unqualified approval to the somewhat revolutionary two-year course proposed, while many of the dissenters rejected it in the fear that it would not be taught properly.

2. The focal point of this dissatisfaction seems to be the students' weakness in the understanding of chemical principles. Many instructors urged a more thorough treatment of principle in high school, while many more preferred to have the descriptive matter taken out of their way in order that they might themselves give a more thorough treatment of chemical principles from the ground up. A further indication of this attitude might be found in the reaction to the two-year course, which might be expected to impart a better understanding of fundamental laws. Many of the opponents of this proposal expressed a fear that such a course might degenerate into a general science course of a type that has been largely descriptive in the past. The surprisingly favorable reaction to Latin and Greek might also be interpreted as an indication of a desire for an increased ability to assimilate principle as opposed to factual knowledge.

Several additional observations have been made, which might prove of interest: A few instructors recommended a firmer foundation in mathematics. More than a few expressed the opinion that a descriptive course in high school is advisable in order to stimulate interest and prevent discouragement. A demand was manifested for the development of powers of logical reasoning and the ability to solve problems. In regard to Latin and Greek, many were undecided because they felt they had not adequate information on the question. Many of the no-es on this question came from schools where it is highly probable that students with training in Latin and Greek are extremely rare; e.g. The University of Arkansas. One gentleman, of the University of Richmond, apologized for a possible prejudice in voting in favor of them. It is comforting in these materialistic times to find someone prejudiced in favor of Latin and Greek. Another gentleman voted "No"; then paradoxically took the trouble to express the desire that students be able to use words.

Eleven Jesuit colleges replied as follows:

Ques.	1.	A.B.:	not required by any.		
		B.S.:	Yes: 2	No: 9	
	2.		Yes: 8	No: 3	
	3.		Pro: 4	Con: 7	
	4.		Same as above.		
	5.	Latin:	Yes: 8	No: 2	?: 1
		Greek:	Yes: 6	No: 2	?: 3
	6.	Quant:	4	Descript: 5	?: 2

ALLIGATION METHODS IN CHEMICAL AND PHARMACEUTICAL PROBLEMS

REV. BERNARD A. FIEKERS, S.J.

Given a solution of concentration, C , and volume, V , the concentration is defined as the weight of solute per unit volume

$$C = w / V \quad (1)$$

so that the amount of solute is given by

$$w = VC \quad (2)$$

On dilution, the weight of solute remains constant, while V and C are adjusted. We may thus write the familiar dilution law

$$VC = V'C' = V''C'' = \text{etc.} = w$$

If, however, solutions of different strengths, generally with solute in common, are mixed, the following expressions are valid

$$W = w + w' + w'' + \text{etc.} \quad (4)$$

and
$$V = v + v' + v'' + \text{etc.} \quad (5)$$

terms to the right indicating the components before mixing; those to the left, the resultant weight and volume after mixing. We suppose at this point that changes in specific gravity are negligible. Accordingly by equations (2) and (4)

$$VC = vc + v'c' + v''c'' + \text{etc.} \quad (6)$$

It will be noted that concentrations throughout may be expressed in any physical terms, such as per cent, grams per liter or specific gravity. Terms such as one to n parts are in reality dilution, D , terms, the reciprocals of concentration terms: $D = 1/C$. They are eminently associated with the straight-line graphing of data.

When the solvent (diluent, thinner or inert ingredient) is, with reference to equation (6), of zero concentration, all terms to the right but the first drop out. Equation (3) is thus a special case of equation (6).

Thus far we have algebraic justification to the *Method of Alligation Medial*, which has numerous traditional applications in problems of dilution and concentration. It is interesting to note the comment of Bradley and Gustafson¹ on this method:

"It is surely too handy to be dismissed (as it has been by many arithmeticians) as a medieval curiosity. Its weakness perhaps lies only in its compression which makes it difficult for us either to label its terms or to defend its validity—unless we refer to the fundamental method from which it is derived."

¹ Bradley, W. T. & Gustafson, C. B., "Pharmaceutical Calculations," Lea & Febiger, Phila. 1946. p. 193.

The combination of equations (5) and (6) justifies algebraically the *Method of Alligation Alternate*. This method has the utter simplicity of a thumb-rule and extremely valuable applications in calculating, among other quantities, volume ratios required to produce on mixing, a desired concentration that is the intermediate and resultant of the ingredients. Once it is applied to mixing two ingredients, it can be applied to mixing the third and so on. By equation (5), V C to the left of equation (6) becomes $V'C + V''C$, so that

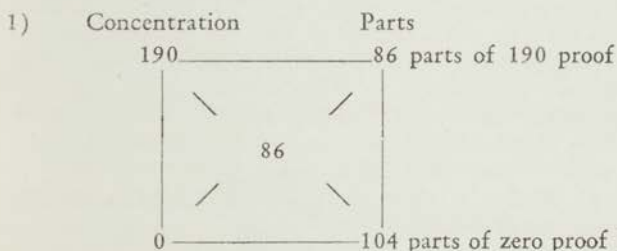
$$V'C + V''C = V'C' + V''C'' \quad (7)$$

and

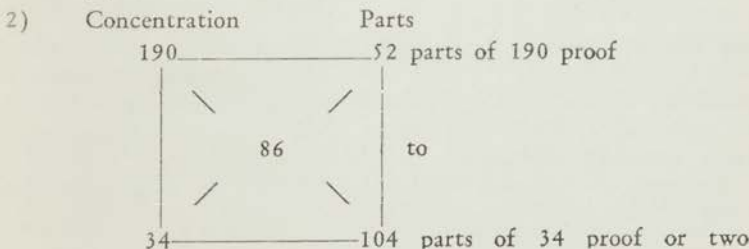
$$V'/V'' = \frac{C'' - C}{C - C'} \quad (8)$$

Many chemists are familiar with *Pearson's Square Method* for the standardization of milk and cream.² It is an application of equation (8).

The following problem serves to show how Pearson's square method is an application of equation (8). How may 86 proof alcohol be prepared from a 190 proof sample, 1) with water as diluent? 2) with 34 proof alcohol?



190 and 0, the initial concentrations, are laid off vertically to the left of the diagram; 86, the desired concentration is put in the centre; the desired is subtracted from the higher concentration, difference, 104, being written southeast on the diagram; lower concentration is subtracted from desired, the difference, 86, being written NE. These differences as indicated give the ratio. This is the operation of equation (8).



² Lange, N. A., "Handbook of Chemistry," 7th ed. Handbook Publishers Inc., Sandusky, Ohio, 1949. p. 775. From Univ. Illinois Bull., no. 323.

parts of the diluent to one of the more concentrated. Answer.

Many of the equations given above can also be used as reaction equations, as opposed to dilution equations. We are familiar with them in the form,

$$V N = V' N' \quad (9)$$

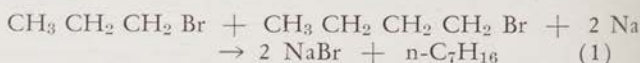
When so used, careful attention has to be given to algebraic sign, and generally concentration terms have to have the stoichiometrical coefficient from corresponding chemical reaction equations applied to them. Thus dilution problems can provide a fundamental and systematic entry to the study of chemical problems.

CHEMICAL RATE EXPRESSIONS. II.

REV. BERNARD A. FIEKERS, S.J.

In an earlier paper¹ probability theory was used in order to develop the mathematical expressions for reaction rates that are used in deriving the equilibrium constants of fundamental chemistry. It was shown that the rate of reaction between two moles of the same species is directly proportional to one half the square of the number of molecules; while the rate of reaction between two different species is directly proportional to the product of the numbers of both, without having to use the factor of one-half. The factor can be incorporated into the rate constant. But a more careful study of it is eminently practical, as shown by a recent article² on the Wurtz reaction.

In order to produce a hydrocarbon with an odd number of carbons atoms, one might be tempted to try using two different alkyl halides in the presence of sodium. For example:



Many teachers and texts usually say that the following reactions

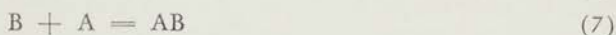
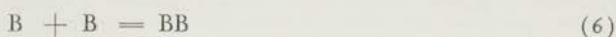
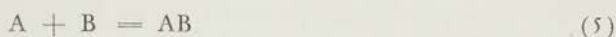
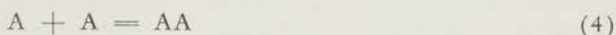


can also take place, because there is such a large number of molecules of all species present, even though equation (1) does not reveal the possibility at first sight. Nor is the exposition thus far faulty. But to predict that, other things being equal (reactivities of the species, etc.), one-third yield each of the hydrocarbons is to be expected—it is this very point that is disproved by theory and experiment in the cited article.

¹ This BULLETIN, 26, 93 - 95 (1949).

² J. Chem. Educ., 26, 606 (1949).

For, in general, under conditions where equal concentrations of A and B can react to form AA, BB and AB, a competition is had and the probable proportions of products are shown by



in which there is a double chance of forming the AB species as compared to that of forming the AA or BB. With N molecules of each reacting species present

$$\text{Rate}_{AA} = K_1 \frac{1}{2} N^2 \quad (8)$$

$$\text{Rate}_{BB} = K_2 \frac{1}{2} N^2 \quad (9)$$

$$\text{Rate}_{AB} = K_3 N^2 \quad (10)$$

Accordingly in the competition mol per cent 25 is expected from the first and second rates, and mol per cent 50 from the third. Naturally, if the concentration of one of the reagents were to be increased, some product with an even number of carbon atoms would increase at the expense of the other two products. The yield of odd-carbon product can never exceed mol per cent 50.

Considerations such as these provide data for the Wurtz reaction and illustrate the role of the proportionality constant in the rate expression. Disproportionation is also an aspect of the entropy of chemical reactions. Here we have an illustration of one of the relations between entropy and probability.

TEACHING BRIEF ON THE PURIFICATION OF ORGANIC SOLIDS BY CRYSTALLIZATION

REV. BERNARD A. FIEKERS, S.J.

This topic seems as complex to teach as it is important to know. But the central fact of the matter can be exposed and illustrated for teaching the elements. Then accessory and incidental material can be briefed for teacher background, or even for teaching purposes, leaving it to the expositor to judge where fundamentals are finished and research begins.

In the purification of organic solids by crystallization, the solvent is chosen so that the main product has relatively high solubility in it at high temperature and low solubility in it at low temperature. Table I. provides a survey of commonly available laboratory manuals on the topic. It includes solubility data that may be of value.

TABLE I
TABLE OF SYSTEMS FOR RECRYSTALLIZATION GIVEN IN
LABORATORY MANUALS

Solute	M.P.	Solvent	B.P. of solvent	Text Ref.	Temp.	gm/100 gm solvent	gm/100 gm solution	Notes & solu- bility Ref. page				
Acetanilide	113-4	Toluene	110.8	9	0	0.22	0.15	Ref. 15, p. 60				
					20	0.54	0.37					
					60	8.69	5.6					
					100	355.50	70.8					
					100	—0.03	0.5					
		Water	100	1,3,5 11 & 13	100	20	83.2	87	98	Transition Ref. 15, p. 60		
											25	0.52
											80	0.56
											83.2	3.5
											83.2	5.2
Benzoic Acid	121.7	Alcohol (abs.)	78.4	4	15	46.6		Ref. 14, p. 39				
					25		36.9	Ref. 15, p. 11				
					25	58.40		Ref. 15, p. 11				
		Water	100	2	100	0	0.170	0.170	Ref. 15, p. 10			
						20	0.290	0.289				
						100	5.875	5.549				
o-Dinitro Benzene	117-8	Alcohol (abs.)	78.4	8	21	1.9		Ref. 14, p. 47				
m-DNB	89.8	"	78.4		20	3.3		Ref. 14, p. 47				
p-DNB	173.4	"	78.4		21	0.18		Ref. 14, p. 47				
Naphthalene	80.2	Alcohol	78.4	1,4,13	0	5.1		Ref. 15, p. 61				
					15.7		7.73					
					20	10.2						
					67.7		73.28					
Oxalic acid	101.5*	Water	100	6,7,13	70	500						
					0		3.416	*Dihydrate				
					20		8.34	Ref. 15, p. 75				
					90.2		8.69					
Urea	132.7	Alcohol	78.4	13	0	2.6		Ref. 15, p. 60				
					20	5.4						
					70	20.2						
		Water	100	12	100	0	40		Ref. 15, p. 11			
						20	52					
						100	88					

In Table I. only those laboratory manuals are consulted which definitely carry technique experiments on this topic. Most manuals, however, discuss it. Most of them, probably include the technique somewhere in their preparative directions. These have not been considered here.

The solvent can be chosen by experimenting with a small quantity of sample, or by consulting solubility data, if available. Caution dictates the avoidance of toxic and/or inflammable solvents where possible. But in academic laboratories, these difficulties can be avoided by choosing experimental materials *ad hoc*. Further, it is obvious that the solvent should not react with the solute unless other special means of recovery are available. Benzoic acid is precipitated from its sodium hydroxide solution, for example, by treatment with strong mineral acid (2). The fact that solvents can be chosen so as to meet these conditions in the great majority of cases, makes the high solubility-high temperature, low solubility-low temperature case the most general and central one. Then the technique for other cases, such as decreasing solubility with increasing temperature, can be readily worked out as a last resort with reference to this general case of central occupancy.

Impurities will presumably be soluble and insoluble, one or many and of relatively low concentration. Their low concentration suggests that they will not be precipitated at low temperature. Even if many species of impurities are present in low concentration, a good separation might still be feasible. Their effect on the solubility of the main product, however, cannot be predicted; so experimentation with small quantities of sample might be required. The solubility or insolubility of impurities, including decolorizing carbon as an insoluble impurity, since it is frequently added to the solution, dictates the technique to be followed:

Sample is heated with *just enough* solvent to dissolve the soluble matter. Decolorizing carbon is then added. The solution is filtered hot. The filtrate is allowed to crystallize by cooling. Slow cooling is frequently necessary in order to prevent the formation of oil or very fine crystals. The crystalline mass is then separated from the mother liquor in the cold by filtration. This is usually done with suction. The crystals are washed with small, successive portions of cold solvent and suitably dried.

If decolorizing carbon is not used, and if other insoluble precipitates are absent, the hot filtration becomes unnecessary. This provides then the technique for recrystallization as opposed to crystallization, where the hot funnel is not necessary. Samples are to be recrystallized to constant melting point. The drying of a small portion of the yield for purposes of melting point determination is thus suggested. Once constancy is established the whole yield may be dried and its melting point may be checked if desirable.

Crystallization as a technique is to be distinguished from other operations. Sugar, for example, is separated from sand by dissolving it, filtering it and then evaporating the solvent. Again when a suitable solvent cannot be found for crystallization, it may be that a suitable one can be found for extracting impurities from it. At times

sublimation is a valuable substitute for crystallization. The techniques of mixed solvents and of fractional crystallization should not go unmentioned here. Fractional crystallization is applied to the separation of similar solids, isomers perhaps, generally present in comparable concentration. Recourse to seeding and other expedients may be necessary in so-called "refractory" cases of crystallization, due to supersaturation.

At times it is possible to use what might be called a "planned system of recrystallization". According to this method, the yield to be recrystallized is kept in one vessel during the many operations.

Product is washed in the cold, and wash is decanted. Solvent is added, heat is applied, followed by cooling. The mother liquor is decanted and the process is repeated to constant melting point. All decanted liquids are collected in a second vessel for later recovery of losses in the mother liquor if that should become necessary. The procedure is efficient and minimizes losses. Sometimes a filter siphon is used in place of decantation.

Considerations of the stoichiometry of solubility provide good background to this problem. Solubilities are listed either as gm. solute per 100 gm. *solvent* or as gm. solute per 100 gm. *solution*. It may be desirable to change from one definition to the other by calculation. Since all data are on the weight basis, specific gravities do not enter the calculation. The relation is not linear. 25 gm. of a substance per 100 gm. solvent = 25 gm. per 100 + 25 gm. solution; That is 20 gm. solute per 100 gm. solution. Conversely 20 gm. solute per 100 gm. solution = 20 gm. solute per 80 gm. solvent, equivalent to 25 gm. solute per 100 gm. solvent. Calculations dealing with the concentrations of impurities seem to be hypothetical and designed to show in a general way that impurities of high solubility and low concentration in the cold do not affect the yield.

It has been well said that analysis for products and by-products is the bottle neck of every research problem in organic chemistry. In many cases crystallization provides the only analysis, giving weighable products—the primary standard of all analytic procedures. It seems important enough then to be emphasized in the elementary stages of the science.

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TO PACK A FRACTIONATING COLUMN WHAT WOULD YOU HAVE DONE?

REV. GEORGE J. HILSDORF, S.J.

After building a fractionating column which is very similar to the one described in *Ind. Eng. Chem., Anal. Ed.* 13, 7, (1941), we were faced with the problem of packing the column with small glass helices 3mm. diam., 0.5mm. thick. The opening in the column through which these helices must be dropped one at a time, is one foot from the ceiling. The column must be in a vertical position when filling. Timing the job on a model revealed that it would take approximately 15 hours to fill the column if conditions were ideal. This is the way we solved the problem so that the filling job could be done at odd hours during the day.

Two four-foot-lengths of glass tubing 10mm.i.d. were joined by a short length of rubber tubing. A piece of rubber tubing about 1 foot long was attached to the upper end. This rubber tube emptied down into a cone-shaped fine wire mesh cage attached to a funnel leading into the upper end of the fractionating column. The lower end of this glass tube was suspended about 3/16 in. above the constriction in a constricted funnel through which a blast of air from a compressor is continuously being sent. Since the funnel is now at

a convenient height, it is possible to brush the single helices into the funnel while seated comfortably. The air column does the rest. The venturi effect pulls the helix into the mouth of the column and the moving column of air easily lifts it into the funnel eight feet above. The fractionating column itself was filled with carbon tetrachloride through which the helices drop gently into place. The vibration of the compressor in contact with the column support, eliminates the need of tapping to insure uniform settling.

Mathematics

A NOTE ON THE SQUARE ROOTS OF A COMPLEX NUMBER

REV. JAMES J. HENNESSEY, S.J.

1. *Introduction.* The purpose of this paper is to show the relation between the square roots of a complex number found without use of DeMoivre's Theorem and the Pythagorean triples. This relation is useful for the teacher who wishes to eliminate arithmetic complications in certain parts of Trigonometry.

In the right triangle ABC, the Pythagorean theorem states that

$$a^2 + b^2 = c^2 \quad (1)$$

In order to find integral solutions for (1) we shall summarize certain well known conditions. Dividing both sides of (1) by c^2 and letting $x = a/c$, $y = b/c$, we obtain

$$y^2 = (1 + x)(1 - x)$$

This equation may be written in the form

$$y(1 + x) = (1 - x) \quad 1y = t$$

Letting $t = v/u$ we obtain $t(1 + x) = y$, $ty = 1 - x$, or

$$t^2 - 1 = -x(1 + t^2)$$

Solving for x and y we have

$$x = (1 - t^2) / (1 + t^2) \quad \text{and} \quad y = 2t / (1 + t^2)$$

Since $t = v/u$, $x = a/c$, $y = b/c$, we obtain

$$\begin{aligned} a &= c(u^2 - v^2) / (u^2 + v^2) = p(u^2 - v^2) \\ b &= c(2uv) / (u^2 + v^2) = p(2uv) \end{aligned} \quad (2)$$

where p is defined by $c = p(u^2 + v^2)$. Hence, from (1) and (2), we have the conditions for *integral* solutions of the Pythagorean theorem, namely:

$$a = p(u^2 - v^2) \quad , \quad b = p(2uv) \quad , \quad c = p(u^2 + v^2) \quad (3)$$

in which we choose p to be an integer, usually 1, and $u > v$. For example, if $u = 5$, $v = 1$, $p = 1$, we obtain the Pythagorean triple, $a = 24$, $b = 10$, $c = 26$.

2. *The Square Roots of a Complex Number.* If we write the square root of $a + bi$ in the form $u + vi$ we have

$$a + bi = u^2 - v^2 + 2uvi$$

Thence we obtain the relations

$$a = u^2 - v^2 \quad \text{and} \quad b = 2uv$$

These are the *same conditions* given for the Pythagorean triple in (3) for $p = 1$. Therefore, if a teacher wishes to give a number of exercises involving the square roots of $a + bi$, he may invent problems by choosing integral values of u and v to obtain integral values for a and b . For example, the reader might compare the evaluation of the square roots of $5 + 12i$, in which case $u = 3$, $v = 2$, with the evaluation of the square roots of $4 + i$.

The condition that $u > v$ is not needed in these problems but it is to be noted that p should be chosen to be the square of an integer. If $u = v$, then $a = 0$, and so the square root of a pure imaginary number is a complex number. Thus, $\sqrt{8i} = 2 + 2i$ or $-2 - 2i$. Negative values may be used for u and v . If $u = -3$ and $v = 1$, then $a = 8$, $b = -6$. If the absolute value of v exceeds the absolute value of u , then a is negative. Furthermore, it may readily be shown by putting $a + bi$ in trigonometric form, that we obtain the trigonometric functions of θ and $\theta/2$ from the fact that $\tan \theta = b/a$ and $\tan (\theta/2) = v/u$.

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FAHRENHEIT — CENTIGRADE INTERCONVERSIONS. II₁

REV. JOSEPH A. MARTUS, S.J.

There are a number of methods for converting readings on these two well-known temperature scales and each method has its own proponents. Below are listed several such methods which have appeared in recent issues of *Chemical and Engineering News* in the *Letters to the Editor* section. In fact each correspondent proposes his method not as an original discovery, but as one easy to remember and easy to apply — and while the temperature does not rise, it was interesting to witness this clash of viewpoints.

The following conversion (2) has attached to it the guarantee that

it can be carried out without the use of paper and pencil. The steps for the change from Centigrade to Fahrenheit are: a) double the Centigrade reading ($20 \times 2 = 40$), b) subtract ten percent of this value ($40 - 4 = 36$), c) add 32 ($36 + 32 = 68^\circ$ Fahrenheit).

The reverse conversion by a parallel method is almost as simple: a) subtract 32 from the Fahrenheit reading ($68 - 32 = 36$), b) multiply by 1.1, 1.11, 1.111 or $10/9$ ths, depending on the accuracy desired ($36 \times 1.1 = 40$), and c) divide the result by 2. ($40/2 = 20^\circ$ Centigrade).

Another correspondent proposed the following method (3), which is known to *our* readers (1), and can also be found in many of the textbooks (1, 4). Since the two scales are the same at *minus* 40 degrees, in order to convert Centigrade to Fahrenheit readings: a) add 40 to the former reading ($20 + 40 = 60$), b) multiply the result by $9/5$. ($60/5 = 12$, and $9 \times 12 = 108$), and c) subtract 40 from the product ($108 - 40 = 68^\circ$ Fahrenheit). In order to convert Fahrenheit readings to Centigrade, use the same procedure, but multiply by $5/9$ instead of $9/5$. ($68 + 40 = 108$; $5/9 \times 108 = 60$; $60 - 40 = 20^\circ$ Centigrade). The writer claims as an advantage that there is "no fooling around with 32 by this method."

A third correspondent proposes the following method (5) for converting the Centigrade scale to Fahrenheit, which is preferable, he claims, for speed and convenience. Add to the Centigrade reading $1/10$ th of its difference from 160. ($160 - 20 = 140$; $20 + 14.0 = 34$); and then double the result ($2 \times 34 = 68^\circ$ Fahrenheit). The advantage here claimed is "no 32, no $9/5$, not even pencil and paper."

A fourth correspondent consigns all the foregoing to "ultima Thule" and proposes the method (6) with which we are very familiar today. Multiply the Centigrade reading by 1.8 ($1.8 \times 20 = 36$); add 32. ($36 + 32 = 68^\circ$ Fahrenheit). For the reverse: subtract 32 from the Fahrenheit reading ($68 - 32 = 36$); divide by 1.8 and the result is the Centigrade reading ($36/1.8 = 20^\circ$ Centigrade). This correspondent claims that this method is less confusing and taxing—especially on the morning after a *Chem. Smoker*. (What section does he belong to?)

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News Items

"Magnopere juverit crebro alios de aliis certiores fieri, ac audire quae ex variis locis ad aedificationem et eorum quae geruntur cognitionem afferuntur."—Const., VIII., I.

CANISIUS COLLEGE

DEPARTMENT OF CHEMISTRY. The Canisius College Alumni Chemical Society Lectures for the 1949 — 1950 are listed on the following program: October 27, 1949, "*The Russian Atomic Bomb and its Implications*," by Ralph E. Lapp, Nuclear Physicist and Author, Former Head of Nuclear Research for the Office of Naval Research; December 5, "*Degradation and Preservation of Cellulotic Materials*," by Carl J. Wessel, Canisius College '34, Asst. Dir. Prevention of Deterioration Ctr., NRC; Feb. 6, 1950, "*Trichloroethylene*," by Benjamin F. Clark, Chmn. Western N. Y. Sec. A. C. S. and E. I. Du Pont de N. & Co., Electrochem. Dept; Mar. 6, "*New Precipitation Processes*," by Hobart H. Willard, Prof. Anal. Chem., Univ. Michigan; Apr. 3, "*Atomic Energy: Weapon for Peace*," by Hubert N. Alyea, Assoc. Prof. Chem., Princeton Univ.; May 1, "*Chemistry of Free Radicals*," by William A. Waters, Prof. Chem., Oxford University.

COLLEGE OF THE HOLY CROSS

DEPARTMENT OF CHEMISTRY. Father Fiekers and Dr. VanHook represented the College at the New England Conference on Graduate Education, held May 6 and 7, 1949 at the University of Connecticut, Storrs, Conn. This Conference is publishing a New England Directory of Opportunities in Graduate Work which is designed to aid college seniors in their choice of graduate work through the many details of fields, requirements and so forth which it will contain. The booklet is now in press.

Recent departmental publications include: VanHook, A., Baril, O. L. and Moroney, T. (S), "Effect of manganese sulfate on sucrose solutions," *Sugar*, 44 (12), 44, 45 & 48 (Dec. 1949). Mr. Moroney worked here during the summer of 1949, supported by funds from the Sugar Research Foundation. He will receive the M. S. degree in February 1950. On November 23, 1949, the first post-war issue of the student chemical publication of the department, the *Hormone*, vol. 16, nos. 5 & 6 came off the press. We intend to publish it occasionally for the rest of the year and we hope to publish it regularly next year. The first installment of an article on the history of the department appeared in the latest issue. Many notes of congratulation were received by the student editor. These

included one from Robert F. Sutton, Curator of the Edgar Fahs Smith Collection in the history of chemistry at the University of Pennsylvania, and one from Dr. Wertheim of the University of Arkansas, noted author.

The department recently completed a set of the *Chemist Analyst*. It is one of the few completed sets of this item in the country. Sixteen of the many scientific journals in the department's library are now completed.

Perusal of Chemical Abstracts Author Index for 1949 reveals eleven publications by alumni holding the M.S. degree, starting from 1927, making a total of 138 items over these years.

The first meeting of (tentative title) the Worcester County Organic Chemistry Symposium was held in the department on December 1, 1949. Dr. Roger Jeanloz of the Worcester Foundation for Experimental Biology discussed "Some aspects of the Structure of the Polysaccharides." This venture in getting a small group together so that all may take part in the discussion seems to be able to achieve its purpose. Thus it will be interesting to watch its development.

Recent granting of doctorates in chemistry brings the overall known total for alumni up to twenty as the best known figure. The total number of alumni, engaged in doctorate work in chemistry at present, is estimated to be fifteen at ten different universities.

In January the department acquired a new Model B, Beckmann Spectrophotometer.

VARIA

A *Father Power Memorial Award* is the title of an editorial tribute to the late Rev. Francis W. Power, S.J. from the pen of Walter J. Murphy, Editor of *Analytical Chemistry*, 21, 1297 (1949). This is at once a tribute to Fordham University for founding the award.

A portrait of the Rev. James J. Pallace, S.J. of Canisus College is carried on the front cover of *The Chemist* (vol. 26) for April 1949, and the issue contains a short biography (page 28). Both items contain a glowing tribute to *our* men and to *our* way of life. *The Chemist* is the official monthly of the American Institute of Chemists. Father Pallace ran for secretary of this organization against Lloyd Van Doren of the New York area, long time secretary and present incumbent of the office. At present Father Pallace is Chairman of the Niagara Section, A.I.C. Many of *our* chemists are members of the A.I.C. and most of us are familiar with the *Institute*. We also recognize the names of Prof. R. K. Carleton of Boston College, Contributing Editor to *The Chemist*, and of the Rev. Edward S. Hauber of Loyola College in Baltimore, former chairman, and now vice-chairman of the Baltimore Chapter of the A.I.C.

The Rev. Albert F. McGuinn of Boston College is a National Councillor for the Northeastern Section of the American Chemical

Society and a member of the Standing Committee for Chemical Education in the National Society for 1949 — 1951. Our lay leaders in the chemical profession and the three members of our ASSOCIATION who reflect their training under the late Father Power so well, are to be congratulated for their zeal among professional chemists.

Father Roger Leclaire of the Province of Lower Canada completed his Ph.D. at Georgetown last Fall and has been assigned to the Vatican Observatory.

Father Gherzi writes from Hong Kong that he has been refused readmission to China after attending the Meteorological Congress in Manila during August. The Reds have taken over Zi-ka-wei Observatory completely. More cheerful to tell—Father Gherzi has been teaching pilots at the Kai-tak airfield near Hong Kong. He has been invited by the Portuguese Government to start a scientific research center at Macau for work on cosmic rays, the ionosphere and echoes from the troposphere. He had been doing quite a bit of work on this program at Zi-ka-wei. The National Geographic Society had presented him with a radar receiver for the work.

Must We Hide is the title of a book on atomic energy by Dr. R. E. Lapp, well-known physicist and authority on atomic energy. Dr. Lapp majored in physics at Canisius College and went on to the University of Chicago to work under A. H. Compton for his Ph.D. He published *Nuclear Radiation Physics* with H. L. Andrews. *Must We Hide* is an Addison Wesley Publication.

Reviews and Abstracts

REPORT ON THE SURFACE TENSION OF MILK. Measurements of the surface tension of samples of skim and whole cow milk and human milk by one of the seniors at St. Peter's point to the following conclusions about the surface tension of milk.

Milk is a surface-active system, the active agent being the casein. It can be diluted more than five times its volume without a significant change in surface tension. The inhibiting action of the fat particles is quite evident from the difference in rate of decrease of surface tension skim milk and whole milk with increase of temperature. The skim milk shows the same rate of decrease as water. Perhaps this difference in rates would serve as a way to tell milk dilution.

Human milk has much less casein than cow milk. That casein is the active agent is shown by a comparison of the changes in pH and surface tension for both samples when casein is precipitated with acid.

ANNOTATED BIBLIOGRAPHY OF THE USE OF ORGANOLITHIUM COMPOUNDS IN ORGANIC SYNTHESIS. A review of the literature published prior to January 1948. Metalloy Corp., Rand Tower, Minneapolis, Minn. Division Lithium Corporation of America, Inc. 8½ by 10¾ in. 223 entries alphabetically by contributors plus 18 pages of index to the principal compounds. B. A. Fiekers, S.J.

BACK ISSUES OF SCIENTIFIC JOURNALS REQUESTED AN IMPORTANT NOTICE

Father F. X. McFarland, S.J. of Saint Mary's College, Kurseong, Bengal, India, D. H. Rly, requests back issues of BULLETIN with the exception of the following, which he has XX/4, XXIII/1,2,3, XXIV/1-4, XXV/1-5 and XXVI/1-4. Before sending please consult Rev. John C. Baker, S.J., Calvert & Madison Sts. Baltimore 2, Md. in regard to expenses involved. Father McFarland is also interested in receiving anything in the seismology line that you may care to donate for the work in the missions.

Former editor-in-chief, Fr. Gerald F. Hutchinson, S.J., of Fairfield University, Fairfield, Conn., is on the lookout for the following journals: Journal of the American Chemical Society, anything previous to volume 41, 1919; Journal of Chemical Education, vols. 1-5, 1923-1928; Chemical Abstracts, vols. 1-12, 1906-1918, also vol. 41, no. 24, 1947; vols. 32-38, 1938-1944, incl; vols. 42 & 43, 1948 & 1949; Industrial and Engineering Chemistry, vols. 1 through 10, 1909-1918, vol. 28, no. 6, 1936; vol. 31, nos. 7 & 8, 1939; Industrial and Engineering Chemistry, Analytic Edition, vol. 5, no. 5, 1933 and vol. 11, no. 8, 1939. Any other scientific journals would be gratefully received. Before sending, please check with Father Hutchinson by letter and avoid unnecessary duplication.

The Jesuit Scholasticates of the Austrian Missions, driven from China to the Philippine Islands, are in urgent need of scientific textbooks and other publications of all sorts. Possibly some of our departments could help by disposing of duplicate items adjudged to be of value to the refugees. The Rev. August Silbernagel of Holy Trinity Rectory, 140 Shawmut Ave., Boston, Mass. or the Rev. John Walchans of the Cranwell Preparatory School in Lenox, Mass. would be pleased to negotiate shipments of anything you may care to offer. Please notify them before shipping.

Editor's Note. Space permitting, we will be glad to publish any want notices of this sort. Please try to submit a manuscript in the style used above. Editor has on hand certain want lists, that should be brought up to date before publication. Also on hand are certain lists of extra holdings. It is gratifying to observe that the publication of the twenty-five volume index of the BULLETIN has created a demand for back-issues.