The examination covers five grades, with salaries ranging from $2,600 to $5,600 a year, less the retirement deduction. Applications should be on file with the Commission’s Washington office on August 19. Further information regarding these examinations may be obtained from the Secretary of the Board of U. S. Civil Service Examiners at any first- or second-class post office, or from the U. S. Civil Service Commission, Washington, D. C.

Alpha Epsilon Delta, the national honorary premedical fraternity, recently installed a new chapter at the Ohio State University. On May 31 Dr. Emmett B. Carmichael, of the School of Medicine of the University of Alabama, who is executive councilor of the fraternity, installed thirty students and four members of the faculty of the charter group as the Ohio Alpha Chapter. Members of the faculty initiated as honorary members of the fraternity were: Dr. H. E. Setterfield, associate professor of anatomy in the College of Medicine; Dr. Alva W. Smith, associate professor of physics; Dr. Raymond J. Seymour, professor of physiology in the College of Medicine, and Dr. Joseph X. Miller, instructor in parasitology.

The Desert Laboratory at Tucson, Arizona, has been turned over by the Carnegie Institution of Washington, D. C., to the Forest Service. The Desert Laboratory was concerned with the study of arid and semi-arid regions which comprise almost a fourth of the area of continental United States.

A Fellowship has been established in the National Research Council for the year 1940–41 through funds provided by the RCA Manufacturing Company, Inc., for the purpose of investigating biological problems such as the structure of viruses, bacteria and other micro-organisms, and tissue cells with the electron microscope. It will carry a stipend of $3,000 and will be known as the RCA Fellowship, to be awarded by the following committee of the National Research Council, who will act also in an advisory capacity to the fellow: Stuart Mudd, chairman, M. Demerec, Caryl P. Haskins, J. H. Kempton, C. W. Metz, W. M. Stanley and V. K. Zworykin. The work will be carried on in the Research Laboratories of the RCA in Camden, N. J.

In considering candidates, preference will be given to versatile young men of United States citizenship, who have sound training in micro-biology, a doctor's degree and a record of original work. Applications, in quadruplicate, on forms which will be supplied on request, together with supporting documents, should be submitted on or before August 15 to the Division of Biology and Agriculture, National Research Council, 2101 Constitution Avenue, Washington, D. C.

Appropriations of the Federal Government to the various states for improvement of game conditions amount to the sum of $2,300,000. Michigan received the largest amount, $127,322; Texas was second with $120,297, and New York third with $120,163. Participating states are required to contribute 25 per cent. of the cost of any project. The total sum available in aid of wild life for the present year is $3,066,667.

DISCUSSION

The Nature of the Intermolecular Forces Operative in Biological Processes

In recent papers P. Jordan has advanced the idea that there exists a quantum-mechanical stabilizing interaction, operating preferentially between identical or nearly identical molecules or parts of molecules, which is of great importance for biological processes; in particular, he has suggested that this interaction might be able to influence the process of biological molecular synthesis in such a way that replicas of molecules present in the cell are formed. He has used the idea in connection with suggested explanations of the reproduction of genes, the growth of bacteriophage, the formation of antibodies, and other biological phenomena. The novelty in Jordan's work lies in his suggestion that the well-known quantum-mechanical resonance phenomenon would lead to attraction between molecules containing identical groups and to autocatalytic reproduction of molecules. Jordan himself expressed some doubt as to whether resonance attraction could really be operative in this way; after studying the question, we have reached the conclusion that the theory can not be applied in the ways indicated by him, and that his explanations of biological phenomena on this basis can not be accepted. In this note we wish to state our objections to Jordan's hypothesis and to formulate briefly our view of the present status of the chemical problems involved in these phenomena. We shall not discuss here Jordan's biological arguments for the occurrence of autocatalytic reactions, as distinct from the arguments concerning their mechanism.

Let us consider two identical molecules or parts of molecules, A and B, which interact with each other, the interaction being perhaps the electrostatic interaction of electric dipoles in the molecules, as considered by Jordan. If both molecules are in their lowest
states the interaction is normal. If, however, one is in its lowest state and the other in an excited state there occurs a resonance phenomenon; the wave function is either the symmetric or the antisymmetric combination of two functions, one representing molecule A normal and molecule B excited, and the other the reverse. For one of these symmetry types there is a resonance stabilization and attraction between the two molecules, and for the other a resonance repulsion.

It is this resonance stabilization between identical molecules which Jordan invokes as the cause of his postulated process of synthesis of molecules similar to a molecule present in the cell. His argument requires, of course, that the stabilization occur only between identical molecules, or, at any rate, between molecules which differ only slightly. Moreover, since the phenomenon does not occur for two molecules in their lowest energy states, he assumes that there exist excited energy states differing from the lowest state by a small amount of energy (~kT), so that thermal excitation raises the molecules to these excited states.

Now let us examine Jordan's argument. In addition to those objections which the author himself has pointed out we may advance the following ones.

1. The resonance stabilization between two identical molecules is equal to the resonance integral
   \[ H'_{\sigma} + H''_{\pi} \] (here \( H' \) and \( H'' \) are quantum numbers for the states involved in the resonance), which to effective in determining the behavior of the system must be at least of the order of \( kT \) in magnitude. But under the assumed circumstances the resonance between unlike molecules would be nearly as great as that between like molecules.\(^2\) If the two molecules \( A \) and \( B \) are unlike, but have excited states with nearly the same energy difference (~kT) from their normal states, then the resonance stabilization will be equal to the resonance integral; even if the energy values of the excited states for the two molecules differed by as much as one half the resonance integral (~1/2kT), the resonance stabilization would still be about three quarters as great as for identical molecules.\(^3\)

2. For large molecules in solution, such as protein molecules, the complexity of the molecules and the perturbing influence of the environment would be such as to make the energy spectrum of a molecule effectively a continuum, and would wipe out the distinction between unlike and like molecules.

3. The resonance stabilization is equal to the resonance integral, and must be of magnitude \( kT \) or greater to be effective; i.e., it must be as great as the energy difference between ground state and excited state. On the other hand, the theory requires the excited state which is involved to be non-degenerate. But by definition a “non-degenerate” state in perturbation problems is one for which the energy differences with all other states are greater than the resonance integral; hence Jordan's argument is inconsistent.

Summing up, then, we find that under the conditions of excitation and perturbation prevailing in aqueous solutions the resonance interaction could not cause a specific attraction between like molecules and therefore could not be effective in bringing about autocatalytic reactions.

It is our opinion that the processes of synthesis and folding of highly complex molecules in the living cell involve, in addition to covalent-bond formation, only the intermolecular interactions of van der Waals attraction and repulsion, electrostatic interactions, hydrogen-bond formation, etc., which are now rather well understood. These interactions are such as to give stability to a system of two molecules with complementary structures in juxtaposition, rather than of two molecules with necessarily identical structures; we accordingly feel that complementariness should be given primary consideration in the discussion of the specific attraction between molecules and the enzymatic synthesis of molecules.

A general argument regarding complementariness may be given. Attractive forces between molecules vary inversely with a power of the distance, and maximum stability of a complex is achieved by bringing the molecules as close together as possible, in such a way that positively charged groups are brought near to negatively charged groups, electric dipoles are brought into suitable mutual orientations, etc. The minimum distances of approach of atoms are determined by their repulsive potentials, which may be expressed in terms of van der Waals radii; in order to achieve the maximum stability, the two molecules must have complementary surfaces, like die and coin, and also a complementary distribution of active groups.

The case might occur in which the two complementary structures happened to be identical; however, in this case also the stability of the complex of two molecules would be due to their complementariness rather than their identity. When speculating about possible mechanisms of autocatalysis it would therefore seem to be most rational from the point of view of the structural chemist to analyze the conditions under which complementariness and identity might coincide.

From the biological side it would seem most rational to postulate the possibility of both processes; viz., formation of complementary non-identical structures and formation of complementary identical structures,
and to proceed by analyzing experimental data for clear-cut evidence as to their occurrence.

**Linus Pauling**

Gates and Crellin Laboratories
of Chemistry,
California Institute of Technology

**Max Delbrück**

Physics Department,
Vanderbilt University

A NEW CALCULATION OF THE C=C BOND STRENGTH AND OF CERTAIN RESONANCE ENERGIES

In the current table of bond energies used for interrelating the structures of molecules and thermal data relating to them and for predicting resonance energies, a strength of 100 is assigned to the C=C bond. (Bond strengths are given in kcal./mole units, bond lengths in Angstroms.) This value appears to be at variance with the data relating to ethylene and allene.

The heat of combustion of gaseous ethylene is 337.28. The heat of combustion of gaseous methane is 212.79. Writing $4d$ for the amount by which the ethylene C–H bonds exceed the methane bonds in strength, we deduce that the C=C bond in ethylene has the strength 94.29-4d. Using the heat of hydrogenation of ethylene and the heat of combustion of ethene, it follows that this bond strength is 94.51-4d. Correspondingly, from the heat of hydrogenation of allene and the heat of combustion of gaseous propane, it follows that the strength of the C=C bond in allene is 92.57-2d', where d' is the amount by which each allene C–H bond exceeds the methane bond in strength. The C–H bond lengths in ethylene and in allene are quoted at 1.087, which is smaller than the C–H bond length in methane, quoted at 1.093. Hence it must be presumed that d and d' are positive and that the C=C bond strengths in ethylene and allene are less than 94.29 and 92.57, respectively.

This considerable modification in the C=C bond strength implies a considerable modification in the resonance energies of benzene, naphthalene, etc., as at present defined. For example, the resonance energy of benzene, defined as $E-E'$, where $E$ is the heat of formation and $E'$ the sum of the strengths of $3C-C+3C=C+6C-H$, is now increased by at least 17: naphthalene correspondingly, whose $E'$ function includes $5C=C$ bonds, has its resonance energy increased by at least 28, and for anthracene and phenanthrene the increase is at least 39. Other molecules have their resonance energies increased at least by the following amounts: pyridine, furan, pyrrole and thiophene 11, quinoline and indole, 22, carbazole 34, and so on.

**Dorothy Wrinch**

The Johns Hopkins University

AVOIDING OBVIOUS RESIDUE FROM NICOTINE–BENTONITE SPRAYS

Because of reports, from many places, of the unsatisfactory obviously heavy residue on fruit and foliage resulting from the use of nicotine-bentonite combinations, we wish again to call attention to our experience.

Using Wyo-Jel bentonite obtained from the Wyodak Chemical Company, Chicago, Illinois, we proceeded first to wet weighed portions of bentonite, using a mechanical stirrer, before adding the nicotine. The spray resulting from this method left a very marked residue on fruit and foliage which was quite obvious from some distance. The trees gave the appearance of vegetation which has been covered with dust along a very dusty dirt road. McCrory and Vinson described in 1938 a method of mixing nicotine sulfate (Black Leaf 40) and bentonite which gave no obvious residue when the material was used as a spray. The method consists in adding a known quantity of Black Leaf 40 to a weighed portion of dry bentonite. The materials are mixed in the dry condition with a stick or other suitable stirrer. The mixture is then allowed to stand in a tightly closed container over night. By the following morning the lumps crumble and all is passed through an eighteen-mesh screen. The screened combination disperses readily in the spray tank to form a stable suspension. Such a spray gives no visible residue on fruit or foliage. Eight sprays of such a preparation in 1938 and six in 1939 resulted in no obvious residue. Certainly there was no suggestion from the appearance of the fruit at harvest that any kind of 'cleaning' was necessary or desirable.

Control of codling moth by such a nicotine-bentonite combination gave results which compared very favorably with that obtained by the standard spray of lead arsenate. About eighty-seven thousand apples were counted from the sprayed plots in 1939. The percentage of clean fruit from plots sprayed with the nicotine-bentonite combinations was 92.4 and the percentage of clean fruit from the lead arsenate plot was 91.3. The number of entries was slightly reduced and the number of stings was greatly reduced under those for the lead arsenate.

**C. G. Vinson**

S. A. McCrory

University of Missouri

1 Contribution from the Department of Horticulture, Missouri Agricultural Experiment Station Journal Series No. 634.