phenylserine mixtures implies the entrance of both of the amino acids into the bacterial cells rather than the selective exclusion of phenylserine by tyrosine.

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References and Notes

1. S. Simmonds, M. T. Dowling, D. Stone, *J. Biol. Chem.* 208, 701 (1954).
2. This study was aided by grants from the Nutrition Foundation and the Rockefeller Foundation.
3. C. H. Gray and E. L. Tatum, *Proc. Natl. Acad. Sci. U.S.* 30, 404 (1944).
4. From the Nuclear Instrument and Chemical Corp., Chicago, Ill.
5. S. M. Partridge, *Biochem. J. (London)* 44, 521 (1949).
6. W. H. Stein and S. Moore, *Cold Spring Harbor Symposia Quant. Biol.* 14, 179 (1949).
7. B. D. Davis, *Harvey Lectures* 50, 530 (1956).
8. S. Simmonds, E. L. Tatum, J. S. Fruton, *J. Biol. Chem.* 169, 91 (1947); S. Simmonds, *ibid.* 185, 755 (1950).
9. G. N. Cohen and H. V. Rickenberg, *Ann. inst. Pasteur* 91, 693 (1956).

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Bony Mechanism of Automatic Flexion and Extension in the Pigeon's Wing

In 1875 Garrod (*1*) noted that Bergmann, and later Strauss-Durckheim, had earlier described a mechanism for automatic flexion and extension in birds' wings. Garrod also credited Alix for an observation of the same thing, reported in 1874 in Paris. Coues (*2*) further described the device. The function was suggested from gross examination of dissections, and no experimental evidence was offered. Since the date of these papers, no further research on this apparatus has been published.

Briefly, the theory of operation was that the radius and ulna move in a fashion similar to a pair of "drawing parallels." The proximal end of the radius butts against the humerus, while the distal end is in contact with the fused carpals (scapholunar), which in turn are in contact with the anterior (digit II side) surface of the carpometacarpal articulation (Fig. 1). Humeroulnar flexion forces the radius distally, and the radius forces the manus into a flexed position, using the distal end of the ulna and the fused posterior carpal bones (cuneiform) as the fulcrum. Extension at the humeroulnar joint, through ligamentous attachments between the various bones, pulls the radius proximally and drags the manus into an extended position (with the same distal fulcrum as in flexion).

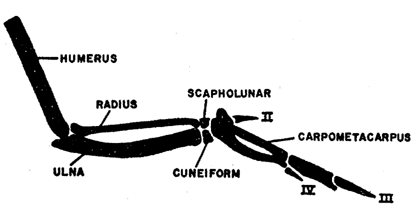

Fig. 1. Diagram of bones in pigeon's wing.

Experiments were devised to test these views of bone movement in the bird's wing. In two domestic pigeons, *Columba livia,* all flexors of the manus were cut; the birds were under general anesthesia, and it was a simple matter to cut all flexor tendons at the "wrist." After recovery from the operation, these birds flew in near-normal manner, but when they were perched the manus seemed to droop (extend) slightly. After 1 month, flight was so nearly normal that it was difficult to distinguish experimental birds from others in the room.

Cutting of the extensor tendons to the manus caused some further loss of delicate control, but the birds soon were able to fly. Eventually, these birds that had no muscular control of the hand flew easily, but they were always distinguishable in their awkwardness.

In two other pigeons, surgery was used to shorten the radius and prevent its simultaneous contact with the humerus and scapholunar. The left and right forewings were entered dorsally and a 5-millimeter section of the radius was sawed from the middle of the length of this bone. After insertion of a bone pin in the marrow cavity, the cut ends of the radius were pulled together with metal sutures. After recovery, the birds could fly, and wing-action was nearly the same as before the operation.

The flexor tendons for the hand were then cut. The birds could not fly, and the manus remained in an extended position at all times. Further surgery, to cut the extensor tendons, caused the hand to dangle, without visible control.

An attempt was subsequently made in each wing to remove the bone pin and insert a longer one to bring the radius back to its normal length. This was successful only on one side of one of the two birds; in the three other sites of bone shortening there had been too great a deposit of calcium on the outside of the bone to permit further surgery. The manus of the one wing in which the length of the radius had been restored was flexed and extended as the bird jumped from perch to perch.

At autopsy it was found that the radius had been shortened only 3 millimeters in one instance and 4 millimeters in the other two; normal length in the radii, as measured from x-ray photographs, was 48 millimeters.

It thus seems evident that flexion and extension of the manus can be accomplished without contraction of muscles extending to the manus. Flexion and extension at the humeroulnar joint, through action of the muscles of the upper arm, causes the same actions at the wrist.

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References

1. A. H. Garrod, *Proc. Zool. Soc. London* (1875), p. 82.
2. E. Coues, *Publ. Am. Assoc. Advance. Sci.* 20, 278 (1871).

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Liquid Scintillation Counting of C^{14}- and H^3-Labeled Amino Acids and Proteins

The method for tritiation of organic compounds described by Wilzbach (*1*) makes it possible to prepare with relative ease a wide variety of labeled compounds of high specific radioactivity. The applicability of the method in the labeling of intact protein molecules has now been demonstrated (*2*). Although the labeling procedure leads to degradation of a portion of each sample, a good yield of native protein of high specific radioactivity is obtained, as is evidenced by chromatographic homogeneity and retention of full enzymatic activity.

Effective use of these compounds in biological studies depends on the availability of a simple and sensitive system for radioassay. This is provided by the liquid scintillation counting technique. But, because the phosphors used in this system are nonpolar and are generally incorporated into an organic solvent (*3*), significant quantities of highly polar substances such as amino acids and proteins cannot be dissolved in the phosphor solution in unmodified form. A method for suspending such material in scintillating gels has been described for use in counting C^{14}-labeled compounds (*4*), but this is not applicable to the assay of tritium.

Passman *et al.* (*5*) have reported the use of a methanolic solution of the hydroxide form of a quaternary amine, Hyamine (*6*), to form a complex with $C^{14}O_2$ which is soluble in organic solvents, thus making it possible to dissolve up to 5 mmole of $C^{14}O_2$ in 35 ml of phosphor-containing toluene. As is described in the next paragraph, this same quaternary amine hydroxide (and several other quaternary amine hydroxides —for example, choline and tetraethyl ammonium hydroxide) can also complex amino acids and intact proteins. The phosphor dissolved in toluene can then be added to the methanolic solution of protein-amine complex, providing a clear