and is then transferred directly to another solution, the phenomenon observed in (1) no longer occurs. But if the latter solution is strongly under-cooled ($>7°$ C) and if it is stirred, needles tend to grow out of the ends of the crystal, and these break off from time to time, and grow independently. This effect we call 'true' breeding.

(3) At the moment the aforementioned needles break off there is often also produced a shower of very small crystallites. This we call 'splinter' breeding.

(4) If the crystals growing in a stirred solution are free to collide with each other or with the walls fresh nuclei are very easily produced, even at low supersaturation, and with relatively gentle collisions. This we call 'attrition' breeding.

Results obtained with aqueous potassium bromide were generally similar to the above, but differed in some details. Fuller results will be published elsewhere.

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Conduction in Nucleic Acid Components

In a recent paper[1] DNA was shown to possess a small semiconductivity in the dry state, the specific conductivity following the equation :

$$\varkappa = \varkappa_0 \exp(-\Delta\varepsilon/2kT),\ \Omega^{-1}\text{cm}^{-1}$$

with $\Delta\varepsilon = 2{\cdot}42$ eV, $\log_{10}(\varkappa_0,\ \Omega^{-1}\text{cm}^{-1}) = 3{\cdot}4$. It was suggested that the conductivity was associated with the π-electron overlap of the paired bases, adenine–thymine, and guanine–cytosine. In the Crick and Watson double-helix for DNA structure these base pairs are arranged one on top of the other, with an interplane spacing of 3·4 Å, similar to that found in graphite[2]. A similar result was found for the electrical conductivity of RNA, which may now be related to its high content of double-helix structure[3]. We have examined the solid-state electrical conductivity of some of the component structures of the nucleic acid, using d.c. with the polycrystalline specimen compressed between nickel electrodes at 80 kg cm^{-2}, in a vacuum of 10^{-6} mm mercury. The bases adenine, thymine, guanine, cytosine and uracil were first examined. These gave very low conductivities, around $10^{-15}\ \Omega^{-1}\text{cm}^{-1}$ at 400° K, but sublimation (even in a nitrogen atmosphere) and thermal decomposition precluded the establishment of accurate $\Delta\varepsilon$ values. The nucleosides had conductivities of 10^{-11} – $10^{-13}\ \Omega^{-1}\text{cm}^{-1}$ and the nucleotides 10^{-7}–$10^{-12}\ \Omega^{-1}\text{cm}^{-1}$ at 400° K. The results are listed in Table 1.

Table 1. Nucleosides and Nucleotides

Substance	$\Delta\varepsilon$, eV	$\log_{10}(\varkappa_0, \Omega^{-1}\text{cm}^{-1})$
Adenosine*	4·5	15
Yeast adenylic acid†	1·8	2·7
Muscle adenylic acid†	2·0	2·0
Adenosine triphosphate (DiNa, DiH salt)	2·0	2·5
Adenine phosphate	2·0	3·3
Uridine*	5·2	22
Uridylic acid†	1·3	0·6
Guanosine*	2·1	2·6
Guanylic acid†	1·5	1·8
Thymidine*	4·7	17·4
Cytidine*	4·9	19·4
Cytidilic acid†	2·2	1·6
Riboflavin	2·4	1·6
Riboflavin-5-phosphate (sodium salt)	2·2–2·3	5·0

*Denotes nucleoside. †Denotes nucleotide.

We have to compare the following $\Delta\varepsilon$ values : (*a*) base + ribose (nucleoside) 4·5–5·2 eV ; (*b*) base + ribose + phosphate (nucleotide) 2·0–2·2 eV ; (*c*) RNA, DNA 2·4 eV.

It has been suggested that $\Delta\varepsilon$ for DNA corresponds to excitation of π electrons to the first excited state $\pi\rightarrow\pi^*$ (or $n\rightarrow\pi^*$) followed by tunnelling of electrons and holes at right angles to the planes of the bases down the axis of the double helix[1]. This mechanism is made possible by the overlap of π-orbitals between the parallel-stacked bases[4], which stacking does not occur apparently in the nucleosides or nucleotides. It is suggested that to obtain electron tunnelling between the widely spaced bases in the nucleosides excitation of π electrons to the second excited state is necessary, $\pi\rightarrow\pi^{**}$. In nucleotides, in the specific case of cytidilic acid, the bases are connected by hydrogen bridges via phosphate groups[5]. If generally true for nucleotides, this may explain the $\Delta\varepsilon$ of 2 eV, since again the $\pi\rightarrow\pi^*$ excitation would be adequate for electron tunnelling. Clearly, there may be other possible mechanisms for bridging of charge-carriers since guanosine has $\Delta\varepsilon = 2{\cdot}1$ eV, and riboflavin 2·4 eV, and an explanation of these low values, similar to the nucleotides, must await information on their crystal structure.

On band theory $\varkappa_0 \sim 4\mu$, where μ is the average mobility of electrons and holes. On this basis the observed values of μ are comparable for DNA and nucleotides, but the values for nucleosides, as for small aromatic molecules[6], are much too high to be interpreted in this fashion, and an alternative to band theory must be sought in such cases.

These substances obeyed Ohm's law accurately up to 3,000 V/cm, deviations at this voltage being adenine 5 per cent, uridine 7 per cent, thymidine 2 per cent, riboflavin-5-phosphate 5 per cent. This is a clear indication that we are not dealing with space-charge limited currents[7,8]. This interesting fact, which also holds for the proteins, also of very high resistivity[9], is not explicable on band theory.

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Helix-coil Transmission and Electronic Conductivity of the Amylose–Iodine Complex

The first linear polymer of biological origin which was shown to exist in a helical configuration was amylose, the linear polymer of glucose. This polymer has long been known to exist in a helical form in its familiar blue complex with iodine[1–3]. Subsequent discoveries of the helical structure of other biological polymers such as polypeptides[4] and polynucleotides[5] have created great excitement and stimulated many detailed studies into the properties of these polymers. However, possibly because amylose fulfils a rather mundane biological function and is derived solely from plant origin, equivalent studies on this material have not been carried out.

One of the most interesting properties which has been intensively studied in the aforementioned polymers is their ability to undergo rather sharp transitions from a highly ordered helical rod to a disordered randomly kinked structure[6,7]. Furthermore, electronic conductivity has recently been reported for polypeptides and proteins[8,9]. In this communication I present results of experiments which show the iodine–amylose helical complex exhibits similar properties.

Fig. 1 shows the dependence on temperature of the adsorption maximum of the helical amylose–iodine complex in a mixed solvent of five parts water and one part dimethyl sulphoxide. No added ions are present. The molecular weight of the fractionated amylose sample was