cannot differ in this last sense are identical, viz. : melting and boiling point, specific gravity, &c. But the crystalline form, which may show enantiomorphism, indeed shows this difference in the isomers in question; and especially the behaviour (in the amorphous state) towards polarized light differs in the sense that the plane of polariza­tion is turned to the left by the one isomer, and exactly as much to the right by the other, so that they may be termed “ optical anti­podes.” All these differences disappear with the asymmetric carbon, and the succinic acid, HO2C∙CH2∙CH2∙CO2H, from tartaric acid is optically inactive and shows no stereo-isomerism.

2. *Compounds with more than one Asymmetric Carbon Atoni.—* Stereo-isomerism and the space relation of atoms in compounds with higher asymmetry can best be developed by aid of graphic representa­tions, founded on the notion of space relations in ethane, H3C∙CH3. A consequence of the tetrahedral grouping in methane is the con­figuration given in fig. 3, where the six hydrogen atoms are substituted by six atoms or groups R1,...R6. The second (above) carbon atom is sup­posed to be at the top of the lower tetrahedron, and vice versa. Each other position, obtained by turning R1R2R3 around the ∙C—C∙ axis, is also possible, but since no isomerism due to this difference of relative posi­tion, which might already show itself in ethane, has been observed, we may admit that one of the positions ob­tained by the above rotation is the stable one, and fig. 3 may represent it. For simplicity’s sake this figure may be projected on a plane by mov­ing R3 and R6 respectively upward and downward, with R1R2 and R4R5 as axes, which leads to the first of the four configurations representing the stereo-isomers possible in the above case. They differ in the two possible spatial arrangements of RιR2R3 and R4R5R6:—

As one asymmetric carbon introduces two stereo-isomers and two introduce four, *n* asymmetric carbon atoms will lead to 2n isomers. They are grouped in pairs presenting enantiomorphic figures in space, as do the first and the last of the above symbols, which correspond to the character of optical antipodes, whereas the first and second correspond to greater differences in melting points, &c. A well-studied example is offered by the dibromides of cinnamic acid, C5H6∙CHBr∙CHBr∙CO2H. They have been obtained by Liebermann in two antipodes melting at 92°, and two other antipodes, differing in optical rotation from the first, and melting at 195°.

A simplification is introduced when the structural formula shows symmetry, as is the case in R1R2R3C∙CR3R2R1. The four above- mentioned symbols then are reduced to three:—

of which the first and last show the enantiomorphism corresponding to the character of optical antipodes, while the second shows sym­metry and corresponds to an inactive type. A well-studied example is offered here by tartaric acid: the two antipodes, often denoted as *d* and Z, have been found, viz. in the ordinary dextrogyre form and the laevogyre form, prepared by Pasteur from racemic acid, while the third corresponds to mesotartaric acid; such internally compensated compounds are generally termed “ meso.”

3. *Cyclic Compounds.—*Three or more carbon atoms may link to­gether so as to produce ring systems such as

It is in these cases that the principle of the asymmetric carbon, which in the above case leads to 23 = 8 stereo-isomers, is easily applied by means of graphical representations in a plane, derived from the space relation shown in fig. 4. The six groups, R1 . . . R6, are either under or above the plane in which the carbon ring is supposed to be situated, and this may be indicated by the following symbol :—

where the carbon atoms are supposed half-way between R1 and R2, R3 and R4, R5 and R6.

One of the most simple examples is offered by the trimethylene-dicarboxylic acids

for which three formulae can be deduced :—

the first, where the carboxyl groups ∙CO2H lie on the same side of the carbon ring, called, as Von Baeyer proposed, the *cis*-form, the others *trans*-forms. The trans-forms show enantiomorphism and correspond to optical antipodes, whereas the first symbol may be considered as corresponding to mesotartaric acid, symmetrical in configuration and inactive; this third stereo-isomer has also been met with.

Special attention has been given to those ring systems of the general form :—

This trans-form corresponds to a cis-form, where both R2 and R1 are on the same side of the plane containing the ring. These latter are enantiomorphic in the ordinary sense of the word, but the particular feature is that the trans-form, though offering no plane of symmetry, is yet identical with its mirror image, and thus not enantiomorphic and not corresponding to optical antipodes but to the meso-form.

There correspondences have been realized by Emil Fischer in derivatives of alanine; H3C∙CH(NH2)∙CO2H, which exists in two antipodes *d* and Z. Two of these molecules can be combined to alanyl-alanine:H3C∙CH∙NH(COCΗ∙NH2·CH3)∙CO2H, which, as con­taining two asymmetric carbons, may be had in four stereo­isomers *dd, ll, dl* and *ld.* In their anhydrides

we meet the above type, and find that *dd* and *ll* formed the predicted antipodes, while the anhydride of *dl* and *ld* is one and the same substance, without any optical activity. Such cases are often termed “ pseudo-asymmetric.”

4. *Isolation of Optical Antipodes.*—The optical antipodes are often found as natural products, as is the case with the ordinary or *d*-tartaric acid ; generally only one of the two forms appears, the second form (and, more generally both forms) being obtained syn­thetically. This is a problem of particular difficulty, since the artificial production of a compound with asymmetric carbon, from another which has no asymmetric carbon, always produces the two antipodes in equal quantity, and these antipodes, by their identity in most properties, *e.g.* melting and boiling point, solubility, and also on account of their analogous chemical behaviour, cannot be separated by customary methods, the application of which is rendered still more difficult by the formation of a so-called racemic compound.

The method called “ spontaneous separation ” was first observed by Pasteur with racemic acid, which in its double sodium and am­monium salt crystallized from its aqueous solution in two enantio­morphic forms, which could be separated on examination. One of the two proved to be the ordinary sodium-ammonium-tartrate, the other its laevogyre antipode; thus *l*-tartaric acid was discovered, and racemic acid proved to be a combination of *d-* and Z-tartaric acid. The further examination of this particular transformation showed that it had a definite temperature limit. Only below 27° is Pasteur’s observation corroborated, while above 27° a racemate appears; these changes are due to a chemical action taking place at the given temperature between the solid salts:— 2C4O5H4NaNH4∙4H2O (C4O6H4NaNH4)2∙2H2O+6H2O, one molecule of the *d-* and one of the *l*-tartrate forming above 27°, the racemate with loss of water, while under 27° the opposite change occurs. This temperature limit, generally called transition-point, was discovered by Van't Hoff and Van Deventer. It is the limit where the possibility of spontaneous separation begins, and is relatively rare, so that this way of separation is an exceptional one, most antipodes forming a racemic compound stable at all tempera­tures that come into question.

The use of optically active compounds in separating antipodes