The site of the John Innes Horticultural Institution, July 1910. E.J.O.
1910 The John Innes Horticultural Institution opens

Two acres of John Innes’ estate at Merton Park, his Manor House and conservatories, become the John Innes Horticultural Institution.

William Bateson’s directorship starts on 1 January 1910 and the Bateson family move into the Manor House in August. Most of Bateson’s researchers move from Cambridge with him making the John Innes Horticultural Institution the centre of British genetics. The Trustees purchase additional land and increase the original site to 6 acres. Work begins in two small laboratories and four glasshouses.

1910 William Bateson founds the Journal of Genetics with associates

The Journal of Genetics, published by Cambridge University Press and edited by Bateson and R. C. Punnett, was launched as a quarterly periodical ‘for the publication of original research in Heredity, Variation and allied subjects’.

Bateson used the Journal to promote his particular view of what the subject of genetics should include. In the early years this meant that most papers were reports of Mendelian hybridisation experiments and Bateson used his influence to actively discourage research on chromosome theory. However, in line with his view that genetics was the study of the ‘physiology of descent’, the journal also included papers on the physiology of sex determination.

The Journal was an important focus for British geneticists who faced powerful opposition from EW Macbride, Professor of Zoology at Imperial College, London, and a member of the governing body of John Innes (from 1913), and Karl Pearson, Professor of Applied Mathematics and Mechanics at University College. ‘They stood at the entrance of the Royal Society like the leographs which guard the portals of a Burmese Buddhist temple’ (Crew, 1969).

1910 Drosophila genetics begins

Thomas Hunt Morgan and his group at Columbia University, New York select the fruit fly Drosophila melanogaster as a model organism to study genetics. Their experiments show that the flies can be easily kept in stoppered wide-necked milk bottles and fed on slabs of fermenting banana. Drosophila has only four pairs of chromosomes that differ markedly in size and shape from each other. In the salivary glands of the larvae the chromosomes are relatively enormous. A mated pair produces scores of offspring in a 10-day cycle. All of these advantages make Drosophila good potential material for studying the effect of chromosomes on heredity.

However, the wild flies lack clearly visible characteristics. It is not until Morgan’s team start to breed flies that the laboratory stocks of Drosophila develop well-marked and unusual characteristics. By selecting and breeding flies with visible mutations they turn Drosophila into a laboratory tool for studying inheritance. Morgan’s group includes Alfred Sturtevant, Hermann Muller and Calvin Bridges.

Morgan publishes two papers on chromosomes: the first expresses his view that Mendelian factors could not possibly be carried by the chromosomes. Before this appears in print Morgan’s second paper is published; this provides convincing evidence that the factors for sex-linked characters are definitely carried in the X chromosome.

See:
1911 The student gardener scheme begins at JIHI

Under the Scheme of the Charity Commissioners the Institution was directed to provide a certain amount of hands-on horticultural training. To meet this requirement six student gardeners (prior to 1930 called ‘exhibitioners’) are taken on to work in the gardens and glasshouses and attend lecture courses on horticultural topics prepared by members of staff. Students are encouraged to attend additional evening classes in Wimbledon and London. To be eligible for the two-year grants applicants need four years practical gardening experience. One of the first intake of student gardeners is Morley Benjamin Crane.

Bateson requires high standards from his garden staff. Unlike practical gardening where it is possible to scrap 20 to 50 per cent of seedlings at prickling-out time, genetics experiments need every seedling that can be got to live.

1911 Muriel Wheldale joins JIHI

Muriel Wheldale is appointed to one of the first scientific studentships at the Institution. Wheldale had worked with Bateson as a student at Cambridge and continued to collaborate with him on the inheritance of plant pigments, especially in Antirrhinum. Wheldale proves to be a talented biochemical geneticist and in 1916 publishes The Anthocyanin pigments of plants.

1911 Research on rogue peas begins

On the advice of Suttons, a firm of nurserymen at Reading, Berkshire, JIHI staff work to produce rogue-free strains of peas in three commercial varieties. The first rogue-free strain is grown in bulk in 1915 and is bought by Suttons

1911 Thomas Hunt Morgan shows that genes on chromosomes are the units of heredity

Using their fruit flies Morgan and his students show that ‘factors’ (genes) are arrayed on linear chromosomes. They develop gene theory, including the idea that some genes are linked together on the sex chromosomes. Their first examples are the genes for white eyes, yellow body, and miniature wings in Drosophila. Morgan proposes that these genes are linked together on the X chromosome.

1912 Cambridge University founds a chair of genetics

AJ Balfour offers William Bateson the new professorship: ‘To you, more than to anybody else, is owed the impulse which started the Mendelian school at Cambridge, and, through that school, the foundation of the new Chair. Would you be prepared to resume your investigations as its occupant? If you would, I think it would be a great gain, both to Cambridge and to science...’

Bateson declines the offer, preferring to remain as Director of John Innes. Bateson recommends his friend and colleague RC Punnett for the Cambridge post.
1913 A. H. Sturtevant produces the first Genetic Map in Drosophila

Alfred Sturtevant, an undergraduate working with Morgan at Columbia, provides the experimental basis for the linkage concept in Drosophila and devises a visual representation or ‘map’ to show the links.

1913-14 Nikolai Vavilov joins the JIHI as Visiting Researcher

Nikolai Vavilov, a recent graduate of the Moscow Agricultural Institute, and on an official tour of the main biological laboratories of Western Europe, arrives at the JIHI with an established interest in plant selection and the work of Gregor Mendel. He is deeply impressed with Bateson, both as a scientist and as a democratic administrator who allowed his staff great freedom to pursue their individual scientific ideas and experiments. Vavilov completes his postgraduate thesis at JIHI which entitles him to become a professor on his return to Russia. In 1917 he became a professor at Saratov University, south-east of Moscow and in 1921 moved to head the Applied Biology Branch at Petrograd (St Petersburg). From these beginnings he built up the All-Union Institute of Plant Breeding, one of the world’s most distinguished centres of research in plant selection and genetics.

1914 Bateson is President of the British Association in Australia

Bateson leaves for Australia in June to preside over the British Association meeting; he returns in November. Extracts of Bateson’s lectures on the mechanisms of inheritance and on eugenic themes at the Melbourne and Sydney meetings are published in The Times and in the American press where they arouse interest and opposition. Bateson continues to deny chromosome theory. T H Morgan responds ‘We ourselves are going to get after you soon in a small book we are writing on ‘The Mechanism of Mendelian Heredity’

1914-1918 World War I

The war of 1914-1918 curtails the work of the Institution. By September 1915 Bateson has already lost from his scientific staff G. O. Sherrard (self-sterility in fruit trees); J. W. Lesley (potato breeding); M.A. Bailey (plant pathology); C. B. Williams (entomology), and C. W. Richardson (strawberry breeding) to the war effort. Many of the garden staff have also left for the army or for munitions work. Those that remain are having difficulty making ends meet as inflation spirals; they successfully agitate for an increase in wages. By 1916 the Board of Agriculture is encouraging the Institution to use space not required for experiments to grow vegetables. About 20,000 seedling vegetables are raised and distributed free to local allotment-holders. In 1917 only three research workers remain. Many do not return: the workers not lost to the war are lost to the Empire.

After the war Bateson recruits new staff and enlarges the premises by adding two larger laboratories and a library.

1915 T H Morgan and his colleagues publish Mechanism of Mendelian Heredity

Morgan’s team offer a comprehensive chromosomal interpretation of heredity. They teach that the determinants of the hereditary characters are the genes which are resident in the chromosomes, each gene having its own particular place or locus in a particular chromosome.
1915 A new artist for JIHI

After Muriel Wheldale's resignation in 1914 Bateson searched for someone who, like her, could ‘draw a flower’. Scientific recording of flowers at this time involved painting or hand-coloured photography. Herbert Osterstock, congenitally deaf and dumb, a gifted artist and photographer, was appointed to fill this niche. In 1925 Osterstock was appointed official artist to JIHI.

1916 ‘15 years of Mendelism’

Bateson delivers a lecture on the history of Mendelian genetics at the Royal Institution in London.

1917 ‘The Rumpus’ - criticism from local residents

The JIHI receives complaints that the ‘institution appears to … have been devoted for the last eight years principally to research and postgraduate work, in total disregard to local claims- the few local employees, such as they were, being employed in “barrow” work’. Representatives of the Boroughs of Merton and Morden wanted the John Innes bequest to be used to found a technical or industrial institute or secondary school for training local students. The arguments that ensue become known as ‘The Rumpus’.

1918 JIHI’s Garden Superintendent dies

The Garden Superintendent EJ Allard dies in the influenza epidemic in October. His obituary records that his increased responsibilities at JIHI during wartime with depleted staff contributed to his death. He is replaced by Albert Hosking from the Glasgow and West of Scotland Agricultural College. Reginald Gregory, volunteer worker 1910-18, and William Courthope, Trustee, die in the same epidemic.

1918 Plans for the reconstruction of agriculture

A. Daniel Hall of the Development Commission writes to Bateson asking him to draw up an ideal programme of research and development for JIHI over the next ten years. The JIHI had not so far made any call on the Board of Agriculture for funding. Bateson responds with detailed plans for the expansion of the scientific staff, and ideas for creating links with other institutes, especially the ‘Cambridge Svalöf’.

Bateson is nevertheless reluctant to tie the Institution down to government lines of research and fears the loss of independence. He writes: ‘... the drag in the economic direction is likely to prove too strong to be successfully resisted. It becomes therefore the more desirable that at least one Institution should retain its financial independence complete, although prepared to co-operate with the state-aided institutions in all possible ways…. proper provision must be made for the purely scientific side of the work, neglect of which has rendered much of the labours of the American Stations trivial and unfruitful’.

1919 William Bateson and E R Saunders found the Genetical Society

On 25 June 1919 William Bateson and E R Saunders convene a meeting in the Linnaean Society’s rooms at Burlington House, London to discuss the proposed foundation of a Genetical Society. William Bateson takes the Chair and the proposal is approved unanimously. AJ Balfour is proposed as the first President; William Bateson, E. R. Saunders and AW Sutton as Vice-Presidents, and C Pellew and RC Punnett as Secretaries. The first meeting of the Society is held in Cambridge on 12 July 1919. Thirty-four members attend and are treated to demonstrations on experiments with stocks, by Saunders, on sweet peas by R. C. Punnett, on cereals by RH Biffen, on colour inheritance in rats by JBS Haldane, and on the genetics of hen-feathered cocks by R. C. Punnett. In the early years John Innes staff form a high proportion of the membership.
1920s Timeline
1920s Nucleic acid found in chromosomes

Nucleic acid is found to be a major component of chromosomes but its molecular structure is thought to be too simple to carry genetic information.

1920s William Bateson tests chromosome theory

William Bateson investigates T. H. Morgan’s chromosome theory by experiments on peas. He tests Morgan’s assumption that the number of independent elements cannot exceed the number of chromosomes. For the next few years Bateson also continues to work on physiological aspects of plants and forms of reproduction where segregation of chromosomes plays no part. He studies root cuttings, chimaeras (plants composed of tissues of two or more genetically distinct types), variegated plants, and rogue peas (peas that do not come true from seed), all in the hope of finding an alternative to Morgan’s chromosome theory. Bateson’s objections to the chromosome theory stemmed from his requirement that it should not only explain heredity but also differentiation and development in plants. Other genetic research at JIHI focuses on studies of linkage.

1921 A new laboratory and library at Merton

The building of the new Laboratory and Library at Merton is completed. The laboratory provides seven new bench-places, prep rooms, a dark room, and office space. The library is a handsome room, fitted with a lantern for slides. It serves as a lecture room and enables JIHI to accommodate large scientific meetings.

1921 JIHI develops new plants for the horticultural industry

The first plant of economic value resulting from the application of the theory of linkage is produced at JIHI. Dorothea de Winton’s new combination of red stigma and red foliage in Primula sinensis is given to the seed firm of Suttons in Reading, Berkshire, who after purifying the petal-colour and raising a stock, exhibit the new variety as ‘Etna’, winning an RHS Award of Merit. This work laid the foundation of many other striking colour-combinations.

Morley Benjamin Crane begins a research programme on apple root-stocks with East Malling Research Station. This collaboration later results in the development of the MM and MI series of rootstocks for woolly aphid resistance and to control tree vigour. Crane’s main research is concentrated on elucidating the fertility, sterility, and cross-incompatibilities of fruit trees.
1921 Bateson addresses the American Association for the Advancement of Science in Toronto

‘Evolutionary Faith and Modern Doubts’

In December 1921 William Bateson gives a plenary address to the American Association for the Advancement of Science annual meeting at Toronto. Press reports misrepresent Bateson’s comments on evolution as lending support to the campaign against teaching evolution in state schools. Bateson views the campaign as ‘a terrible example of the way in which truth can be perverted by the ignorant’. In a second lecture to the Zoology section of the meeting titled ‘The outlook of genetics’, Bateson pays homage to T. H. Morgan’s work and announces his partial conversion to chromosome theory but withholds his assent to what he calls the ‘many extensions’ of chromosome theory, including linkage theory. He is en route to visit Morgan’s lab in person and other plant and animal breeding centres in the USA including Cold Spring Harbor, Bussey Institution (Boston), Wistar Institute, and the universities of Pennsylvania (Philadelphia), Cornell (Ithaca), Michigan (Ann Arbor) and Yale.

See also A. G. Cock on Bateson’s two Toronto:


1922 R. C. Punnett’s work supports the chromosome theory

Bateson’s former collaborator R. C. Punnett publishes a comprehensive analysis of the sweet pea in the Journal of Genetics.

The result of his important investigation is consistent with the chromosome theory of linkage.

1921 Bateson visits T. H. Morgan’s laboratory in New York

William Bateson visits T. H. Morgan at Columbia University in New York in December. He spends a week there in laboratory sessions and at Morgan’s home and accepts the principal points of the chromosome theory of heredity.

Bateson was glad that he had visited Morgan and his team to see the cytological work for himself: ‘I was drifting into an untenable position which would soon have become ridiculous’. On his return to JIHI Bateson promotes the study of cytology by appointing W. C. F. Newton

R.C Punnett
1922 T. H. Morgan demonstrates his Drosophila work in England

T. H. Morgan and his Drosophila team come to London. William Bateson arranges for the London branch of Spencer microscopes to lend them as many modern microscopes as they need for their demonstrations at the Royal Society and at the annual meeting of the Genetical Society which is held at JIHI in June. Here Morgan and A. H. Sturtevant demonstrate the brilliant work of the Drosophila school aided by hat-boxes filled with Drosophila melanogaster and D. simulans.

This was one of the most important and successful early meetings of the Genetical Society: 'The enthralled audience [of 120 +] had no difficulty in recognising how greatly Drosophila had contributed to the advancement of genetics... to us it seemed that the vinegar fly was to be regarded as one of the most important immigrants to enter the United States- probably with the bananas from South-East Asia' (Crew, 1969).

At the meeting Bateson's long-time collaborator R. C. Punnett made a 'handsome' retraction of the doubts he had entertained concerning the identification of the chromosome with the physical mechanism of Mendelian heredity but Bateson continued to doubt aspects of the theory until his death.

See also:


Donald Forsdyke, 'Bateson’s enemies after 1926: William Coleman':

http://post.queensu.ca/~forsdyke/bateson3.htm

1923 C D Darlington joins JIHI

After a probationary period in the 'Ladies lab' with Caroline Pellew and Dorothea de Winton, Cyril Dean Darlington is given an 'out-of-date second-hand microscope' and begins cytological research with W C F Newton.

Audio-clip from B Harrison’s interview with C D Darlington describing the circumstances of his arrival at JIHI

From Newton he learns extreme scepticism of all past cytological work, and particularly of the work of British cytologists, John Bretland Farmer, Lettice Digby and Reginald Ruggles Gates.
Bateson, Newton and Darlington are united by a common bond of dislike for Farmer, Gates and E. W. MacBride, the first two they dislike for their (as they see it) unreliable cytological observations, the last for his anti-genetical Lamarckian views. Challenging these biologists gives Darlington’s work direction and momentum until 1930.

Darlington is encouraged to work on three sets of problems. Firstly, studies on the structure, mechanics and division of the chromosomes particularly at meiosis using Liliaceous plants with large chromosomes, this was first done in close collaboration with W C F Newton; Secondly, studies on plants with a known genetic background (and freely available at JIHI) such as Primula sinensis and Prunus species, but with chromosomes that were small and less favourable for study; and Thirdly, the study of variegation by breeding not by cytology, particularly in Vicia faba (broad beans).

Darlington’s first choice is the study of meiosis in large chromosomes, the study of Prunus and Primula is very much a second choice, and the study of variegation is to him a ‘chore’ and an example of assisting the regular staff (in fact, Bateson). Darlington brings all three of these diverse studies to fruition during the course of his career, but it is the first area and the series of papers he produces on meiosis, chiasmata and crossing over and chromosome pairing in diploids and polyploids that, culminating in 1932, makes an immediate worldwide impact.

See:


1923 JIHI work on mangolds results in a new commercial crop

The seed firm Messrs Suttons of Reading, Berkshire, to whom a set of JIHI’s ‘non-bolting’ strain of Golden Tankard mangolds was sent some years ago, sell the seed commercially for the first time.

1924 ‘Progress in Biology’

William Bateson is invited to give an address in March 1924 to mark the centenary of Birkbeck College, London.

In his lecture he pays tribute to T H Morgan and his team of cytologists who had proved ‘some, probably all, of this group of [transferable] characters are transmitted by elements in or attached to the chromosomes. Possibly, . . . the visible distinctions were produced not by the presence or absence of a piece of chromosome material, but by an interaction between the chromosomes as a whole. . . .’

Chromosomes begin to be a feature of Genetical Society meetings.
1924 Bateson visits Scandinavia and debates the ‘chromosome cult’

In August 1924 Bateson is invited by the Swedish Mendelian Society to tour the Scandinavian biological research stations.

He sees experiments directed by Herman Nilsson-Ehle and others and also visits geneticists at Copenhagen and at Stockholm. Bateson comments that ‘collectively, the Scandinavian institutions both in purpose and method have much in common with our own’.

Bateson gives an address on his work. He discovers that the Swedes seem rather ‘half-hearted’ about the chromosome cult and have misgivings about Morgan’s theory. Bateson ‘hammered a few wedges into the cracks’ and was pleased to find support for his distrust of American findings on chromosomes.

1924 Bateson provides advice on sugar beet

Bateson advises the seed firm Messrs Vilmorin of Paris on experiments to eliminate bolting from sugar beet, paralleling methods used at JIHI for mangolds.

1924-25 Expansion of JIHI fruit work

The John Innes Trustees buy 5 acres of land for a new fruit substation and an 8 ft. concrete boundary wall is constructed to prevent pilfering of fruit (the JIHI is surrounded by people who do not have enough to eat). In 1925 the Trustees agree to build a Fruit Room, workshops, a carpenter’s shop and laboratories.

Plants arrive from Wisley for trials of commercial varieties of fruit under a joint committee of the Ministry of Agriculture and the Royal Horticultural Society.

1925 Bateson visits the USSR

William Bateson visits the new USSR to participate in the celebrations to mark the 200th Anniversary of the Russian Academy of Science. He is motivated by curiosity to see the Russian experiment and desires to help restore cultural and intellectual life in that country by reviving scientific interchange.

On his return Bateson publishes an article in Nature giving his impressions of scientific work in Russia. Soviet plant geneticist Nikolai Vavilov commented that Bateson’s remarks were quite true but ‘didn’t please us very much’. However, Bateson was impressed by Vavilov’s Institute of Applied Botany and Plant Breeding near Leningrad (St. Petersburg), housed in one of the former Tsar’s palaces requisitioned by the Communists. Here the main object was to provide varieties of cereals and other economic plants suited to grow in the various climatic regions of Russia.

See also:

1926 William Bateson dies suddenly

William Bateson dies after a brief and unexpected illness on 8 February 1926 at the age of 64. His last paper, ‘Segregation’ is published in the Journal of Genetics. Here he lists his continuing difficulties with chromosome theory, argues that it leaves too many of the problems of heredity and variation in plants unexplained, and concludes that the acceptance of chromosome theory as a general theory of heredity should be postponed. Readers of the Journal, have come to identify Bateson’s ‘Merton years’ with his series of investigations on variegation, bud-sports, root cuttings, and ‘rogues’ in peas.

C D Darlington later wrote: ‘The disappearance of his powerful personality left English genetics looking very empty indeed... the development of genetics was widely resented as a threat to established teaching of botany & zoology in the English universities. The conflict was keenest in the University of London & on the governing body of John Innes itself. Consequently the John Innes Horticultural Institution faced an uncertain future, it was far from clear who Bateson’s scientific successor would be, or in what direction the Institution would be taken.

See: http://jhered.oxfordjournals.org/cgi/reprint/17/12/433

1927 JIHI appoints a new director and head of genetics

Sir Alfred Daniel Hall, who is well known as a former Director of Rothamsted, is appointed Director.

Inexperienced in genetics himself, he appoints J B S Haldane to the staff as part-time head of genetical research.

Hall’s actions and the arrival of Haldane come as a relief to the researchers at JIHI. C D Darlington notes that Hall might well have dismantled the genetics research, or might have followed the promptings of the cytologist R Ruggles Gates, or of E W MacBride or J B Farmer on JIHI’s Governing Council.

By ‘miraculous good fortune’ Hall did none of these things but took Julian Huxley’s advice and recruited Haldane. Haldane went on to develop the application of mathematical theory to genetics.

Under Hall and Haldane biochemical research is introduced at JIHI. A fruit store is equipped as a chemical laboratory with special rooms ‘for polariscope and combustions’ and Haldane announces his intention to start ‘a systematic biochemical study of flower colour variation in the extensive genetical material available’ at JIHI.

1927 Dorothy Cayley discovers the cause of ‘breaking’ in tulips

Dorothy Cayley, JIHI’s mycologist, shows that ‘breaking’ in tulips is caused by a transmissible virus.

The phenomenon of ‘breaking’ in garden tulips had been known for several centuries but the cause was not understood. ‘Breaking’ describes colour variegation of the petals into bicolours; the original colour is broken into splashes, stripes or lines distributed on a white or yellow background. This pretty effect was nevertheless a commercial disadvantage, many tulip growers wanted to ‘rectify’ their tulips to get ‘true’ colours. Dorothy Cayley’s work showed
that colour ‘breaking’ was due to ‘virus or enzyme infection’, probably spread by aphid attack, and that the effect could be artificially produced by bringing the internal tissue of a normal bulb into contact with tissue from a ‘broken’ bulb during the resting stage. Her experiments suggested the degree of breaking was proportional to the amount of infected tissue introduced. Cayley published her results in the *Annals of Applied Biology* in November 1928.

**1927 Hermann J Muller completes important mutation research in USA**

Hermann J. Muller, at the University of Texas at Austin, USA, reports that x-rays cause artificial gene mutations in *Drosophila* in a dose-dependent fashion. During the 1920s Muller established most of the principles of spontaneous gene mutation. In C D Darlington’s office at JIHI Muller’s reprints are kept in a box file annotated with ‘H. G. M.’ and a crown.


**1927 W C F Newton dies and is replaced by C D Darlington**

W C F Newton, JIHI Cytologist, dies at the age of 32. He is succeeded by C D Darlington, and Charles Leonard Huskins is appointed to work on ‘cytology and plant breeding’. A deep antagonism develops between Huskins and Darlington sparked by Darlington’s freedom to pursue his own research and their rival opinions in cytology. Huskins severely criticises Darlington’s book after he leaves the Institution in 1930.

**1928 JIHI launches a summer course in cytology and genetics**

C D Darlington shares a course of 10 lectures with Charles Leonard Huskins comprising the first two-week summer course in cytology at the John Innes Horticultural Institution. These summer courses, which included lectures on genetics by Haldane, were held biennially until World War II and were initiated to fill a gap in higher education in cytology and genetics training. They were usually attended by 30 to 45 undergraduate and postgraduate students from Britain and overseas. The students of London University’s colleges were already offered the opportunity to learn something of the subject from annual visits to JIHI to see chromosomes and the segregating families of *Primula sinensis*, but in the late 1920s there was a feeling that more was needed. There were then only three departments of genetics in British Universities: the Galton Laboratory at University College, London (1904), the Department of Genetics at Cambridge (1909) and the Department of Animal Genetics at Edinburgh (1921). In addition there were a few individuals in departments of Botany and Zoology who were active practitioners of cytogenetics. Consequently opportunities for specialist training in the field were few and far between. Later Darlington commented wryly: ‘The fortnight’s course was regarded as a sufficient and permanent qualification for a teacher in genetics and cytology at most universities. A conclusion flattering to the John Innes Institution but disastrous to the progress of genetics’.
1928 C D Darlington completes important work on polyploidy and on Oenothera

C D Darlington completes two important papers on polyploidy and Oenothera; these are published in *Nature* and the *Journal of Genetics* respectively. On polyploidy Darlington records that his very first idea came in December 1926 when he was travelling to work on the London underground with Alice Gairdner, one of Bateson's assistants and with whom he collaborated on Campanula. They were discussing the effect of polyploidy on fertility, particularly on the tetraploid cultivar of *Campanula persicifolia* ‘Telham Beauty’ and the hybrid *Primula kewensis*. He formulated what became known later as ‘Darlington’s rule’: that there is a negative correlation between the fertility of the polyploid and that of the diploid from which it arose.

This rule became the basis for the study of fertility in species, hybrids and diploids and polyploids until it was added to by Ralph Riley whose research on wheat identified specific genes affecting chromosome pairing.

Darlington’s paper on the evening primrose *Oenothera lamarckiana* united this seemingly anomalous plant with Mendelism, the chromosome theory, and his own theories of meiosis.

On Darlington’s research see also:


1928 Frederick Griffith’s experiments reveal a ‘transforming principle’

British medical officer and geneticist Frederick Griffith, working in the Ministry of Health’s labs on a vaccine against pneumonia infections following ‘Spanish flu’, shows that some component of heat-killed virulent bacteria can ‘transform’ a non-virulent strain to become virulent. The unknown ‘component’ involved is later (1944) identified as DNA.


1929 C D Darlington travels to Iraq, Iran and Russia

In November 1928 C D Darlington is called to the Director’s office and told that he is not co-operating satisfactorily with other members of staff (probably C L Huskins). For this reason he is to be sent to Persia to collect tulips (and anything else of interest) at the joint expense of the Empire Marketing Board and the John Innes, in the company (or custody) of an experienced botanist.

In February 1929 Darlington embarks at Tilbury en route to Iraq and Persia to collect *Prunus* and *Tulipa* species with John MacQueen Cowan, a retired Indian Forest Officer working for the Royal Botanic Gardens at Kew. Cowan’s goal was to collect 5000 specimens of plants in flower, to be dried and sent back to Kew labelled ‘Coll. Cowan and Darlington’. Though
Darlington deprecated the ‘intellectual vacuum’ at the heart of this expedition, the collection of both these genera came to be essential for Darlington’s chromosome studies. These travels also stimulated his later interest in human society. Darlington and Cowan separated at the Russian frontier in June 1929; Darlington went on to make an unescorted visit to Russian geneticist Nikolai Vavilov before returning to England, bearing amoebic dysentery and malaria. Darlington revered Vavilov; his picture hung among the few portrait photographs in Darlington’s lab. Darlington became an activist for Vavilov’s release after his disappearance at the hands of the Russian authorities in 1940.

1929 A D Hall’s *The Book of the Tulip* is published

*A Daniel Hall’s* *The Book of the Tulip* is published in May, beautifully illustrated by Herbert Osterstock’s flower paintings. This and Hall’s sequel *The Genus Tulipa* (1940) were the last occasions that a flower painter was employed at JIHI to illustrate scientific data. Photography became the preferred medium for recording scientific observations.

1929 Rose Scott-Moncrieff begins biochemical work with J B S Haldane

Rose Scott-Moncrieff begins work with J B S Haldane on the chemistry of flower colour with a small grant from the Department of Scientific and Industrial Research. In the early years of their collaboration Scott-Moncrieff is based in the biochemical laboratory of Professor Gowland Hopkins at the University of Cambridge where Haldane holds a Readership. Their experimental material is mainly at Merton where work on the chemistry of anthocyanins can begin on plants of ‘known genetical composition, in order to determine the precise nature of the change produced by a factor’. Haldane puts her in touch with JIHI’s geneticists to begin a biochemical survey of related genotypes. Scott-Moncrieff has already isolated the anthocyanin from purple *Antirrhinum majus* and begins work on the red variety and on flower colour in different races of *Primula sinensis*. Scott-Moncrieff is also mentored by Muriel Wheldale Onslow who in the 1910s worked on the chemical genetics of flower colour variation, first at JIHI and later in Gowland Hopkins’ lab at Cambridge.
1930s Timeline
1930 The first ‘John Innes’ fruit variety is released

A tetraploid blackberry bred by JIHI, which bears large crops of fruit of fine quality, is handed over to Messrs Laxton of Bedford, commercial fruit breeders, to be distributed as the ‘John Innes’ blackberry; it goes on general sale in 1934. This was the first of 49 new fruit varieties released by the Institute over the next five decades.

See: JI fruit varieties in the National Fruit Collection today. Search for apple, cherry, pear and plum varieties using ‘Merton’ as your search term or choose a variety from the ‘JI fruit varieties reference list’

http://www.brogdale.org/nfc_home.php

1930 R. A. Fisher publishes *Genetical Theory of Natural Selection*

Ronald Aylmer Fisher, a statistician at Rothamsted Experimental Station, publishes *The Genetical Theory of Natural Selection*. The book represents a formal analysis of the mathematics of selection and creates a mathematical model of a population of hypothetical organisms. Using complex and innovative mathematical techniques, Fisher demonstrates – among many other conclusions - both how favourable genes spread through a population and how unfavourable variations can survive, maintaining overall genetic diversity.

This work places Fisher as one of three great founders of the field later known as population genetics, together with Sewall Wright and J B S Haldane. The book, though understood by few biologists at the time, fulfilled Wright’s prediction that it would ‘take rank as one of the major contributions to the theory of evolution’.

J B S Haldane
1930s Chemical nature of nucleic acid investigated

Nucleic acid was thought to be a tetranucleotide composed of one unit each of adenylic, guanylic, thymidylic and cytidylic acids. The ubiquitous presence of nucleic acid in the chromosome was generally explained in purely physiological terms.

1930s-40s M B Crane, D Lewis and associates elucidate the genetically controlled incompatibility mechanism in plants and its practical application to economic crops

During the 1930s the study of pollen incompatibility and sterility which has been going on for some years is extended from cherries, plums and apples to pears. Cytological examination of the varieties available begins. Morley Benjamin Crane’s pollination experiments (assisted by W J C Lawrence in the 1920s and A. G Brown from 1935) have allowed fruit trees to be grouped according to whether they are self-fertile (set fruit with their own pollen) or whether they require cross-pollination with another variety. By the end of the 1930s about a million pollinations have been made at JIHI to test the success of crosses that can happen in the orchard, and Crane is able to publish practical rules on which of the main varieties should be planted together to give good crops of fruit and which should not; his advice is regularly sought by fruit growers.

Despite their practical value, these findings in themselves offer no real insight into the genetic mechanisms determining incompatibility relations. The hypothesis that incompatibility relations are determined by a series of allelic genes, denoted by $S_1$, $S_2$, $S_3$, ..., was formulated by E. M. East and A. J. Mangelsdorf in 1925, but it had not been possible to apply this insight to explain the more complicated cases of incompatibility relations in fruit. The first clue came from the young C. D. Darlington’s chromosome counts in a number of *Prunus* species in the mid-1920s which established that sweet cherries were diploid, sour cherries tetraploid and the plums hexaploid. These findings helped to explain some of the complexity in the relationships between pollen and style. Further advances are made by Dan Lewis (Assistant Pomologist) from 1940 using the more amenable species *Oenothera organensis* as a model plant. By inducing tetraploidy in this plant Lewis is able to analyse the relations of pairs of $S$ alleles in detail. Lewis also develops techniques for studying pollen-tube growth in *Oenothera* which he is later able to apply to physiological studies of incompatibility in fruit.

Audio-clip from Brian Harrison’s interview with Dan Lewis in which he talks about his work on incompatibility relations

See also:

*The Fertility Rules in Fruit Planting. John Innes Leaflet No. 4.*, London: JIHI, 1940. On p. 2, Crane estimated that the total fruit crop of the country could be increased 10-20 per cent in value by correct inter-planting.

1930s C D Darlington elucidates cytological mechanisms

In the 1930s, Darlington’s investigations are concerned with pure cytology, with the elucidation of the movements, divisions and pairing of the chromosomes preceding and during the formation of germ-cells. His observations include comparing the behaviour of chromosomes in pure forms with that of the chromosomes in hybrids and various polyploids, where the processes are less regular. For these studies he uses plants with chromosomes that are of large size and in small numbers that can be easily observed. Darlington’s observations are then used to interpret the more difficult cases occurring in species that are the subjects of genetic study at JIHI.

In particular, Darlington’s studies are directed to determining the exact changes undergone by the paired chromosomes during the prophase of meiosis, the critical stage in regard to the mechanism of crossing-over. In general, all Darlington’s observations confirm the chromosome theory of heredity. He concludes that the hereditary properties carried by the chromosomes not only determine the characters displayed by an organism but also the behaviour of the chromosomes themselves.

By 1931, Darlington has fifteen people studying under him, the largest cytological school of its kind in the world (Harman, 2004, p. 83). In the early years, Darlington is assisted in his studies of meiosis by E. K. Janaki-Ammal (in diploid and tetraploid Tulipa), S. O. S. Dark (in the grasshopper Stenobothrus), Kenneth Mather (in triploid Tulipa), and Alice Gairdner (in Campanula persicifolia).

See also:


1930s New directions in genetics

Most of JIHI’s work in genetics, with Primula sinensis and other plants, continues to be concerned with linkage. However, in addition to supplying information on the association and position of genes in particular chromosomes, genetics work is now directed to providing material for testing C D Darlington’s theories of the inner mechanism of the nucleus determining meiosis and mitosis. Linkage studies of plants that have both tetraploid and diploid forms become particularly important. Cytological work is carried out in connection with every species that is the subject of genetic investigation at JIHI.

Alice Gairdner
1930s L F La Cour develops new cytological techniques

In 1929 Len La Cour publishes his first paper on ‘New fixatives for plant cytology’ in Nature. This is followed up in 1931 by ‘Improvements in everyday technique in plant cytology’ in the Journal of the Microscopical Society. These modestly titled contributions mark the start of La Cour’s career as a pioneer in the development of techniques for studying the chromosomes of plants (and animals). By this time he has become highly skilled in the preparation of chromosomes from a wide variety of difficult material from ferns to flowering plants and insects. At the age of 24 he is acknowledged as the expert in this field and he mentors all students who come to JIHI to see chromosomes. His experiments yield important improvements in pre-treatment, fixation, embedding and staining of material. Before his work methods, all using light microscopy, were only just satisfactory for ‘easy’ species with low numbers of large chromosomes. Even simple chromosome counts were fraught with problems, and each species and tissue required different treatments. La Cour’s techniques helped reveal the inner structure and coiling of the chromosomes, and Darlington’s contributions to cytological theory were based on his preparations. La Cour has worked his way up from his first job as a lab-boy, whose tasks at Merton included cleaning windows.

See also:

1931 Geneticists in USA provide cytological proof of crossing-over

Harriet B. Creighton and Barbara McClintock, at Cornell University, Ithaca, New York, demonstrate cytological proof of crossing-over in maize. Their work shows that genetic recombination is caused by a physical exchange of chromosomal pieces. Darlington had laid the foundations of this idea in his work on meiosis in 1929-30. In contrast to ‘classical’ cytological theory, which favoured a system that retained the integrity of the chromosome, Darlington’s theory required breakage and rejoining of chromatids as the cause of crossing-over and the exchange of genetic information.

See:

1931 JIHI affiliates to the University of London for postgraduate research and higher degrees

The liberal policies of the University of London allow workers at affiliated research institutes to register for higher degrees without any formal or informal contact with a college or school of the University. This arrangement remains until 1960.
1931 John Innes Gardeners’ Association formed

In the early days of the Institution, the social and educational welfare of the student gardeners was fostered by means of the Mutual Improvement Society, and the annual Cricket Match against the laboratory staff. The function of the latter fell into disuse as ‘age overtook the staff whereas youth was constantly renewed among the student gardeners’. The new Association inaugurated by E J Collins in 1931 aims to promote a closer union between the Mutual Improvement Association, and the Social and Cricket Clubs of JIHI. It also organizes an Annual Reunion Dinner for past and present student gardeners. In another move to strengthen ties with past members, the Association founds a journal, to ‘keep alive in them the object for which they were brought together — the improvement of Horticulture’. The first number of the Journal of the John Innes Gardeners’ Association appears in 1934 (Gardeners’ is dropped from the title in 1935 and the membership is broadened to include anyone who has worked for more than a year on the scientific or garden staff). The Journal appears annually until 1958 when the title changes to Journal of the John Innes Society, marking the Association’s merger with the John Innes Club to form a new staff society.

1931 Kenneth Mather begins his career at JIHI

In October 1931 Kenneth Mather joins JIHI to begin a three-year Ministry of Agriculture scholarship to study genetics and cytology. He is put to work with C D Darlington, and within four months is writing his first paper on ‘The origin and behaviour of chiasmata’. In 1932, while Darlington is abroad, he collaborates with L H A Stone in the study of chromosome changes induced by X-rays. By carefully timing the irradiation with the visible changes in the chromosome during nuclear division he is able to show that the chromosomes reproduced into two strands recognizable by X-rays long before they were visibly double under the microscope. Mather gains a PhD in 1933 for two published works and two papers that were never published (on the cytology of Lilium and the genetics of Antirrhinum), in place of a thesis. In September 1933 he leaves JIHI to spend the third year of his scholarship under Herman Nilsson-Ehle at Svalöf in Sweden. On his return he gains a post with R A Fisher at the Galton Laboratory, University College, London but continues to collaborate with JIHI workers. He returns to JIHI as Head of the newly formed Genetics Department in 1938.

1932 W J C Lawrence becomes ‘Curator of the Gardens’

A reorganisation of the garden staff in the autumn results in W J C Lawrence taking charge of JIHI’s gardens. The demands that geneticists make on Lawrence's garden staff are high: in the five years from 1931, 45-65,000 plants are raised annually to meet their requirements. Lawrence also becomes responsible for the education and discipline of the student gardeners. Under the old arrangements responsibility for the students was divided between the Garden Superintendent (William Lamberton) and Dr E J Collins (JIHI Botanist); the divided authority ‘had been taken advantage of by some young men and had led to trouble’.
Students receive a regular programme of lectures during their two-year course; in 1932 these are on soils and manures (Daniel Hall), Systematic Botany (E J Collins), Plant Physiology (F W Sansome), Plant Breeding (J Philp), Fruit (M B Crane) and General Horticulture (W J C Lawrence and J Newell). The lectures are supplemented by demonstrations, and students gain practical experience by working in rotation in the various ‘departments’ of the gardens. However, the scheme by which students spend three months of their training each year learning to grow ornamental plants ‘in good style’ is dropped and the ornamental plants are sold. This remains a very intensive course. JIHI’s prestige as a training establishment is reflected each year in the healthy competition for places.

The JIHI gardens continue to be used for the practical examination in Horticulture for the B.Sc. (Hort.) of the University of London.

1932 C D Darlington publishes Recent advances in Cytology and develops cytogenetics

Darlington’s book makes an impact that is ‘immediate and world wide’. At the fifth International Genetics Congress at Ithaca, New York (1932) the leading cytologists John Belling, Curt Stern, Harry Federley and C. L. Huskins devote substantial parts of their addresses to trying to disprove Darlington’s theories. Darlington ‘was given just five minutes to defend his views, and was shouted down by a storm of critics’ (Harman, 2004, p. 84). Across the cytological departments of the United States Darlington’s book is met with hostility. Darlington’s scheme of chromosome behaviour is imperfect; he has to make a priori predictions because technical difficulties mean that no preparations are available to him to test the facts directly. Leading critics, like Karl Sax at Harvard’s Arnold Arboretum, have many objections to Darlington’s generalisations and will not allow him the room to speculate without meeting their high standards of observational truth. His book is regarded as ‘poison for students’. Gradually the objections are retracted and by the end of the thirties Darlington’s scheme has become scientific orthodoxy (Harman, 2004, pp. 90-94, 102-4). His innovative book ultimately secures him a world reputation as a scientist ‘converting the chaos of the cell into the science of cytology’ (Lewis, 1982, p. 162), and his ideas become for a time the backbone of cytogenetics, with many more geneticists adding cytological methods to their work. Darlington’s contribution also means that the evolutionist can begin to use cytogenetic work. Darlington provides powerful arguments in the last chapter of his book, ‘The evolution of genetic systems’, for placing chromosomes at the centre of evolutionary enquiry.
1932-33 C D Darlington visits America and Japan

Darlington is awarded a Rockefeller Fellowship which takes him away from JIHi from June 1932 to September 1933. During this time he is in company with some of the great names of genetics and cytology, spending 3 months at Woods Hole Marine Biological Laboratory (where he meets E. B. Wilson), 2 months in Berkeley, California (E. B. Babcock’s department), 6 months at California Institute of Technology in Pasadena (T. H. Morgan’s laboratory), where he collaborates with Theodosius Dobzhansky and meets George Beadle and Calvin Bridges, and 2 months in Kyoto. Darlington devotes his attention to showing that chiasmata (the X-like figures) corresponded with crossing-over in frequency in various organisms. Using material of maize and *Drosophila* available at Cal Tech, Darlington obtains results that confirm his simplified chiasmatype hypothesis.

On his return Darlington finds that his cytological school has been more or less dispersed and has to be rebuilt with the help of Margaret Upcott and Margaret Richardson. The cytological work progresses greatly, particularly in techniques at the hands of Len La Cour, Margaret Upcott, P. T. Thomas and Pio Koller. Darlington calls his group a ‘school’ because there are no departments at the Institution, only the Director and research workers.

On Darlington’s chiasmatype theory and how it differed from classical theory of the structure of chiasmata,

See:

1932 A landmark in the 'synthetic theory of evolution'

J B S Haldane publishes *The causes of evolution* (1932), a collection of papers elaborating a mathematical theory of evolution, in which he demonstrates that Darwin’s theory of natural selection can be integrated with Mendel’s theory of inheritance to form a coherent account of evolutionary change. For this work Julian Huxley (in 1942) lionised Haldane (along with Ronald Fisher and Sewall Wright) as a founder of population genetics and a leading figure in the ‘modern synthesis’ or ‘synthetic theory of evolution’. Historians have considered the ‘modern synthesis’ either as a project to reconcile hitherto rival schools of biology (especially biometric and Mendelian approaches in Britain), or as a device to limit biological perspectives on evolution within the context of a struggle for institutional resources. Whichever narrative is accepted, it remains true that Haldane produced one of the first works of that enterprise, and that Britain, the home of the ‘Oxford School’ of broad Darwinian thinkers (Haldane’s first University), was very much involved in the effort to bring evolutionary theory into classical genetics (Harman, 2004, p. 112).

See also:


http://en.wikipedia.org/wiki/Modern_evolutionary_synthesis
http://students.washington.edu/gwo/modernsynthesis/

1933 Rose Scott-Moncrieff joins the staff and contributes significantly to the development of biochemical genetics

In December 1933 Rose Scott-Moncrieff joins the staff of JIHI to pursue her studies of the biochemistry of flower colour under the direction of J B S Haldane. She has already collaborated with JIHI staff for several years, and from 1931-32 held the title ‘volunteer worker’ at JIHI. Haldane encourages her to extend her early research on naturally occurring anthocyanins to the quite separate chemical and genetic studies of flower pigmentation that were being undertaken at the time. Armed with experience gained in Professor Robert Robinson’s labs in London and Oxford, Scott-Moncrieff is able to use new and quick qualitative methods; for the first time it has become
possible to analyse whole plant families chemically as well as genetically. Scott-Moncrieff is able to show not only that chemical differences in pigment structure and cell environment are controlled by a single gene, but that these simple biochemical differences are similar and have the same or combined blueing effects upon flower colour throughout all of the families studied. The large range of species at Merton enable Scott-Moncrieff to make a wide survey of colour variations in plants, a survey that reveals surprising uniformity in the nature of gene action. Her work contributes significantly to the development of biochemical genetics: by the end of the thirties the basic biochemical nature of the action of genes involved in anthocyanin synthesis is clear.

From 1934 Scott-Moncrieff offers an annual short course on biochemical and genetical aspects of flower colour variation at the School of Biochemistry in Cambridge for Part II Biochemistry and Botany students. Her work also reaches a wider public through her BBC broadcast on ‘The Colour of Flowers’ in 1936.

**1934 Research on disease-resistant apples goes global**

Investigations into the inheritance of immunity to woolly aphid in apples carried out by Morley Benjamin Crane at JIHI in collaboration with East Malling Research Station continue. Considerable progress has been made in the selection of immune seedlings and the assessment of their value as rootstocks. Representatives of some of the immune clones are sent to Argentine, Australia, Canada, India, Morocco, New Zealand, South Africa and Russia, where they undergo entomological tests to determine whether their resistance to attack will be maintained in different environments.

**1933 J B S Haldane takes Chair of Genetics at University College**

As Professor of Genetics at University College (a part-time post), Haldane begins lectures on plant genetics to elementary and advanced students in London. These lectures are made possible by the generous provision of living and dried plant material, and lantern slides, by the John Innes Horticultural Institution.

**1933 T. H. Morgan wins Nobel Prize**

Morgan receives a Nobel Prize in Physiology or Medicine for his development of the theory of the gene. He is the first geneticist to receive this award.

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**See also:**

1934 Research on ‘John Innes’ composts begins

Only 22 per cent of the Primula sinensis seeds sown in 1933 survive to give living plants. This loss is a catastrophe for the geneticists and results in W J C Lawrence beginning to look for an alternative growing medium. He is helped at the start of his search by Messrs Suttons of Reading whose resident expert on primulas had already devised a successful special compost. Lawrence adapts the recipe, changing three variables at once, and in mid-winter 1934, 1,000 plants die or wilt as before. J B S Haldane said he should be sacked for his foolishness! To prevent another disaster in the 1935 crop, Lawrence begins to investigate the whole procedure of making seed and potting composts. Assisted by John Newell, he makes a large number of tests on the ingredients used for potting composts, including pH determinations, seed germinating capacity, and the effect of steam sterilisation on germination and growth. His aim is to produce a standard sterilised compost giving superior results. By 1935 Lawrence has established the optimum amounts of N, P and K fertilisers and introduced two standard soils for use at JIHI, one for sowing and one for potting, while continuing his investigations. His work pays off: the 1935-36 crop of primulas is one of the best crops the JIHI has ever had and ‘primula wilt’ is eradicated. Lawrence begins to consider whether the composts will work for all species and continues testing. After hundreds of trials, Lawrence arrives at two basic composts, a base fertiliser for use in the potting compost and a standard feed. The formulae of these, as yet unnamed composts, are published in 1938. The name ‘John Innes Compost’ is allotted in 1938-39; the horticultural retail trade in the composts makes ‘John Innes’ a household name.

Before John Innes composts were developed, gardeners and horticulturalists made up their own mixtures. These were subject to so many unstandardised conditions that it was impossible to identify the cause of failures to grow healthy, vigorous plants, and sterilised soil was hardly ever used for potting, either in private or commercial practice. It was common to raise three times as many seeds as the number of plants required to allow for deaths from damping off and other troubles.

See also:
1935 JIHI obtains its first grant from the Ministry of Agriculture

Hit by wider economic recession, the John Innes Trustees are forced to reduce the annual income of the Institution from £21,000 to £18,000 in 1931. In 1935 the loss is partly offset by a Ministry of Agriculture (Development Fund) grant of £885, rising to £1000 per annum in 1940. Daniel Hall obtained the grant to appoint an Assistant Pomologist (Dan Lewis) and another assistant (P. T. Thomas) to help Morley Benjamin Crane with the genetics and cytology of fruit breeding. In 1940 the income of the Institution falls again to £11,000. The Development Commissioners step in with a block grant of £3,000. The supplementary grant is made to reflect ‘the special circumstances in which the Institution finds itself as a result of the war’ and there are no guarantees that it will be renewed annually. From 1st April 1940 the administration of the grant is taken over from the Ministry of Agriculture by the Agricultural Research Council (founded 1931).

1935 J B S Haldane calculates the spontaneous mutation frequency of a human gene

Outside of his work for the John Innes Horticultural Institution, Haldane works on various problems of mutation and selection based on the mathematical tools that he had developed. In an outstanding paper in 1935 Haldane provided the first estimate of the rate of mutation of a human gene based on his calculation of the equilibrium between mutation and selection. Here he established what came to be called the indirect method of estimating mutation rates.

1935 Controversy at the International Botanical Congress

In July C D Darlington publishes three extensive papers on the internal mechanics of the chromosomes in species of *Fritillaria* as determining their movements in the phases of meiosis. This difficult question has become the subject of active controversy; debate is conducted with some animus at the International Botanical Congress in Amsterdam following Darlington’s paper on crossing-over and chromosome disjunction. His former colleague, C L Huskins, is at the centre of arguments against him in all the sessions. Privately, Huskins offers to come across the Atlantic and punch his head off (Harman 2004, p. 88). Cytologists have not seen these processes for themselves, and in their discipline ‘seeing’ is believing; they are intensely sceptical about Darlington’s observations. Darlington’s scheme is complex and many of the details are speculative.

See:

1936 A staff crisis at JIHI results in major reorganisation

Antagonism has developed between the Director A D Hall and some of the old Batesonian staff, and between J B S Haldane and Hall. While the senior member of the old Batesonians, Caroline Pellew, is away in South Africa, the affairs of the Institution come to a head.

Supported by their colleagues, C D Darlington and Dorothy Cayley present proposals to the Governing Council for a new deal. Their demands include that Staff should have written contracts and a fixed age of retirement as in Universities. In breach of normal procedure, the proposals are put direct to the Council, not through the Director.

The reorganisation that follows results in the establishment in 1937 of four new departments: Genetics, Cytology, Pomology and Biochemistry, each with a head and one permanent assistant. Darlington is made head of the Cytology Department.

Hall is asked to stay on as Director following an interview between Haldane and the Council at which Haldane fails to impress with his plans for the Institution. Haldane leaves to fight in Spain in December 1936; his parting shot is a letter to Dame Helen Gwynne-Vaughan, head of the Botany Department at Birkbeck College in London, giving his opinion that while Hall is Director the JIHI should not be recognized by the University of London as a place for training PhD students in genetics.

Haldane, who had originally been appointed on the understanding that he would succeed Hall, formally resigns on 1 October 1937 and takes the Weldon Chair of Biometry at University College, London. During his time at JIHI Haldane has improved standards of accuracy in experimental work, introduced new mathematical approaches to the handling of biological data, and facilitated the development of biochemical approaches to genetics.

Audio-clip from B Harrison's interview with C D Darlington describing the circumstances of the dispute
1937 T Dobzhansky publishes *Genetics and the Origin of Species*

A milestone of evolutionary genetics, Dobzhansky's book is sometimes considered as the first account to embody the spirit and direction of the 'modern evolutionary synthesis'. However, this is to ignore the important early contributions of E. B. Ford's *Mendelism and Evolution* (1931) and J B S Haldane's, *The Causes of Evolution* (1932) in Britain. C D Darlington's *Recent advances in cytology* (1932) initiated a further new strand of evolutionary genetics. He wrote about the importance of recombination as a source of genetic variation available for natural selection and led the field in understanding its evolutionary importance. Darlington's approach and his introduction of the concept of genetic systems is not employed in a wider sense until Dobzhansky's book; Dobzhansky cites him more than any other researcher besides Alfred Sturtevant and Sewall Wright. Through the medium of this book Darlington's ideas come to be incorporated into the mainstream of genetics. Harman explains Darlington's failure to gain the credit he deserved to his 'anomalous position [as] a cytologist extrapolating to evolutionary phenomena' (Harman 2004, p. 113).

For a summary of the many histories of the 'modern evolutionary synthesis' and Darlington's place in evolutionary genetics see:


1938 X-ray diffraction of DNA

William Astbury, a physicist and molecular biologist working at the University of Leeds on X-ray studies of proteins, obtains the first X-ray diffraction pictures of DNA. Diffraction studies of molecular structure, based on passing an X-ray beam through a crystal, had previously been limited to simple chemical compounds. Astbury, whose initial appointment at Leeds in 1928 was as Lecturer in Textile Physics, had been exposing fibres of much more complex protein molecules. His diffraction studies of DNA began in 1937 and revealed that DNA must have a regular, periodic structure. Astbury finds that the spacing between the bases in DNA is the same as amino acids in polypeptide chains. He is unable to propose the correct structure of DNA from his data but his insights prove to be important steps in the investigation.


1938 Plans for Britain's self-sufficiency in food

War with Germany now seems inevitable. Strategies for food and agriculture developed between 1936 and 1938 have formed an important part of Britain's re-armament programme. By 1938 plans for Britain's self-sufficiency in food are well advanced.
1939 The 7th International Congress of Genetics is overshadowed by war

The Seventh International Genetical Congress takes place from 23rd-30th August 1939 in Edinburgh. The Congress, usually held every five years, is two years late, the Russians having abandoned their plan to hold the Congress in Moscow in 1937. The suppression of genetics in Russia has begun and the Russians withdraw ten days before the Congress. Nikolai Vavilov was to have been the President but his place has to be filled by Francis Crew. On Wednesday 23rd August 600 geneticists from 55 countries assemble in Edinburgh. By the end of Thursday 24th August international events begin to take over, the German delegation are the first to leave, followed by the Dutch, Hungarian, Scandinavian and Swiss. The Congress closes prematurely on the 29th of August. At the Congress leading British and American geneticists consider a question set them by the Washington-based Science Service, an organization for communicating science to the public: ‘How could the world’s population be improved most effectively genetically?’ Their response is published in Nature on 16 September 1939. This short statement, later dubbed ‘The Geneticists’ Manifesto’ is often heralded as the moment when geneticists, several of them active in the eugenics movement, spoke out to challenge the scientific and political assumptions of eugenics. J B S Haldane and C D Darlington are among the signatories.

1939 Britain declares war on Germany

On September 1st German troops invade Poland. Adolf Hitler does not respond to Chamberlain’s ultimatum that German troops be withdrawn from Poland immediately. On September 3rd Prime Minister Neville Chamberlain announces on the radio that Britain is at war with Germany.

http://www.eyewitnesshistory.com/vocham.htm

On Britain’s war preparations in 1939, see:
http://www.bbc.co.uk/ww2peoplewar/timeline/

1939 Sir Daniel Hall retires

Daniel Hall retires on 30 September 1939. During his thirteen years as Director the teaching and research activities of JIHI have extended. The number of exhibitions offered to student gardeners increased from eight to twelve and the total staff from 52 to 65. Hall’s legacy includes affiliation with the University of London, and the biennial summer courses in genetics and cytology which bring the Institution into regular contact with teaching and research students. C D Darlington once unkindly described Hall as in the stage of ‘advanced comitteeosis’ when he joined JIHI. However, Hall’s personal connections with the powerful organisations behind agricultural and horticultural research proved extremely valuable to the Institution, both in terms of grants and additional land resources for the extension of fruit trials. Hall’s stature within Britain’s agricultural research community can be gauged by the book Agriculture in the twentieth century: essays on research, practice and organization (1939), a series of essays written in celebration of
his seventy-fifth birthday by some of his old students and colleagues showing the progress in agricultural science and practice since he had begun his career.

1939 C D Darlington is appointed Director and JIHI prepares for war

Darlington’s first job as the new Director is to prepare the Institution for war. The war affects JIHI in three ways: air-raid precautions, enlistment, and food production. Darlington arranges for four air-raid shelters to be built, and for all irreplaceable books and journals to be sent to Long Sutton and Wisley for storage. JIHI’s library is used for monthly Air Raid Protection (A.R.P.) lectures and many members of staff (including Darlington) assist in A.R.P. services. Nearly all the student gardeners and several members of the permanent garden staff have become liable for military service. The depletion of staff is partly made good by the employment of boys. The garden work is reduced to manageable proportions by transferring about half the land from experimental to economic crops. To compensate for the reduction of area under experimental crops and reduce the cost of experiments, genetics work is partly transferred indoors. Kenneth Mather uses *Drosophila* for experiments, with a view to applying the principles to crop plants.

The emphasis of research is re-directed towards the immediate problems of food production in war. Darlington encourages staff to turn to problems of seed production at home so that growers need not rely on imported supplies. M B Crane and Mather work on raising hybrid tomato seed, G H Beale works on beans, Dan Lewis on cucumbers and Crane on marrows. The formulae of the useful seed and potting composts that have been devised by William Lawrence and John Newell for growing difficult experimental plants are more widely publicised, and beginning in February 1939 leaflets on composts, soil sterilization, seed production and fertility rules for fruit-planting are produced and distributed. For some time ‘John Innes’ composts and base fertilizer have been available to the public. The standard ‘feed’ devised at JIHI for use with pot-plants is now being sold by fertilizer manufacturers in two forms: John Innes Feed ‘L’ for liquid feeding and ‘D’ for dry feeding.

Audio clip from Brian Harrison’s interview with C D Darlington on the leaflets distributed by JIHI during the war
1940s Timeline

[Image of a building]
1940 Plans for evacuation and permanent relocation

In October 1940 the Council approves C D Darlington’s plans for the temporary evacuation of JIHI in an emergency. To minimise the expense of removal Darlington suggests that it would be desirable to select a site that will also be suitable as a permanent home. With Daniel Hall’s help Darlington has begun to explore the possibility of moving the JIHI to Waterperry House, a stately home and estate lying in a loop of the River Thames, seven miles east of Oxford. The house, the property of Magdalen College, Oxford, is in use as a Horticultural School for training girls in practical gardening. Early in 1941 negotiations for taking over the lease of Waterperry break down. The reduction in staff due to war work removes the urgency of finding new accommodation and plans for a new and larger site for the Institution are postponed until after the war.

1940 War measures and food production

Three of the scientific staff, J. R. Price (biochemist), H. N. Barber and H. G. Callan (cytologists), are engaged in temporary technical work for the Government. Dr G. H. Beale (geneticist) is in the army.

All of the student gardeners and three of the permanent garden staff are in the armed forces. These men are partly replaced by four junior students, who are later replaced by women gardeners. The garden staff overall has been reduced from 33 to 22. This depleted workforce also has Air Raid Protection duties and regular fire watching to carry out. The reduced labour available means the usual work of the Institution is no longer possible. However, the laborious genetic experiments have been largely replaced by research on food crops, including onions, tomatoes, leeks, carrots, beet and cabbages. In the greenhouses M. B. Crane supervises a programme of tomato and cucumber seed production to supply the seed firm Messrs Carter and Sons. The Institution also begins to cultivate species of drug plants in co-operation with the Therapeutic Requirements Committee of the Medical Research Council, in particular, strains of Digitalis purpurea for the production of ‘digitalin’.

Audio-clip from Harrison’s interview with Dan Lewis explaining why cucumber production was important during the war (to miners)!

1940s JIHI seedling fruit tested at ‘fruit out-stations’

The Institution’s first fruit out-station (in Godstone, Surrey) was arranged by A D Hall in 1931. By 1940 JIHI has twelve stations distributed in seven counties for testing the seedling fruits that result from JIHI’s fruit breeding work (apples, blackberries, cherries, plums, strawberries and pears) on an approximate total of 10 acres. All of this space is given to the JIHI rent and cultivation free.

War has significantly changed the nature of the trials. For example, the 1000 seedling pear trees planted in February 1941 at the Lord Wandsworth Agricultural College, Long Sutton, Hampshire receive no spraying programme for disease control, nor any pruning, manuring or other cultivations after 1943 owing to war-time difficulties. These conditions, though accidental, provide
valuable information on scab resistance.

In 1946 five of JIHI’s seedling cherries (Merton Favourite, Merton Heart, Merton Premier, and Merton Bounty) in the National Fruit Trials at the Kent Farm Institute are given awards by the Royal Horticultural Society. These seedlings were raised in 1921-3. It has taken about 25 years to determine their commercial possibilities.

1940 Outdoor Tomato trials and breeding begin

In 1940 raising tomatoes out of doors is a relatively new practice; traditionally tomatoes are grown in glasshouses. The Pomology Department at JIHI begins a series of experiments on varieties of tomatoes grown out of doors to determine yield, times of maturity, and other characters. These form part of an experiment to compare the best varieties and the best $F_1$ hybrids with a view to using hybrid vigour in practical cultivation. Altogether 45 varieties are grown and the results of the trials are published as John Innes Leaflet no. 5 (1942). The breeding programme aims to bring forward tomato maturing dates to make outdoor growing viable; breeding and selection with bush and dwarf forms to produce a new type is also in progress. In 1947 work begins on rogue tomatoes (off-type plants); the aim is to reduce the percentage of rogues in tomato crops by determining the genetic or physiological cause.

One of the successful varieties raised at Merton is ‘Puck’, a dwarf tomato released in 1946 and notable for its good pollen and fruit setting qualities even in low-temperature conditions. Puck is later used as a parent, particularly in Canada, to introduce these characters into other tomatoes.

1940-48 Kenneth Mather and associates develop statistical approaches to genetic analysis

In 1940 Mather is two years into his appointment as Head of the newly formed Department of Genetics at JIHI. Since beginning his career he has gained experience in chromosomes from C. D. Darlington, in plant breeding techniques from J. V. Rasmusson at Svalöf in Sweden, in statistics and experimental design from R. A. Fisher at University College, London, and in Drosophila genetics and evolutionary theory from A. H. Sturtevant and T. Dobzhansky in California.

Mather’s consuming interest is in the genetics of quantitative characters. Early in his career, plant breeder Sir Frank Engledow told him: ‘If you are interested in genetics and want to help the plant breeder you should study the inheritance of quantitative characters such as yield and height’ and this message has been reinforced through Mather’s association with Svalöf and with Fisher. Using Fisher’s statistical techniques, Mather sets himself the problem of analysing the genetics of quantitative variations. His aim is to answer questions of economic importance in plant breeding and, also, to further understanding of the role of quantitative variation in natural populations and the mechanism of evolution.

Most existing selection and biometrical experiments so far have been done on a one-worker, one organism basis on subjects such as chickens, mice, fruit flies and maize. Mather’s diverse research background means he is able to take full
advantage of data from more than one organism. Each organism has complementary experimental advantages: Mather uses especially *Drosophila* (ideal for multi-generation selection experiments) and inter-fertile plant species such as *Petunia axillaries* and *P. violacea*, *Antirrhinum majus* and *A. glutinosum* (excellent material for studying the effects of polygenes on natural breeding systems). All of the *Drosophila* workers in Mather’s lab also work on plants so that results quickly obtained from fruit flies can be integrated into the planning and interpretation of long-term experiments on plants.

Quantitative characters (characters that show a continuous range of variation in their expression) follow Mendelian inheritance but are the result of the action of many genes each with a small effect, some positive and some negative, and some, but not all, showing dominance. These genes interact with each other and with the environment to determine the course of development of the organism. In Europe these effects have been discussed by geneticists as ‘polymeric inheritance’ and in the United States as ‘multiple factor theory’, which has been applied to guide observations on the inheritance of size, yield, height and other measurable traits (Dunn, 1961, p. 100). Mather coins the term ‘polygenes’ to describe these genes and during the 1940s develops his own theory of polygenic inheritance. His first paper on polygenic variation is published in 1941 and by 1945 seven more have followed. The early work of the biometricians and Mendelians, and Mather’s own work with his collaborators at John Innes, Brian Harrison and Lambert Wigan, is synthesized into the first book on *Biometrical Genetics* in 1949. This book is the first to emphasize the estimation of genetic components of variance for plant populations and explains the basis of quantitative genetic analyses. Its publication marks Mather’s rise to prominence as one of the most distinguished geneticists of his time and his role as founder of post-war developments in the field.

See also:


A selection of Mather’s early articles on polygenic inheritance can be found at: [http://bulnrose.org/Heredity/Mather/polygen1.htm](http://bulnrose.org/Heredity/Mather/polygen1.htm)
1941 Advisory work takes off

As a result of the publication of leaflets (10,000 distributed by 1941) and of broadcasts by M. B. Crane and W. J. C. Lawrence, the advisory work of the JIHI multiplies several times over. Between 1939 and 1942 the Pomology Department receives over five thousand public enquiries. This work has brought JIHI into a closer relationship with horticulturalists in the practical and educational sphere. It has also led to the adoption of JIHI’s improved methods of raising garden crops. In mid-1941 JIHI estimates that in England 40% of the larger commercial growers and 17% of the smaller ones have adopted the use of John Innes composts. The advance has been less rapid in Scotland. During the 1940s there are many requests for talks on the JI composts and on the new methods of cultivation under glass.

In 1943-44 the first instructional film is taken at John Innes, a colour cinema film to illustrate John Innes Leaflet no. 4, ‘The fertility rules in fruit planting’ (30,000 copies of this leaflet have been distributed since its publication in 1941). The first sequences shot include pollen development, fertilization, and fruit formation. The film is aimed at fruit farmers and teachers.

1941 One gene, one enzyme

At California Institute of Technology, USA, George Beadle and Edward Tatum’s experiments on the red bread mould Neurospora crassa show that the function of genes is to direct the formation of enzymes which regulate chemical events. They propose that in general each gene directs the formation of one (and only one) enzyme – affirming the ‘one gene, one enzyme’ hypothesis. This hypothesis, which Hickman and Cairns (2003) argue began with French biologist Lucien Cuénot in 1903, is usually attributed to Archibald Garrod and his pioneering work on ‘inborn errors of metabolism’ (1903). William Bateson also suggested in 1909 that certain Mendelian traits were due to the presence or absence of an enzyme.

For further information on Beadle and Tatum’s experiments:

http://www.genome.gov/25520248

http://www.genetics.org/cgi/content/full/166/1/1

For a discussion of Archibald Garrod’s seminal lecture series (1908):

http://www.encyclopedia.com/doc/1P3-1487595401.html

1942 Kenneth Mather and the Russian controversy

In 1942 Mather publishes a critique of the Russian government’s opposition to genetics in Nature. Unlike many fellow geneticists he does not emphasize the unscientific nature of plant science in Russia under the leadership of Trofim Lysenko but gives a measured appraisal of the development of genetics over 40 years. He acknowledges that genetics has neglected aspects that are of importance to the breeder (that is, the study of quantitative characters) and has consequently disappointed those looking for a practical return. Affirming his commitment to the study of
polygenes Mather concludes: ‘What is required is experimental research in polygenic behaviour, so that genetical theory may be enlarged until the full potential value of genetics to evolutionist and breeder is realized’.

See also:

On the Lysenko affair:
http://www.sciencedirect.com/science?ob=ArticleURL&udi=B6V81-4HGM724-4&_user=1549459&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&acct=C000053657&version=1&urlVersion=0&userid=1549459&md5=2daa3363ff7bc318d601061b6b5ef2a5

1942-45 Isolation requirements of seed crops
To help plant breeders who are struggling to maintain the shortfall in seed supplies arising from the loss of imports from central Europe, workers at JIHI set out to solve the problem of establishing the adequate isolation distances of seed crops to ensure the purity of the stock. Kenneth Mather, M. B. Crane and A. J. Bateman devise and execute experiments to measure the amount of pollen carried over distances from 1 to 100 metres. The work begins with radishes and turnips (self-incompatible and insect pollinated), beet (self-incompatible and wind-pollinated), and maize (self-compatible and wind-pollinated) and is extended to other crops. Their findings are surprising in that after 1-2 metres the pollen flow falls to very low levels with no further reduction over 100 metres; this is in sharp contrast to the repeated references of growers to much larger contamination distances. The practical result is that the land used for seed production can be reduced without fear of increasing the contamination. Bateman’s experiments are published in a series of papers in Journal of Genetics (1947 (Aug.), 48: 257-275) and Heredity (1947 (Oct. & Dec.), 1: 235-46 and 303-36).

1943 A new tool for plant breeding- the Colchicine method
Colchicine, a poisonous alkaloid drug obtained from the seed and corm of the autumn crocus (Colchicum autumnale), is introduced as a research tool in plant breeding work at JIHI. Since the mid-1930s there has been an explosion of publications on colchicine around the world, particularly from 1938 to 1942, after a research group in the pathology lab at the University of Brussels established that this molecule acts dramatically upon mitosis in animal and plant tissues. The migration of colchicine research from medicine to plant breeding is accelerated when geneticist Albert Blakeslee of the Carnegie Institution at Cold Spring Harbor, New York, reports in 1937 that colchicine produces polyploidy in plants. Such is the interest in the general cellular effect of colchicine in biological communities that scientists are talking about a ‘colchicine fad’.

The first recorded experiments on colchicine at JIHI take place in 1937 in the Cytology Department as part of their research on cell division. Colchicine is of interest because it implies control over dividing cells, and chromosomal numbers in plant cells frequently double after treatment (because colchicine...
inhibits the spindle fibres so that sets of divided chromosomes fail to separate and are enclosed in a common nuclear membrane). The multiplication of chromosomes is also often associated with desirable traits in the plants such as being larger in size and more robust. Hence the ‘Colchicine Method’ is seen as potentially useful for making artificial polyploids (plants with cells that contain multiple, complete sets of chromosomes). In many cases colchicine is found to be much more effective in inducing polyploidy than the ‘heat-shock’ treatments that are already in use.

By the early 1940s many experiments are underway at JIHI to produce new polyploids. These studies have gathered sufficient momentum by 1943 for C D Darlington to announce ‘the invention of new methods of making polyploid plants’ (by P. T. Thomas in the Pomology Department) as a major branch of plant breeding work at JIHI. The intention is that the new polyploids will be used either to produce new hybrids, or to preserve existing hybrids by restoring their fertility. For the first time the prospect of creating new ‘synthetic’ plants is opened up and the term ‘genetics engineer’ is already in circulation. Much later, the possession of this new molecular tool was important in getting biologists to think of biological processes in molecular terms (Goodman 1998).

1943 Discovery of Streptomycin

The success of penicillin stimulated Selman Waksman, a soil microbiologist at Rutgers University in New Jersey, in 1940 to examine the collection of actinomycete bacteria that he had assembled over thirty years for antibiotic production. Soon after, in 1943, Waksman’s group discovers streptomycin, a natural product made by the bacteria *Streptomyces griseus*. By 1947 streptomycin – commercialised by the American pharmaceutical company Merck and Co., who had supported Waksman’s research- proves to be wonderfully successful against tuberculosis, a major killer disease worldwide for which there has been no effective drug treatment. Streptomycin is also effective against several other diseases and its discovery is followed by the finding of many further antibacterial and antifungal drugs. The actinomycetes shoot to fame from relative obscurity and many actinomycete products are discovered in the 1950s and 1960s in a period afterwards regarded as the ‘Golden Age’ of antibiotic discovery.

See also:


Streptomyces genetics will form a major line of research at John Innes after 1968.

See: Biographical information on Selman Waksman

For a history of research on Streptomyces see:


1943 Working courses replace JIHI’s summer schools in genetics

The biennial summer courses in cytology and genetics held at the John Innes from 1928 to 1938 have been interrupted by war. These courses were introduced to try and remedy the shortage of recruits trained in genetics. Between 1943 and 1948 Kenneth Mather re-introduces the tradition of providing genetics training at JIHI with a series of working courses, held each year in July and August, for the special service of the Genetics Department. Nevertheless the Institution still finds itself, like other research stations, lacking applicants trained in plant breeding. The Institution has to recruit staff from other countries, from non-botanical departments, or engage undergraduates for training. There is still a pressing need for the establishment of new genetics departments in British universities to produce the new generations of geneticists.

1943 Experiments on new methods of raising plants

W J C Lawrence has achieved highly standardised techniques for the preparation and use of seed and potting composts; he now has ambitions to standardise the methods of handling plants. Fulfilling this objective involves the Garden Department at JIHI in many experiments to test the effects of various plant treatments between 1943 and 1950. The results, summarized in Lawrence’s *Science and the Glasshouse* (1948, 1950), bring the standard of cultivation at Bayfordbury to new heights.

The experiments begin in February 1943 when Lawrence and John Newell notice that two pans of tomato seedlings, differing only in pricking-out dates, show marked differences in growth. Lawrence’s follow-up experiments confirm that early pricking-out gives much better growth. Lawrence’s findings are against traditional horticultural methods which pre-suppose that it is better to move seedlings when they have grown to a decent size, rather than when they are young and delicate. In tomatoes the gain from early pricking out is found to be 25 per cent early yield. Lawrence publicises the advantages of early pricking-out and other plant treatments in illustrated public lectures and leaflets.

See also:

1944 Flying bomb offensive hits JIHI

Until 1944 damage to the Institution from enemy attacks has been slight. Only one bomb, which fell in the Old Garden in May 1941, directly damaged the premises. A serious attack in the neighbourhood in February 1944 also leaves the Institution unscathed. The flying bomb offensive launched in June 1944 is more prolonged, and in the Merton locality, more dangerous than previous attacks. One of the first flying bombs kills the Assistant Secretary to the Council of JIHI. Between June and August 1944 eight flying bombs damage the buildings and private houses of the Institution but there are no further casualties. The last of these bombs, falling on the Sunday afternoon of August 20th, causes extensive blast damage to glasshouses, and the windows, roofs and ceilings of JIHI’s main buildings; the main water pipes are also fractured. Despite a general scene of ‘appalling desolation’ no books are destroyed and very little apparatus lost. Nor is there any structural damage to the buildings. Most of the immediate problems with the buildings are quickly rectified and within a fortnight work is again possible. The glasshouses take longer to replace - it is not until November that glass (cloudy glass) becomes available. Many of the trees, crops and experimental plants are ruined and some (for example, the entire Antirrhinum crop) are totally obliterated. As a result of the damage the greater part of the breeding work of the year is spoiled, jeopardized or delayed.

1944 Colour photography is introduced to JIHI

Since H. C. Osterstock’s death in 1942 the Institution has felt the need of a means of representing fruits, flowers and microscopic objects in colour. They could not expect to replace Ostertock in skill of painting but in 1944 obtain the advice of an expert colour photographer, G. D. H. Waddington. The Institution purchases new photographic equipment and Waddington agrees to make a series of colour photographs of important fruits, flowers and vegetables, and especially new varieties raised by the Institution. Waddington also trains Len La Cour and Gavin Brown in the ordinary techniques of colour photography. A new senior photographer, L. S. Clarke, is appointed in July 1948 to fill Osterstock’s long-vacant position.

1944 DNA is ‘transforming principle’

Physician and medical researcher Oswald Avery at Rockefeller University Hospital in New York City, with co-workers Colin MacLeod and Maclyn McCarty, shows that DNA can transform the properties of cells. Avery and his team’s experiments on Streptococcus pneumoniae followed up the work of Frederick Griffith who in 1928 showed that some component of heat-killed virulent bacteria can ‘transform’ a non-virulent strain to become virulent. Avery and his colleagues working in the early 1940s demonstrated that the ‘transforming principle’ identified by Griffith was not some kind of protein as had been supposed but was a substance rich in nucleic acids. This agent (DNA) was able to produce heritable change in organisms. Avery’s work helped
clarify the chemical nature of genes but scientists, who thought that chromosomal proteins carried hereditary information, were sceptical until the early 1950s. By that time biochemists no longer regarded DNA simply as a structural chemical in chromosomes with a relatively unimportant role but as the key transmitter of genetic traits.

http://www.genome.gov/25520250

1944-48 Jumping Genes

Barbara McClintock, working on colour variations in maize at Cornell University and later at the Cold Spring Harbor Laboratory, develops the hypothesis that genes can jump around on chromosomes. The classical model of genetics at this time assumed that genes had fixed positions on chromosomes but McClintock’s experiments suggest that genes can be transposed from one position to another. During the 1940s and 1950s McClintock’s microscopic studies of this phenomenon show how genes turn physical characteristics on or off. McClintock’s astonishing finding that genes can move was not accepted by the biological community for many years since it conflicted sharply with the assumptions underlying the core work of geneticists. The construction of linkage maps and the physical mapping of genes onto chromosomes presupposed a regular relationship among genes. The importance of McClintock’s work on transposition was not widely recognised until the late 1960s, and only then after the discovery of similar jumping genes in the bacterium Escherichia coli, wherein they could be studied much more precisely by molecular methods, which put their existence beyond doubt. Jumping genes (now called transposons) were subsequently found in all kinds of organisms from bacteria to humans. McClintock was awarded a Nobel Prize in 1983.

For further biographical information see:
http://www.nap.edu/html/biomems/bmcclintock.html

1945 Britain celebrates V E Day

On 18th May 1945 Britain and her western allies celebrate victory over Hitler’s army. The war is over in Europe but the problem of adequately feeding the nation remains. Food rationing, which was introduced in Britain in 1940, will remain in place until 1953. Raising the home-production of food remains a priority for Government.

http://www.bbc.co.uk/ww2people/timeline/1945

1945 The John Innes Trustees purchase Bayfordbury Estate

In 1943 the John Innes Trustees approach the Charity Commissioners for sanction to sell the land and buildings at Merton and to acquire a new property. With permission obtained, C. D. Darlington is asked to look for a suitable site for relocating the Institution. The flying bomb damage in August 1944 adds urgency to the search. Darlington considers forty possible sites before finding one in March 1945 that seems to satisfy the varied requirements of the Institution. This is Bayfordbury Park in Hertfordshire located 16 miles north of London on the edge of the green belt, overlooking the River Lea and standing one mile
southwest of Hertford. The Trustees agree to purchase the mansion, farm buildings, stables and cottages and most of the land (together including 372 acres) and the purchase is completed on 12 December 1945. The new setting for the Institution is rather grand: the 80-room mansion, framed by magnificent cedars, was built in 1759 by William Baker and is set in a mature park designed by John Claudius Loudon. In recent years (until September 1945) the estate has been let to Dr Barnardo’s Homes.

1945 Experiments on glasshouse design

As ‘Curator of the gardens’, W J C Lawrence is charged with the task of designing the new glasshouses at Bayfordbury. He has to begin ‘with not a single piece of scientifically derived information on glasshouse design’. He starts to systematically monitor the effects of orientation, ventilation and heating systems. Model glasshouses are constructed at Merton to test orientation effects. This data helps Lawrence to formulate plans for the Bayfordbury glasshouses; these are prepared ‘to make the whole new construction into a large experiment’. Topics for investigation include the behaviour and durability of glasshouse materials; efficiency of natural light and heat loss under different designs; variables affecting glasshouse climatology; efficiency of ventilation, and the effect of humidity. The Bayfordbury glasshouses are erected 1948-1950 and cover nearly an acre with glass. Two innovations, new to Britain, are included in them: forced ventilation with humidification, and automatic ventilators.

The end of six years of blackout restrictions means that Lawrence is also free to experiment on artificial illumination (something he had tried unsuccessfully in 1936); he begins with a purchase of seven fluorescent lamps in December 1946, the first purchase he has ever made for pure experimental work. These lamps increase the yield of the early crop of tomatoes by 55 per cent. Between 1947 and 1953 tests on fluorescent, mercury, neon and sodium light sources proceed. The practical results are published in 1952 and the full scientific results in 1954.

See also:


1946 JIHI becomes a grant-aided station of the Ministry of Agriculture

The Ministry of Agriculture’s small grant-in-aid of the Pomology Department, first awarded in 1935, is greatly increased in 1942. However, spiralling costs after the war make it necessary for the JIHI to seek further assistance from the Ministry. The John Innes Trustees successfully apply for a permanent maintenance grant (initially £16,000 p.a.) in September 1946, which becomes effective from 1 October 1946. To conform to Ministry practise, the Institution’s financial year is changed to begin on 1 October instead of 13 January (a date deriving from the inauguration of the Charity Commission Scheme in 1909). The Ministry also agrees to meet the capital cost of converting the buildings at Bayfordbury and of building a glasshouse unit for the use of the Institution.

This was a serious step; the JIHI had been one of very few research institutions in Britain which had been able to carry on without Government assistance and it had valued its independence. However, the needs of the Institution had outgrown the resources of the John Innes Charity. Three factors were important in bringing about this change: first, the general rise in scientific salaries; second, the expansion of other research stations, and third, the planned development of a national training service in agriculture after the war. The first two changes made it impossible to continue research on a satisfactory scale without Government help. The third made it unlikely that the previous system of training student gardeners at JIHI could ever be restored.

1946 C D Darlington attacks science in Soviet Russia

In December 1946 Darlington sends a scathing article on ‘The retreat of Science in Soviet Russia’ to the editor of the popular journal *Fortnightly Review*. Darlington has long maintained strong views about the suppression of genetics in Russia and believes that the JIHI is one of the few places ‘perhaps the only place’ where the full enormity of the statements being put forward by the Soviet school can be grasped. He has held back to protect his scientist friends there; now all but one are dead.

Darlington fails to get the article published in *Fortnightly Review* or *Nature* but is able to place it in *Discovery*, a scientific magazine. Darlington’s condemnation of ‘the official overthrow of truth and reason’ in Russia earns him the support of author George Orwell but not all Western scientists are convinced that attacking the Soviet regime is the right strategy. Over the next year the situation in Soviet genetics worsens; in August 1948 Mendelian genetics is officially denounced, institutions are closed, and geneticists are made to recant. Lysenkoist (Lamarckian) science becomes official Soviet biology. The political dimensions of these rival theories of inheritance also preclude serious debate over cytoplasmic inheritance in the West.

See also:


On the Lysenko affair:
http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V81-4HGM724-4&_user=1549459&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000053657&_version=1&_userid=1549459&md5=2daa3363ff7b318d601061b6b5ef2a5


1947 CD Darlington and R A Fisher found the journal Heredity

C D Darlington co-founds Heredity: An International Journal of Genetics with the biological statistician Ronald Fisher. They address this new journal to botanists and zoologists with interests in evolution and systematics; to physiologists (cytology and experimental technique); to medical researchers (diagnosis and treatment); to social scientists studying nature and nurture; to agriculturalists engaged in plant and animal breeding and finally to physicists and chemists seeking to bridge the gap between their sciences and biology. Underlying this broad appeal is the belief that genetics is a key causal framework for biology, social sciences and medicine. Darlington and Fisher are self-consciously striking out the narrow limits of Bateson's Journal of Genetics. Privately Darlington is also motivated by difficulties getting his own work published in peer-reviewed journals (paralleling Bateson's early experiences). Some of his submissions have been rejected as too cytological for Journal of Genetics, not experimental enough for Journal of Experimental Biology or have been excluded from the Proceedings of the Royal Society by hostile reviews from his rivals John Farmer and Reginald Ruggles Gates. Additionally Darlington wants to be able to publish his judgements on a range of issues uncensored. Fisher is deeply interested in the project, especially explorations of genetics and man, but it is Darlington who effectively acts as editor of the new journal.

See also:
1947 Advanced horticultural training ends

The Student Gardener scheme has been in suspension since the outbreak of war due to the lack of available students. In April 1946 JIHI takes on twelve new students under the Ministry of Agriculture’s scheme for training former service men and women in horticulture. In April of 1947, however, the Institution is compelled to give up its part in the scheme owing to the heavy demands on the still depleted staff from the planned removal to Bayfordbury. The Institution’s activities in the advanced training of gardeners, inaugurated in 1910, have come to an end.

The Governing Council express regret at this decision since the training scheme was the branch of work that most faithfully represented the original interests of the founder, John Innes. In future, special horticultural training will be provided by Universities, Agricultural Colleges, and Farm Institutes. The staff at JIHI feel that these facilities will not entirely remove the need that was met by the provisions of their Foundation and worry that they will not readily find such a source of expert craftsmanship as they have had in their Student Gardeners. The hope that JIHI might offer horticultural training again after the removal is complete is not realised. It is decided that it is not longer possible to continue the training programme for gardeners without detriment to the research work of the Institution.

1947 Agriculture Act

In a climate of post-war austerity, the British government introduces measures designed to deliver stability and prosperity to farmers in a bid to increase the home-production of food. Government initiatives help to increase investment in new technologies (including new crop varieties) in agriculture and in the long-term farmers achieve marked increases in production.

See also:


http://www.nfu100.com/x176.xml?StartDate=08/06/1947
http://www.ecifm.rdg.ac.uk/postwarag.htm

1948 Fruit and the Soil

Some 62,000 copies of the John Innes Leaflets series have been sold by the Institution since they were first published in 1940. In March 1948 a collected edition titled Fruit and the Soil is published by Oliver and Boyd. This booklet comprises revised and enlarged versions of the six leaflets already issued and a new leaflet by Angus Bateman on growing pure seed, based on his experiments. This edition of 4000 copies is sold out in June and a revised edition The Fruit, the Seed and the Soil (1949) is prepared. This includes three new leaflets: Raising Plants in Soil Blocks, Making New Plants (the Colchicine Method) and Sweet Corn in England.
1948 National Rose Species Collection founded at John Innes

In 1945 the Agricultural Improvement Council forms a scheme to establish national collections of shrubs, roses, and bulbs. The aim is to make the collections as complete as possible at each centre so that they will be ‘unique and of international interest’. Collections are formed at the Royal Botanic Gardens, Kew (Dianthus); Cambridge University Botanic Garden (Tulipa; Narcissus); the Royal Horticultural Society, Wisley (Dahlia and Chrysanthemum); and the Royal Botanic Garden, Edinburgh (Narcissus). The John Innes Horticultural Institution is selected as the centre for roses with the brief to co-ordinate research on practical problems of interest to rose breeders and growers.

The nucleus of a ‘National Rose Species Collection’ is assembled at the John Innes Horticultural Institution in Merton, Surrey, shortly before the move to Bayfordbury in Hertfordshire in 1949. To look after the collection the JIHI receives £300 a year for a whole-time foreman-gardener and £50 a year for ‘incidental expenses’. This is the largest grant awarded under the scheme. From 1948-1961 the Institution employs Gordon D. Rowley as ‘Keeper of the Rose Collection’. About five acres of the heavier land adjoining the mansion at Bayfordbury is set aside for the collection which begins with the wild species already existing in botanic gardens. One of Rowley’s first tasks is to rename the plants in public collections that were disorganized by war.

C. D. Darlington sees the rose collection as an opportunity for a long-term model experiment in the classification of a genus. Chromosome studies are an indispensable tool in the new systematics, which includes the study of geographical distribution, comparative morphology and breeding relationships. For growers the JIHI promises new methods of raising new stocks and new varieties, of improving germination, and producing polyploids. Over the next ten years JI will use chromosome studies to assist breeders in planning crosses, test techniques to speed germination and make field trials of different rootstocks.
**1948 Angus Bateman studies promiscuity in fruit flies**

Angus Bateman, a member of the Genetics Department at John Innes since 1942, publishes his observations on the mating behaviour of fruit flies in *Heredity*. Bateman has been combining groups of *Drosophila melanogaster* in vials, each fruit fly carrying a different dominant genetic marker. He is able to measure the reproductive success of each individual by counting the number of times the marker appears in the next generation. These experiments lead him to formulate what later becomes known as 'Bateman's principle' or the theory that females almost always invest more energy into producing offspring than males, so that in most species females are a limiting resource over which the other sex will compete. He also concludes that promiscuity is more advantageous to the male than the female; hence males have evolved an 'undiscriminating eagerness' to mate and females a 'discriminating passivity'—a fundamental sex difference that Bateman suggests applies even to humans.

‘Bateman’s principle’ became one of the grounding paradigms of behavioural biology, though later research has demonstrated many exceptions and counterexamples.

See also:

Donald A. Dewsbury on the ‘Darwin-Bateman paradigm in historical context’:
Jonathan Knight on Bateman and sexual stereotypes

**1948 Kenneth Mather becomes Professor of Genetics at Birmingham**

In October 1948 Kenneth Mather leaves the John Innes Horticultural Institution to take up the newly established chair of genetics at the University of Birmingham. In 1949 he is also appointed Director of the Agricultural Research Council’s new Unit of Biometrical Genetics at Birmingham marking the start of his leadership of an influential ‘Birmingham School’ of biometrical genetics. The Birmingham school is one of two institutions dominating statistical genetics in post-war Britain; an Edinburgh school of ‘quantitative genetics’ being the other major research group.

C. D. Darlington comments: 'It was clear that Dr Mather was marked out to found a new school of genetics and, while his loss is a severe blow, there is no doubt of the service he will be able to render us in his new post. A lack of recruits trained in genetics has long been a problem for the Institution'. In recognition of the work he completed during his time at the John Innes Mather was elected a Fellow of the Royal Society in 1949. Dan Lewis succeeds Mather as head of the Genetics Department at JIHI.

See also:

1949 The John Innes Horticultural Institution moves to Bayfordbury

The removal of the Institution takes place between 22 August and 18 October 1949. The operation consists of three stages, all undertaken by contractors. In Stage One, the personal possessions of staff are moved (several staff live on site both at Merton and Bayfordbury). In Stage Two, the movable buildings and the contents of the workshops, offices, laboratories and library are transferred. Finally, the trees, shrubs, herbaceous plants and seeds in the care of the Garden Department are moved. During November and December the gardens at Merton are gradually cleared so that at the end of the year nothing remains except the glasshouses which are to be sold by auction in January 1950. The whole estate at Merton is transferred to Surrey County Council. At Bayfordbury, noise, dirt and displacement are suffered by JIHI staff well into 1950.

1949 The John Innes Club is re-activated

The reconstituted John Innes Club opens at Bayfordbury on 22 October 1949. The club (which in pre-war days catered mainly for the student gardeners and younger members of the laboratory staff) has been in suspension since the beginning of 1940 because most of its members joined the forces. The Committee forms three sections to cater for the social, sporting and cultural activities of the Club. The first section arranges a dance in November and Christmas, New Year and children’s parties. The second section arranges table tennis and billiards in the Mansion and a squash court for use in winter. Two hard tennis courts are being prepared for the summer. The third section arranges musical evenings and produces several plays. A fourth horticultural section is added in 1950. This section is open to any member of staff whether members of the Club or not. Its objects are purely educational and the organizers arrange lectures, film shows, brains trusts on gardening matters and visits to places of gardening interest. Bayfordbury is removed from the amenities of a town, so the Club assumes more importance than in the past in catering for the social welfare of the staff.

1949 Darlington and Mather publish Elements of Genetics

Comparatively little was published in genetics during World War II. After the war the first major textbook of genetics to be published was Cyril Darlington and Kenneth Mather’s The Elements of Genetics (London: MacMillan). This widely-used textbook was influential enough to be reprinted, with a new introduction by Darlington, in 1969. It is salutary to look with hindsight at some of the descriptions of key genetical events in the original 1949 publication, notably the idea that the nucleic acid ‘coat’ was ‘thrown off’ the chromosomes at a particular stage in cell division. Evidently the cytogeneticists at John Innes had not been impressed by the results of the Avery group on the ‘transforming principle’ (DNA).
1950 Bayfordbury officially opens

The official opening of the John Innes Horticultural Institute at Bayfordbury takes place on Friday, 2nd June attended by 500 guests, including Lord Rothschild, Chairman of the Agricultural Research Council and representatives of 15 countries. Visitors are welcomed by Colonel F. C. Stern, chairman of Council, and are able to see the buildings, demonstrations of work in the laboratories, the experimental plots and the newly completed glasshouses. The occasion is described in Nature on June 17th.

A village, known as Broad Green, has been built for the married staff and twenty families are now accommodated on the estate.

1950 Flower pigment research begins again

Research on the genetics and chemistry of anthocyanins carried out at Merton from 1930 to 1940 had to be terminated through war-time lack of staff. Since then the advent of paper-chromatography methods, first introduced to biochemistry in 1941 to separate and identify mixtures of compounds that are, or can be coloured, has simplified methods for studying the anthocyanins and has opened up new fields of pigment research. It is now possible to analyse flavones and similar compounds; formerly the analytical techniques available were too laborious and the quantities of material needed too large to make genetic work with flavones practical. In 1950 work on flower pigments resumes at JIHI with investigations of anthocyanins and flavones in Antirrhinum, Rosa, Primula sinensis and Chrysanthemum maximum. The JIHI staff are trained in chromatography methods by E. C. Bate-Smith and T. Swain at the Low Temperature Research Station in Cambridge.

1950 Weekly seminars resume

Weekly seminars were given by the staff and visitors to the Institution in the winter season from 1911 to 1915, from 1920 to 1926, and were continued irregularly from 1926 to 1939. They were completely interrupted during 1939-1946 and again from 1948-1949. At these seminars the chief genetic discoveries of the last 40 years have been propounded. Among the speakers have been Baur, Beadle, Biffen, Blaringhem, Bridges, Buller, Chambers, Fisher, Goldschmidt, Goodspeed, Gowen, Haldane, Harland, Johannsen, Lotsy, Mohr, Morgan, Muller, Punnett, Seifriz, Sturtevant, Vavilov, Watson, and Winge. The weekly seminar programme resumes at JIHI in October 1950.

1950 Garden Research Department established

In recognition of the fruitful work that William Lawrence has overseen as head of the Garden Department, and to relieve him from routine work, Darlington puts Lawrence in charge of a new ‘Garden Research Department’. John Newell becomes ‘Curator’ in charge of the gardens in his place. Lawrence’s services to horticulture are also recognised by the award of a Royal Horticultural Society ‘Victoria Medal of Honour’ in this year. One of the new projects that Lawrence oversees is the study of glasshouse climatology, aided by the appointment of a physicist, Dr Raymond Whittle, in 1952. The experience gained during these studies is later put to use in the design and
operation of JIHI’s new controlled growth rooms. Lawrence (1980) wrote:

‘I doubt if members of the JI staff during the 50’s will ever forget Raymond Whittle’s array of instruments which from time to time, ‘cluttered up’ one house or another, to the incredulity, and sometimes chagrin, of the genetical staff! There were radiometers, solarimeters, recording photometers that clicked up the foot-candle-hours, electrolytic dc light integrators, potentiometric recorders, electrical resistance thermometers, power meters, katharometers, ratemeters, and from time to time, during the recording of ventilation rates, the glasshouse air would be contaminated by hydrogen, krypton and argon gases also common smoke’.

The glasshouse climatology experiments attract many visitors; Whittle and Lawrence summarise their conclusions in a series of five articles in the Journal of Agricultural Engineering Research in 1960.


1950s Research on hybrid vigour brings new John Innes varieties

The Pomology Department sees results from its breeding programmes on tomatoes and sweet corn which use hybrid vigour to produce new varieties. Others had published theoretical studies of hybrid vigour using tomatoes and sweet corn in 1937 and 1939, but there were no investigations on hybrid cultivated tomatoes in England until Morley Crane, Kenneth Mather and Gavin Brown commenced a study of hybrid vigour as measured by increased fruit yields in 1939. These experiments have continued annually at JIHI, both at Merton and at Bayfordbury, and have led to the introduction (in 1952) of two successful John Innes F1 hybrid tomato varieties. Trials show that ‘Hertford Cross’ and ‘Ware Cross’, are capable of higher yields and earlier and better quality fruits than either of their parents or other varieties tested with them. Both varieties receive the Royal Horticultural Society’s Award of Merit in 1958.

Two other new JIHI tomato varieties are released in 1950-51, ‘Antimold A’ and ‘Antimold B’; these are resistant to leaf-mould disease (Cladosporium fulvum). Though initially of interest to growers in the north of England where this disease is most severe, growers’ trials unfortunately show that most of JIHI’s best lines are also resistant to yield (Day 1992).

Nevertheless JIHI research generates much information of value to tomato growers since many of the experiments on simple cultural problems make use of tomato seedlings, both because the tomato is the most important glasshouse crop and because it is a good test plant.

JIHI’s breeding programme for sweet corn, which started in 1936, is described by Gordon Haskell in ‘Sweet Corn in England’ in 1949. The crop is so new to his British readership that Haskell has to explain that ‘Sweet corn is to Americans what cabbage is to Englishmen. It is a form of maize with sugary instead of starchy seeds. It is picked unripe, boiled for ten minutes and eaten hot on the cob with butter and salt’. Work at JIHI has involved trials to establish the best methods of growing and storing the crop, as
well as finding the best varieties for English conditions. Two F₁ hybrid varieties of sweet corn developed at JIHI, ‘John Innes I’ and ‘II’, produce early and high quality cobs. They were selected after a series of trials to be good quality and early maturing. Earliness is particularly important with sweet corn in the English climate, and these hybrids can be relied on to produce ears in most regions. By the mid-1960s ‘John Innes II’, also known as Canada Cross, has become popular and is one of the main varieties grown in England.

See also:


1951 Controlled rooms constructed at Bayfordbury

For the first time staff at Bayfordbury have access to controlled environment facilities for plant experiments. Two rooms, planned by Dan Lewis with the General Electric Company, offer light and temperature control (–8ºC to +40ºC), but a suitable method for the control of humidity is yet to be established. Genetics experiments in the past had to ignore variations in the environment and were confined to investigations in which external changes played a minor part. The new rooms bring investigation of genotype-environment interactions, the complex of environmental factors affecting the fertility of hybrids and the behaviour of cell components, within the practical reach of JIHI’s scientists.

1951 JIHI exhibits at the Festival of Britain

JIHI joins with the research stations of East Malling (Kent) and Long Ashton (Bristol) to arrange a series of exhibits at the Festival of Britain, a national exhibition which opened in May. The exhibits, demonstrating incompatibility in fruit trees and the importance of planting the right kinds together, have taken the Pomology Department two years to prepare. Much of London is still in ruins after the German bombing campaign and the Festival is an attempt to foster in the public a feeling of national recovery and progress and to commemorate the achievements of British science.


1951 MM series of rootstocks launched

A series of woolly aphid-resistant apple root-stocks, raised jointly by JIHI and East Malling Research Station, are sent this autumn to a number of research stations in the Commonwealth and the United States. To recognize the results of this collaboration (which began in the 1920s) the root-stocks are to be known as the Malling-Merton series. Clones of 14 selections, MM. 101 to MM. 114, are distributed. This series, which also carries genes...
for powdery mildew resistance, was produced by crossing Malling and Merton rootstocks with Northern Spy.

By the mid-1950s the focus of the apple-breeding programme has moved away from producing new varieties to helping growers reduce their costs of production, especially their losses from frost damage and disease. Research on apple mildew (Podosphaera leucotricha) and apple scab (Venturia inaequalis) begins as many popular varieties are highly susceptible to both diseases. The apple scab research is a collaborative project with researchers in America, Canada and Europe and advanced scab crosses are screened for resistance to powdery mildew, and promising material incorporated into the breeding programme. The variety ‘Gavin’ (released c. 1980) resulted from this work.

1951 Postgraduate Summer Courses revived

JIHi’s biennial Summer Courses in genetics and cytology are revived this year for recommended postgraduate students. Fifty-six students attend lectures in the history of genetics; mitosis and meiosis; chromosome breakage; nucleus and cytoplasm; origins of cultivated plants; gene mutation; chimaeras; chemistry of flower pigments; incompatibility and isolation; and contamination in seed crops. Students are also given demonstrations in chromosome projection, staining techniques and chromatography, and, outdoors, in genetic experiments, the glasshouses and composting methods, and the National Rose Species Collection.

1951 First Bateson Lecture given by Professor Ronald Fisher

C D Darlington establishes a Bateson Lecture to commemorate the founder of JIHi, William Bateson; it is twenty-five years since Bateson’s death on 8 February 1926. The first Bateson Lecture serves as a grand finale to the Summer Course for postgraduate students. Professor Ronald Fisher, FRS gives a talk on ‘Statistical Methods in Genetics’ which is afterwards published in Heredity, the journal Darlington and Fisher co-founded in 1947. Fisher has held the Balfour Chair of Genetics at Cambridge University since 1943, and from 1952 will become a member of JIHi Council. Fisher receives a knighthood for his services to genetics in 1952.

1952 JIHi Symposium on chromosome breakage

In June 1952 the Cytology Department at JIHi host a Symposium to bring together in one place (and later in one volume) knowledge about the breakage of chromosomes: spontaneous, radiation, and chemical breakage. It is 25 years since Hermann Muller discovered the nature of the permanent effects of radiation on the cell, due to changes in the structure of chromosomes. Study of chromosome breakage in cells has lagged behind research on gene mutation.
(which is studied by observable effects in whole organisms), because it has proved technically less accessible. Now it is a focal problem in biology, both in connection with the study of cancerous tumours in medicine and as a way of understanding more about chromosome structure and behaviour as well as for the mapping of genes on the chromosomes. Of the 24 contributions to this (mostly British) Symposium, nine are by JIHI staff. C D Darlington, A. Haque, Len La Cour and J. W. Morrison present work on radiation breakage; John McLeish discusses chemical breakage, while Darlington and A. P. Wylie, and J. B. Hair, examine secondary and spontaneous breakage of chromosomes.


For Hermann Muller’s mutation research which won him the Nobel Prize in Physiology or Medicine in 1946:

1952 Genes are made of DNA

Alfred Hershey and Martha Chase at Cold Spring Harbor Laboratory, New York show that only the DNA of a virus needs to enter a bacterium to infect it. Their experiments on the T2 phage, a virus infecting *Escherichia coli*, the workhorse of bacterial genetics, provide strong support for the idea that genes are made of DNA. Their work affirms the conclusion that Oswald Avery and his colleagues at Rockefeller University Hospital proposed in 1944 from their work with the *Pneumococcus*, namely that DNA not chromosomal protein is the transmitter of genetic information.

For more information see:
http://www.nap.edu/html/biomes/ahershey.html

1953 DNA Double Helix

Francis Crick and James Watson describe their double helix model of the structure of DNA. Presented at the Cavendish Laboratory in Cambridge, their two-dimensional stick and ball model represents DNA as a ‘twisted-ladder’ structure, with the sugar-phosphate backbone on the outside of the helix and the four bases (adenine, thymine, guanine and cytosine) on the inside (the rungs of the ladder). Most people unable to see the physical model in Cambridge will have seen the schematic drawing by Odile Crick published in *Nature* in April 1953. It is a conceptual simplification, omitting atomic detail and precise co-ordinates (which are still uncertain). A more detailed version and a small photo of the wire model are published in 1954.

Crick and Watson have built their model on the X-ray diffraction research of Alex Stokes and Maurice Wilkins at King’s College, London, which at the beginning of the 1950s suggested that DNA molecules are arranged in a helical fashion. In addition, Rosalind Franklin and Raymond Gosling, continuing the work of the King’s College school, provided evidence that ‘gave several of the vital helical parameters’. Crick and Watson are also inspired by the work of physical
chemist Linus Pauling, an expert in the chemical structure of proteins at the California Institute of Technology, who had recently proposed a triple helix model for DNA. The double-helix model quickly supersedes Pauling’s model, and ‘immediately suggests a possible copying mechanism for genetic material’ (Watson and Crick, 1953). The original Watson and Crick paper is not cited frequently until the end of the 1950s when the double helix model becomes iconic, making its first appearance on television in 1958. However, locating the double helix as the origin of molecular biology is problematic. The double helix has a slow and indirect impact on research directions at Cambridge and a programme in ‘molecular genetics’ takes root only several years later.

See also:

1953 Director C D Darlington resigns

Cyril Darlington’s application for the Sherardian Professorship of Botany at Oxford University is successful and in October he leaves JIHI to join a department that has no history of research in cytogenetics. Under his Directorship of 14 years the Institution has grown from 64 staff at Merton to 100 at Bayfordbury. Darlington’s views and books, especially The Evolution of Genetic Systems (1939) have been a constant stimulus to staff.

The Directorship is advertised in March and eight applicants are considered for the post. JIHI’s Council also approach Kenneth Mather but to their great disappointment he declines their offer and decides to remain at Birmingham. The strongest candidates include biophysicist Professor J. T. Randall of King’s College, London who wants to bring some of his medical and biophysics units, including a biochemical unit, with him. In the 1940s and 1950s biophysics encompassed diverse research traditions, including electrophysiology, protein crystallography and radiation studies; much of the territory later occupied by ‘molecular biologists’ was first claimed by biophysicists. John Randall had been interested in applying physical methods to biological material since before the war and had discussed this with Darlington. War mobilisation had produced new instruments and people with new skills and Randall wanted to use them to investigate sub-cellular structures, especially chromosomes. Randall’s unit at Kings’ (founded 1947) is one of the biggest centres for biophysical research in Britain and includes Rosalind Franklin, Raymond Gosling and Maurice Wilkins who had recently contributed decisively to the structure determination of the DNA molecule.

Randall’s surprise application leads to discussions in favour of the introduction of biophysics and the expansion of biochemistry at JIHI and the
search for a new Director is extended from the biological to the biochemical field. The Council also hears arguments against too great a departure from the Institution’s genetics and plant breeding tradition. The Council find it impossible to make an appointment by the time of Darlington’s departure so they invite William Lawrence, Head of the Garden Research Department, to be ‘Acting Director’.

For an exploration of the emerging and complex field of biophysics see;


**1953 Trials of rose stocks and experiments on rose propagation begin**

In association with JIHI’s work on the National Rose Species Collection, a programme begins at Bayfordbury to help solve some of the outstanding problems of rose propagation. Modern garden roses are dependent on borrowed roots for their vigour, and so considerable economic importance is attached to the choice of stocks. Most of the stocks in use are selected strains of wild species or vigorous first generation crosses, but until recently nothing had been done in Britain to breed new stocks or standardize the existing types on lines similar to those employed for fruit stocks. In 1953, after a study of rose stock trials in France, Gordon Rowley assembles a collection of 31 of the most popular rose stocks for experiments on methods of propagation, compatibility problems, and field trials on different soil types.

During the next eight years tests of the stock/scion effect on questions of vigour, susceptibility to black spot and mildew, and cold resistance show that some of these problems (vigour, cold resistance) are connected with the type of stock used. Trials demonstrate that the choice of stock greatly influences plant size, the number of flowers produced, and the extent to which suckering occurs. Other rose breeding work reveals that rose cuttings can be made more successfully with rooting hormones, and that the germination of seeds of the dog rose used for understocks can be made more certain by artificial cold treatment. These results are of considerable interest to rose growers.

See also:


1954 A new John Innes compost developed

The basic John Innes compost formula is modified (the lime content replaced by sulphur) to produce a special compost for ericas, rhododendrons and other calcifuge plants which in some cases had shown signs of chlorosis when grown in John Innes composts. The formula of the standard John Innes compost has remained unchanged since 1936 and after nearly 20 years is now used by 80 per cent of nurserymen and gardeners.

1954 K S Dodds is appointed Director and potato genetics begins

Kenneth Dodds is appointed in March 1954 and brings with him experience as a Lecturer then Professor of Botany and Genetics at the Imperial College of Tropical Agriculture, Trinidad (1937-49); Officer-in-Charge of the Commonwealth Potato Station at the School of Agriculture, University of Cambridge (1949-51) and Director of the Agricultural Research Council's Potato Genetics Station at Cambridge (following the transfer of the Potato Collection to the ARC). With Dodds' appointment the Institution accepted responsibility for the Commonwealth Potato Collection, the bulk of which was collected in 1939 and whose primary object was to provide material for the study of variation in potatoes and a reservoir of hereditary characteristics for breeding. For ten years the resistance of member lines of this collection to diseases, pests and frost was studied by workers under the Commonwealth Agricultural Bureaux. Later, under ARC control, the collection was used for cytological and genetic research. Dodds led a group studying the South American potato collection, looking at the breeding systems of diploids, the genetics of pigmentation and the inheritance of resistances, particularly to virus Y and Late Blight. Dodds hopes that the new experimental programme at JIHI will ultimately have benefits for commercial potato breeding.

Dodds arranges for an additional block of four glasshouses to be added to the Bayfordbury site to accommodate the needs of the new Potato Genetics Department (Dodds, J. B. Harborne, Ellis Marks and G. J. Paxman).

1954 JIHI’s departments re-organized

One of Kenneth Dodds' immediate actions as new Director is to change the names of three of JIHI's departments (which up until now are Genetics, Pomology, Garden Research, and Cytology): the Pomology Department becomes the Department of Plant Breeding to recognize the considerable effort that has always been devoted to the production of improved varieties of plants and to plant breeding methods. Mr Watkin Williams is appointed to head the new Department in December, replacing Gavin Brown who has been Acting Head since Morley Crane's retirement. Williams, a senior agricultural botanist from the University of Durham, has in the past directed a legume breeding
programme at the Welsh Plant Breeding Station and has a close acquaintance with the problems of the commercial seed industry. The Garden Research Department, led by William Lawrence, is renamed the Department of Physiology and Plant Culture to highlight changes in emphasis since this Department was established in 1950: attention is now mainly given to the physiological responses of plants to controlled environments. Finally, the Cytology Department is gradually subsumed within Dodds’ planned new Department of Cell Biology.

1955 Shortage of laboratory space in Bayfordbury mansion

Dodds’ review of the laboratory accommodation of the various departments at Bayfordbury reveals that the Department of Plant Breeding has few facilities for experimental pathology; the biochemists have no separate rooms for their balances, chromatographic equipment and spectrometers, and the Department of Physiology needs a laboratory. The problem of lab space is intensified by the arrival of the new Potato Genetics department and by Dodds’ intention to build up a small group at the Institution working on cell biology and using a cytochemical approach to the study of cell processes.

1955 New directions in biochemistry and cell biology

Dodds establishes a small collaborative group of cell biologists at the Wheatstone Laboratory of the Department of Biophysics, King’s College, London. This group includes cytologist Joseph Chayen and physicist J W C Crawley, who develop with the helpful cooperation of Professor J. T. Randall. Crawley receives the training necessary to maintain an electron microscope and experience in building electronic equipment, particularly for measuring DNA on chromosomes. John McLeish, a JIHI cytologist, is sent to them for several months in 1956 for training in cyto-chemical techniques.

Dodds’ vision is to fully develop chromosome and genetics research at Bayfordbury by integrating the disciplines of the cytologist, geneticist, biochemist and biophysicist into a functional whole (meaning free exchange of ideas and apparatus). This integration cannot be achieved within the confines of Bayfordbury mansion so a new block of modern laboratories to house biochemistry and cell biology is planned. Until this is done JIHI’s new group of cell biologists will remain at the Wheatstone Laboratory in London.

1955 Publication of new Chromosome Atlas of Flowering Plants

It is ten years since the publication of Chromosome Atlas of Cultivated Plants by C D Darlington and E. K. Janaki Ammal, a systematic arrangement of chromosome counts which aimed to ‘put classification back on a genetic basis’. In this interval the number of plants with known chromosome numbers has nearly doubled; they have now been studied in some fifty thousand flowering plants belonging to nearly twenty thousand species. Ammal (JIHI cytologist 1931, 1935, 1940-44) has contributed significantly to these developments in her work at the Royal Horticultural Society’s Gardens at Wisley, and later with the Indian Botanical Survey in Calcutta. Chromosome counting is an important part of the routine
work of JIHI cytologists as Brian Snoad later recalled: 'at that time there was a lot of emphasis on collecting chromosome numbers, rather akin to genome analysis today, with any new numbers being fed into the bible of the day [the Atlas']. The Atlas includes unpublished counts by many correspondents, and by Len La Cour, R. D. Brock, J. B. Hair, B. Snoad and R. de V. Plenaaar, who are able to take advantage of the genetic variability that is so readily available in the parkland, the ornamental gardens and the burgeoning glasshouse corridors at Bayfordbury.

C D Darlington and Ann P. Wylie's new Atlas serves four purposes: first, to show the systematist how chromosome numbers can be used as a basis for plant classification; secondly, to help the plant breeder by showing what species may be crossed and with what results; thirdly, to give the cytologist a bibliographic guide to work in cytology, and fourthly, to provide the geneticist and evolutionist with the rules or laws of chromosome variation. In all Darlington and Wylie include over 15,000 species and 2,500 genera in the catalogue. The interpretation of the data in the Atlas has grown to fill a separate companion volume, Chromosome Botany (1956), which brings chromosome systematics into fertile union with plant geography and plant ecology.

Ann Wylie was also responsible for much of the cytological work on the National Rose Species Collection at Bayfordbury which assisted Keeper Gordon Rowley in his plant identifications. The Collection serves as a model experiment in the classification of a genus. See also:


1955 Dan Lewis is elected FRS

Dan Lewis, Head of the Genetics Department at JIHI, is elected a Fellow of the Royal Society in recognition of his pioneer work on the genetics of incompatibility in flowering plants. Lewis's election follows on from his outstanding 1954 article summarizing 18 years of work and thought at JIHI, giving a comparative treatment of seven genetic systems of incompatibility. Lewis's review becomes a citation classic and brings him widespread recognition, including a Rockefeller Foundation Special Fellowship at California Institute of Technology in 1955-56.

Lewis's work on the incompatibility or ‘S’ gene, is important for three reasons. First, for contributing to understanding of incompatibility relations and breeding systems in higher plants; secondly, for adding to
the tools geneticists have for studying rare spontaneous mutations. Lewis (1949) highlighted the importance of the incompatibility locus of higher plants to biologists engaged in mutation research, and showed its advantages for refined studies in genetics, radiobiology and evolution; thirdly, for its potential agronomic benefits. It is hoped that inducing self-fertility in cross-pollinated species may be an asset in fruit breeding. More generally Lewis’s research raises the interesting possibility of inbreeding and selecting for valuable agronomic traits which might otherwise never be expressed in cross-pollinated plants.

The first application of Lewis’s research is to the sweet cherry, *Prunus avium*, cultivars of which are self-incompatible and will not set fruit when pollinated with their own pollen. Lewis produced self-compatible mutants of *Prunus avium* by irradiation in the mid-1940s. Crosses with these mutants have produced progenies that are all self-fertile. Though Lewis will be denied the satisfaction of seeing the commercial exploitation of his discovery in Britain, his work will lead to the development by the Canadian Department of Agriculture of the first commercial self-compatible sweet cherry, *Stella*.


**1956 Agricultural Research Council becomes responsible for JIHI’s grant-in-aid**

Because of the way agricultural research has gradually grown up in the past, a dual system has operated in England and Wales whereby some research institutes are financed and administered directly by the Agricultural Research Council, while others (including JIHI which has been a grant-aided station of the Ministry of Agriculture since 1946) are on the Vote of the Ministry of Agriculture, Fisheries and Food, although the Agricultural Research Council is responsible for their scientific policy and scientific direction. Following a report of the Select Committee on Estimates, the Government decides that the financial and general administration of these latter institutes, as well as their scientific direction, should be unified under the Agricultural Research Council. The JIHI, like the other institutes transferred from the Ministry of Agriculture, remains under its separate governing body.

**1957 Department of Plant Cell Biology founded**

JIHI’s new Department of Plant Cell Biology is founded under Dr Robert Brown, FRS, Director of the Agricultural Research Council’s Unit of Plant Cell Physiology at Oxford, and the cell biology group at King’s is relocated to Bayfordbury. It is expected that Brown will bring two or three members of his own staff and some equipment from Oxford, and plans for a new cell biology building are now able to make progress. Six new appointments from Oxford
are made in 1958: N. Sunderland, J. K. Heyes and A. J. Tullett from Brown’s lab and three biochemists who had been working under Sir Hans Krebs (J. E. Amoore, R. G. Stickland, and U. Loening). The intention that Brown will become Head of Department is not realised because in 1958 Brown accepts the Regius Chair of Botany at Edinburgh University. In these changed circumstances only Sunderland and Stickland in the Oxford group decide to come to Bayfordbury and the search begins to find a senior scientist to lead the Department.

1957 Arabidopsis thaliana arrives at JIHI

Dr Graham Hussey begins a collection of strains of Arabidopsis thaliana for developmental studies and is also making observations on the growth and flowering of six different wild-type mutants grown under fluorescent lamps. Hussey is a newly appointed postdoc in the Department of Physiology and Plant Culture. He studied Arabidopsis for his Ph.D. at Imperial College, London, under the distinguished plant physiologist F. G. Gregory who has a special interest in the effects of light and temperature on flowering plants. Gregory and Hussey are the only scientists working on the physiology of Arabidopsis in the UK in the early 1950s.

Both are building on the work of Friedrich Laibach (1943), Professor of Botany at the University of Frankfurt, who recognised the potential of Arabidopsis as a model research plant for studies in physiology and genetics. Among its advantages are its short life cycle and small size, it takes up little space so that control of light and temperature can be achieved in modest size installations. It can also be grown easily in vitro, although techniques for doing this are not well developed in the 1950s.

Hussey’s work on Arabidopsis at Bayfordbury is short-lived because he is directed by William Lawrence to concentrate on the effect of light on tomatoes. Although in the 1950s and 60s several research groups begin to follow up on Laibach’s initiative, in particular in Germany, Belgium, the Netherlands, and in Columbia, USA, it will be the late 1980s before Arabidopsis research takes off at the John Innes Institute. As late as the early 1980s Hussey finds himself unable to interest the Director (Harold Woolhouse) in this ‘tiny little weed’.

See also:


For information on the history of *Arabidopsis* as a model organism:

http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V81-4N5KXM7-3&_user=1549459&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000053657&_version=1&_urlVersion=0&_userid=1549459&md5=4ce726eff2496ed29efe48bf9b7ad467

http://www.nature.com/nrg/journal/v3/n11/full/nrg927.html

1957 Search for a new Head of Genetics begins

Dan Lewis, who has been on the staff of JIHI since 1935 and became Head of Genetics in 1948, leaves to take up the Quain Professorship of Botany at University College, London in October 1957. The post remains vacant until April 1960 due to a shortage of suitable applicants; there are very few geneticists experienced in higher plant genetics in their 40s, and only a few more in their 30s, that can be considered as candidates for this post. In addition, more universities are competing for personnel as new professorships in genetics are established. The Council consider a range of potential candidates, not all of whom turn out to be available, including John Thoday, Angus Bateman, John Jinks, J. Alan Roper and John Fincham.

In November 1959 Fincham writes to Dodds expressing his continued interest in the still vacant post: ‘I thought it might be worthwhile asking whether you had definitely decided that I was not the kind of geneticist you wanted, or whether you still considered me as a possibility’. Fincham, Reader in Genetics at the University of Leicester, is a biochemical geneticist whose research interests have so far specialised on the bread mould *Neurospora crassa*. His appointment, which is confirmed in 1960, will establish JIHI as a serious player in the developing field of microbial genetics.

1957 Electron microscopy begins at JIHI

Most of the apparatus required for a preparation laboratory for electron microscopy is installed at Bayfordbury during this year. The electronic equipment for the high-voltage electron microscope they hope to build at JIHI has to be re-designed to improve its stability and enable it to operate satisfactorily from the rather erratic mains electricity supply at Bayfordbury. In the meantime staff have access to the new Siemens electron microscope at Rothamsted. The Institution’s first electron microscope is a high voltage microscope acquired from King’s College, London. It arrives as a box of bits and pieces and is re-built in an old wine cellar of Bayfordbury mansion by John Crawley. By 1958 it is in regular use, both as a survey instrument at low voltage (80kV.) and for experiments with high voltage (up to 200kV.) Having a survey instrument makes it possible to examine specimens as they are prepared, and to select only those really suitable for examination in the high resolution instruments at King’s College or Rothamsted. In November 1959, on the back of plans to expand cell biology, JIHI is able to install a new Siemens Electron Microscope Elmiskop I.
1957-59 JI genetics begins to take a fungal turn

In the early days JIHI work with fungi was dominated by practical considerations of disease control and was pursued independently from the work of the geneticists. Dorothy Cayley, the Institution’s first mycologist, began work in the 1910s with the diseases of peas and fruit. Between 1920 and 1930 she worked particularly on the life history of *Diaporthe perniciosa*, a fungus producing rapid wilt and ‘die-back’ of stone fruits and a cause of rot in apples. In the 1950s Peter Day’s mycological work with *Fulvia fulva* (*Cladosporium fulvum*), the cause of leaf mould disease, was directed at solving a particular problem plaguing commercial tomato growers. JIHI’s Pomology Department had since the 1940s been at work to produce new greenhouse varieties resistant to leaf mould disease but found that resistant varieties were rendered useless after a few years because they encountered physiologic races of the fungus (forms of the species that are specialised to attack different cultivars). Day was soon more interested in the pathogen than the host, but his work was mainly confined to identifying the physiologic races of *F. fulvum* from samples sent by the National Agricultural Advisory Service from various parts of England and Wales. These were needed to select useful major gene resistance for the tomato breeding programme. *Fulvia* unfortunately was not promising material for fungal genetics because it has no known sexual stage and does not readily form heterokaryons (cells with two or more genetically different nuclei). Dan Lewis and Day (1957) were able to use induced pigment markers to demonstrate induced mutation to virulence, but the limitations of *Fulvum* prevented further genetic work.

A key step towards the establishment of fungi as model organisms in the Genetics Department at JIHI occurred with Lewis’s Rockefeller Foundation Fellowship at the California Institute of Technology during 1955-56. While there he isolated some induced mutants of the basidiomycete fungus *Coprinus cinereus* (*C. lagopus*, an ink-cap mushroom). Lewis suggested to Day on his return that he work on *Coprinus*, which Day thought at the time might be a model system for exploring the dikaryons of rusts and other basidiomycete plant pathogens. Conveniently this fungus formed fruit bodies on the farmyard manure heaps at Bayfordbury, providing a local source of wild-type stocks. Day’s training had recently been enhanced by 18 months working in the Department of Plant Pathology at Madison, Wisconsin during which time he attended Professor Joshua Lederberg’s course on microbial genetics. Lewis was in the process of switching experimental materials from self-incompatible flowering plants to explore the multiple allelic system at two unlinked loci, A and B, that govern mating type in *Coprinus*. Their project began with the isolation and characterization of mutants and mapping their linkages with the A and B loci. Day’s work on the genetics of *Coprinus* continued after Lewis left to become Professor of Botany at University College, London. In 1958 Day is joined by Robin Holliday fresh from his PhD work in the Botany School at Cambridge on the genetics of *Ustilago maydis*, a fungal disease of maize (corn smut).
Dodds makes this appointment specifically to provide a 'mutually stimulating' partnership for Day and to keep JIHI 'reasonably up-to-date on fungal genetics'. The turn to fungal genetics is completed by the arrival of John Fincham as the new Head of Genetics in 1960.

1959 Re-launch of Cell Biology and Completion of Cell Biology Building

In August 1959 Henry Harris accepts the post of Head of the new Department of Cell Biology. Trained under Sir Howard Florey at the William Dunn School of Pathology, University of Oxford, Harris has worked on the nature of chemical stimuli affecting cells during tissue injury. Recently his investigations have centred on the physiology and biochemistry of mammalian cells, in particular the factors influencing and controlling cell multiplication. He brings with him two members of his Oxford team, a biochemist, John Watts, and his personal technician Marianne Jahnz. Together they have been developing techniques for the investigation of the biochemical organization of somatic cells. The research they plan to bring to John Innes concerns the factors controlling the kinetics of protein and nucleic acid synthesis in mammalian cells. They are particularly interested in the differences between multiplying cells, both normal and malignant, and non-multiplying cells. Though Harris’ training and experience situate him more comfortably within a medical research environment, Dodds is confident that Harris will achieve a successful marriage between plant and animal cell biology. However, Dodds does have to reassure Council that Harris’ research team will devote a large part of its activities to the simultaneous study of plant cells. The new Cell Biology Building is completed at the end of the year.

Harris later wrote: ‘Although it masqueraded as a horticultural institution, the John Innes was a very distinguished scientific establishment. Its Director in 1959 was Kenneth Dodds and, for reasons that remain obscure to me, he was eager to develop the subject of cell biology. As far as I am aware, this was not then a recognized subject in any university in the world, and he must either have been very far-sighted or he was disenchanted with the further prospects of formal Mendelian genetics on higher plants. In any case, with the support of the Agricultural Research Council, he had constructed a new laboratory at Bayfordbury that he proposed to devote to cell biology’.

See also:
1958-59 JIHI Council debates future research policy and change of name

During 1958 Kenneth Dodds suggests that the John Innes Horticultural Institution change its name, omitting the word ‘horticultural’ which he considers misleading and a ‘hindrance to the recruitment of suitable staff’. This sparks lengthy discussions in Council about what the future research direction of JIHI should be. Dodds wants to move the Institution further towards fundamental research on cytology and genetics, research that cannot be tackled at the Agricultural Research Council’s technological stations: those that have primary responsibility for meeting the needs of public industries (the Plant Breeding Institute at Cambridge, the Glasshouse Crops Research Station at Rustington (Sussex), and the National Vegetable Research Station at Wellesbourne in Warwickshire, for example). His plan is for the Institution to re-visit many of the problems investigated during Darlington’s era, among them polygenes, translocations, chiasmata, and speciation, but using the combined approaches of the new cell biology department, a new genetics department re-oriented to microbial genetics, the potato genetics department and the department of plant breeding.

Not everyone in Council is agreed that the more practical aspects of the Institution’s present programme should be handed on to other stations. In particular, there is dissent over whether JIHI should abandon its tradition in fruit-breeding, supported as it is by the fruit collections assembled by M B Crane. There is a feeling that the new Department of Cell Biology is getting all the limelight and that applied research might be pushed into the shadows. Dodds view is that JIHI can no longer carry out actual breeding work on top-fruit and potatoes, which he maintains would require a scaling up of operations, but should confine its research to fundamental problems. Agreement is reached that JIHI should change its name and that this would be to signal the greatly increased scope of the research undertaken, rather than a complete divorce from horticulture.

1959 Expedition to South America

In November 1959 Kenneth Dodds embarks on a four month expedition to Peru, Bolivia, Chile and Ecuador to collect local varieties of cultivated diploid potatoes. The material brought back will assist Dodds in his investigation of the origin of the diploid potato.
1960 John Innes Jubilee

The John Innes Institute is fifty years old. To celebrate the occasion 350 guests visit Bayfordbury on 8th July 1960. They are welcomed by the Chairman, Sir Frederick Stern, and Members of Governing Council and spend the afternoon in the grounds and glasshouses, and looking at exhibits set up in the laboratories. After tea, HRH the Duke of Northumberland KB presides over the Fifth Bateson Lecture at which Kenneth Mather, FRS speaks on 'Genetics: Pure and Applied'.

During the afternoon, the new building for the Department of Cell Biology is opened for inspection. When fully equipped and staffed it will provide research facilities for about twenty-five scientists.

1960 A new name: the John Innes Institute

The change of name from ‘John Innes Horticultural Institution’ to ‘John Innes Institute’ is announced by Sir Frederick Stern during the Jubilee celebrations. It is hoped that the new title will help to attract scientific staff to work at JII and will better describe the plant and microbial research that is now in progress. It is intended that the new name will signify to a new generation of research workers, who know nothing of the Institution’s past, or the scientific freedom that they would enjoy at Bayfordbury.

1960 John Fincham appointed Head of Genetics

It is now nineteen years since Beadle and Tatum’s (1941) classic paper on the isolation of biochemical mutants in the red bread mould Neurospora crassa. By showing that the function of genes is to direct the formation of enzymes which regulate chemical events their work is often commemorated as the first in a series of fundamental advances that were to bridge the gap between genetics and biochemistry. Neurospora studies started with American mycologist B. O Dodge who influenced Carl Lindegren in the 1930s to study the genetics of Neurospora, working alone, at California Institute of Technology. When George Beadle and Edward Tatum started to isolate biochemical mutants there they started a 'Neurospora revolution' with geneticists around the world beginning to devote their research to microbes; in the UK John Fincham was a key figure in this move to fungal genetics.

Fincham trained in the Botany School at Cambridge, the UK’s original centre of Neurospora genetics. Here Harold Whitehouse had been the first to work on Neurospora under the supervision of cytologist and geneticist David Catcheside, beginning with some cultures of N. sitophila already available at the Botany School. In 1946 Catcheside obtained cultures of wild type and mutant strains of N. crassa and it was on these that John Fincham began work as a new PhD student. In 1948-49, on an Agricultural Research Council Scholarship to the California Institute of Technology, the stronghold of
Neurospora genetics, Fincham worked on the biochemical genetics of *N. crassa* with Norman Horowitz and Sterling Emerson. Fincham’s work on *am* mutants that were deficient in a specific enzyme (glutamate dehydrogenase or GDH) provided very early confirmation (1950) that Beadle and Tatum’s ‘one gene-one enzyme’ hypothesis was correct. The study of *am* mutants and GDH was to become the central feature of Fincham’s experimental research.

Prior to coming to JII, Fincham had seeded a *Neurospora* group at Leicester University where from 1950 to 1960 he was a lecturer, then reader in botany. Catcheside had moved (from Cambridge, then Adelaide, Australia) to a new Chair of Microbiology at Birmingham in 1955, where he led another *Neurospora* group. Other centres of fungal genetics included Guido Pontecorvo’s Department of Genetics at the University of Glasgow which had established *Aspergillus nidulans* as a model microbe for genetic studies. Glasgow was the parent of off-shoot groups of *Aspergillus* researchers at Sheffield and, in the 1960s, in the Cambridge Genetics Department. By 1960 fungal genetics has reached a point in Britain where it is developing but is still a small endeavour compared with the genetics of plants and animals. Fincham’s appointment at JII, unsettling to some on JII Governing Council, is an acknowledgement that much really progressive work in biology is now done with microorganisms and is a strategic move by Dodds to give JII leadership in the field.

Summary of Beadle and Tatum’s work and the Nobel Prize they shared with Joshua Lederberg, see:

For a post 1945 survey of UK genetics departments including fungal genetics:

On the growth of microbial genetics, see:

1961 New Directions in Applied Genetics

Head of JII’s Department of Plant Breeding Watkin Williams, resigns to take up a new post as Professor of Agriculture (Crop Production) at King’s College, University of Durham. Kenneth Dodds takes over as Acting Head and re-names the department Applied Genetics. The Department Dodds inherits has been working primarily on apple breeding (especially for scab and mildew-resistance), pear breeding, plum breeding, cherry breeding (including bacterial canker resistance), strawberry breeding (for yield, red-core fungus and mildew resistance), and tomato breeding. However, Dodds’ new Department has to operate in a new and challenging research environment and changes to the research programme are inevitable. The Agricultural Research Council is steadily
transferring applied work to its other Institutes. Long Ashton (Bristol) and East Malling (Kent) are extending their research on fruit-breeding. The National Vegetable Research Station at Wellesbourne (Warwickshire) and the Glasshouse Crops Research Station at Rustington (Sussex) will between them cover most of the horticultural crops of commercial importance. When the tomato work is transferred from JII to Rustington (c. 1962) Dodds has to develop a research plan that will be unique to his Department to secure its future. He needs a crop that is genetically interesting but one that has not been claimed by any other of the ARC Institutes. Dodds settles on *Pisum* (peas) and re-introduces a pea genetics programme to JII. He begins by collecting a small number of lines from around the world to assess the range of variability. Brian Snod later takes over the collection from Dodds and commences cytological and genetic studies. Pea research, by no means new to JII having been studied by Caroline Pellew from 1910-1941 (rogues, types and linkage), will become increasingly central to the work of Applied Genetics in the future.

**1961 Zuckerman Report recommends re-location of research institutes**

A report to the government entitled ‘The Management and Control of Research and Development’ is published on 5th July 1961. The Committee, chaired first by Sir Claude Gibb and then by Sir Solly Zuckerman, considered, among other matters, the minimum size and location of government-funded research stations in relation to their viability and efficiency. They were concerned that some of the stations of the Department of Scientific and Industrial Research and the Agricultural Research Council (ARC) were too small and too isolated to ‘inspire much hope in their continued success’. The ARC had itself been worried about the relative isolation of the John Innes Institute, especially after the severance of formal links with the University of London in 1957 and had already mooted the idea that JII move to associate with a university. The Zuckerman Report gives further impetus to the re-location proposal though not everyone is convinced by the arguments put forward to support the move, as the JII is only 15 miles from the University of London which by 1965 is itself undergoing reform to restore recognition and cooperation to research institutes in the London area.

For background on the report see also:


**1961 Jacob and Monod publish genetic operator model**

Based on experiments with bacteria, especially their own work on enzyme synthesis in *Escherichia coli*, François Jacob and Jacques Monod at the Pasteur Institute in Paris describe a model for the regulation of protein synthesis. Their model envisages that the mechanisms which regulate the synthesis of proteins do not operate in the cytoplasm but act directly on the genes by
governing the transcription of the DNA into RNA (the 'genetic operator model'). Their study of the control of expression of genes in *E. coli* provides the first example of a transcriptional regulation system.

See also:


### 1961 mRNA ferries information

Sydney Brenner of the Medical Research Council Unit for Molecular Biology in Cambridge, François Jacob at the Pasteur Institute, Paris and Matthew Meselson at the California Institute of Technology (CalTech), publish their hypothesis that mRNA is the molecule that takes information from DNA in the nucleus to the protein-making machinery in the cytoplasm. The hypothesis is based on their experiments on phage-infected bacteria which were initiated while Brenner and Jacob were guest investigators at CalTech.

See also:

http://www.scribd.com/doc/6648046/06-Brenner-Jacob

### 1961-63 Henry Harris pioneers research on RNA metabolism

When Henry Harris takes charge of the Cell Biology Department in 1961 he inherits three biologists who know a great deal about plant cells (Len LaCour, John McLeish, and Norman Sunderland), a biochemist (R. G. Stickland) and a physicist (John Crawley) with a special interest in advanced microscopic techniques. Harris sees at once that they possess skills that could be useful to his research but does not immediately seek to change the direction of their work. In addition, Harris has the collaborators he brought from Oxford (Marianne Jahnz and John Watts), and several newly appointed staff with expertise in biochemistry, physical chemistry and microbiology, making this by far the largest of JII’s departments, with 20 scientists by 1963.

Harris’s team quickly begin work investigating what Harris regards as the most important question in the field of RNA metabolism: where in the cell is the short-lived RNA broken down? With the methods available at the time this is a ‘fiendishly difficult’ task. Watts refines methods of separating the individual RNA components in the cell and they soon find that short-lived RNA is broken down within the cell nucleus.
This phenomenon of great biological importance (i.e. turnover of RNA in the nucleus of animal cells) initially met with a sceptical response. The result was either disbelieved or regarded as an experimental artefact. Robin Holliday witnessed heated exchanges at a meeting in Cambridge (1962) where Sydney Brenner and Harris were both speakers. Scientists were ready to accept that there was an RNA fraction in the cell that turned over rapidly, following the discovery of short-lived messenger RNA in bacteria by Brenner, Jacob and Meselson (1961), but Harris has difficulty convincing them that the short-lived nuclear RNA which he has observed in higher organisms isn’t the messenger.

To provide experimental evidence to back his views Harris turns to a marine unicellular green alga, Acetabularia. He sends Marianne Jahnz to the Max Planck Institute of Marine Biology in Wilhelmshaven and she returns to JII with seed cultures of Acetabularia and the skills to grow them. Their experiments lead them to another discovery: the synthesis of RNA in the cytoplasm of Acetabularia. They are able to demonstrate that the template (the messenger) for protein synthesis is regulated by mechanisms that operate in the cytoplasm and not in the nucleus. This opposes the doctrine that protein synthesis is governed solely by gene switches that work through unstable, short-lived messengers. Harris’s findings do not upset the status quo, however, because scientists assume that Acetabularia is a special case. Harris’s team discover that the relationship between nuclear and cytoplasmic RNA is very complex and they are led to explore another ‘heresy’: the idea that RNA can be synthesised in the cytoplasm. Natural features of cell division in plant cells make them more suitable for pursuing this investigation than animal cells. Harris is able to tap into the expertise of Len LaCour who suggests that he use growing root tips of the broad bean, Vicia faba. They are able to show convincingly that RNA synthesis continues in the cytoplasm during the period that synthesis of nuclear RNA is suspended. The continued opposition of other scientists means that Harris has to devote ‘almost three years to defensive, scholastic experiments’ rather than making progress in understanding the biological significance of the phenomenon he has discovered. It is only in the late 1970s when introns (non-coding regions of genes) are identified that Harris’s discovery of nuclear RNA turnover is understood. The turnover process is part of the elaborate mechanism that eukaryotic cells have for editing introns out of RNA. Once editing is complete the RNA passes out of the nucleus to a ribosome to be translated into protein.

See also:


1962 Just what to do? Debate on future research policy continues

The Governing Council of JII begins discussions with the Agricultural Research Council (ARC) about future research policy, although privately this has been under discussion since 1958. A dilemma faces the Institute. Should they follow the ‘problems of greatest academic interest’ which in 1960s genetics are centred in the study of bacteria, fungi and viruses, or do they continue to work on the genetics of higher plants? Microbial genetics is fundamental to biology but does not help agriculture in the short term; the plant breeder must still rely on classical genetics and biometry to help in selecting the best genotypes.

With research moving to the molecular level, the Institute’s ability to play a part in modern genetic research and meet its shorter term obligations to agriculture is in question, as is the place of JII in the general pattern of state-aided research institutes. It is in 1962 that the ARC first suggests that the direction that JII has taken is too ‘academic’ and that its research programmes might fit better within a university with funding from the University Grants Committee. In June 1962 the idea that JII should form an association with the newly established University of East Anglia is proposed and a move to Norwich contemplated. JII Heads of Departments are told confidentially about the plans but most of the staff do not take rumours about relocation seriously until the move is officially announced early in 1963.

1962 First steps towards cell fusion in mammalian cells

Henry Harris, Head of Cell Biology, has had daily contact with John Fincham, Head of Genetics, since the summer of 1961. This opportunity to observe Fincham’s bread mould Neurospora crassa has concentrated Harris’s mind on the sexual and parasexual processes of mycelial fungi, in particular the way in which the fusion of hyphae brings together within a single cytoplasm nuclei of different genotype (heterokaryosis). This natural phenomenon stimulates in him the idea of producing heterokaryons in somatic animal cells. The prospect of doing this is immensely attractive because it promises to make available to researchers on mammalian cells genetic techniques that are fruitful in the study of bacteria and fungi.

Guido Pontecorvo had already pioneered the idea that parasexual cycle genetics could be applied to human or other animal cells in culture (Pontecorvo 1958, p. 134) and had started work on human genetics in 1959 at Glasgow University, but Harris’s inspiration for thinking about cell fusion by his own account drew from his local circumstances at Bayfordbury.

Later in 1962 reports from Japan of virus-induced cell fusion provide Harris with a laboratory method. Harris will not pursue this lead until after he has left the John Innes Institute; his first report on man-mouse heterokaryons (with J. F. Watkins) is published in Nature in February 1965. The news that an inactivated virus could be used to fuse together different animal species and that the hybrid cells produced in this way are viable grabs the attention of newspapers around the world.
Harris’s subsequent research on cell fusion secures his international reputation. Harris later explained that the lack of an animal virologist in his Department at John Innes, there was no-one there familiar with the standard techniques of virus culture, isolation and titration, was a contributory factor in his postponement of research on cell fusion. More important, however, was his overriding pre-occupation at JII with his work on the metabolism of nuclear RNA.

For Henry Harris’s personal account of research on cell fusion see:

http://www3.interscience.wiley.com/cgi-bin/fulltext/109911447/PDFSTART


For Guido Pontecorvo’s major contribution to genetic analysis in human cells see:


Bernard L. Cohen, Guido Pontecorvo (“Ponte”), 1907-1909, Genetics, 154 (20000): 497-501

1963 Association with the University of East Anglia agreed

Discussions on future research policy have made it clear that the Agricultural Research Council will not continue to support the John Innes Institute in isolation at Bayfordbury. An agreement is reached that JII will be associated with the University of East Anglia (UEA) in Norwich. At this stage in the negotiations it is intended that JII will retain its separate identity and continue to undertake research in genetics, and plant and microbial science. To derive full benefits from this alliance it is decided that JII will move to Norwich. The John Innes Trustees are in the process of acquiring a new site of about 30 acres close to the University (at Colney) on land adjacent to the site on which a new Agricultural Research Council Food Research Institute will be built and populated by scientists moving from the Low Temperature Research Station in Cambridge. The JII site will be large enough for buildings, glasshouses and most of the field experiments required, but a separate Field Station will need to be found for the fruit-breeding work. By 1964 the purchase of the site at Colney is completed, together with a small farm of about 165 acres at Stanfield, 20 miles north-west of Norwich, for fruit breeding. Initially it is envisaged that the new Institute will be erected on the University Campus where Professor T. Bennett-Clark has established a School of Biological Sciences. The plan will bring to the Norwich area a hub of scientific and University institutions that is expected to be mutually beneficial and that over time will attract other scientific initiatives. The association is furthered by the Trustees’ agreement in 1965 to
provide funds for three John Innes Chairs at UEA in Cell Biology, Genetics and Applied Genetics. These positions are later filled by Roy Markham (1967), David Hopwood (1968), and D. Roy Davies (1968) respectively. UEA, founded in 1963, is one of the rising new Universities and is among the first to abandon the old subdivisions of biology (botany, zoology and microbiology) in favour of an imaginative, integrated approach.

1963 Henry Harris leaves JII for Chair of Pathology at Oxford

Harris describes the plans to move JII to Norwich as ‘a worm at the heart of present happiness’. He is opposed to the plan and is not prepared to move to Norwich with JII. When Howard Florey resigns the Chair of Pathology at Oxford University leaving a vacancy Harris makes his decision to leave. Between 1963 and 1965 the Department of Cell Biology will lose another 12 members of staff.

See also:

1963 Highly successful Fungal Genetics first published

John Fincham and Peter Day publish the first edition of Fungal Genetics (Oxford: Blackwell Scientific Publications) a title that will run to a second edition in 1965 and a third in 1971. Fincham invited Day to join him in writing the book in 1961. Day wrote drafts of the chapters on the biology of fungi of genetic interest; the induction, isolation and characterization of mutants; the comparative genetics and physiology of mating type and sexual development; extra nuclear inheritance, and the genetics of pathogenicity. Fincham wrote the chapters on the chromosome theory as illustrated by Neurospora; chromosome mapping; the genetic consequences of changes in chromosome number; the gene as a functional unit; the fine structure of genes and the mechanism of genetic exchange, and the biochemical analysis of gene function. Throughout the months of writing both are greatly in debt to Robin Holliday for his help and constructive criticisms.

1964 Birth of the ‘Holliday Junction’

Robin Holliday in the Genetics Department at JII proposes a model of DNA-strand exchange that attempts to explain on a molecular basis the major features of crossing-over, gene conversion, and post-meiotic segregation that had been documented in several fungi. He chooses what seems to him to be the very simplest molecular configuration capable of explaining most of the facts. This new model of genetic recombination is based on the breakage and reunion of DNA chains, the formation of hybrid (heteroduplex) DNA, and the correction of mis-matched bases. Holliday is working on DNA damage and genetic recombination in Ustilago maydis (corn smut) and the yeast Saccharomyces cerevisiae. His most important experimental work at JII is the isolation of radiation sensitive, repair deficient mutants of U. maydis, which are the first in any non-bacterial organism.

Holliday’s model incorporates the cross-stranded (or cruciform) DNA structure that later became known as the ‘Holliday Junction’ (a mobile junction between four strands of
These junctions have been found to occur from prokaryotes to mammals and are central intermediates in the process of homologous recombination. Holliday's junction has been a cornerstone of recombination models since its introduction, although the 1964 paper was rejected by Nature and Genetical Research, and it was cited infrequently for about 12 years (Holliday 1985, 1990; Stahl 1994; Liu and West 2004). Visualization of cruciform structures by electron microscopy from 1973 and other molecular studies began to persuade geneticists that this recombination intermediate might be real. Forty-five years on, the Holliday Junction is still celebrated and investigated, although the model within which it was embedded has evolved from its original statement to fit the present picture of DNA recombination and repair. For a long time the study of DNA repair in U. maydis was carried out only in Holliday's laboratory; now there are many laboratories using the organism.

See also:

1964, Unstable genes and experiments with Antirrhinum

Brian Harrison, an Experimental Officer in the Genetics Department at JLI from the late 1950s had been studying the genetics of Antirrhinum majus (snapdragon), with a particular interest in mutable or unstable genes. Rosemary Carpenter has recently become his assistant in this work, soon after joining JLI from school in August 1962. Harrison's experiments have not been published but are of great interest to John Fincham, who is well aware of the work of Barbara McClintock (1956) in maize, which many regarded as bizarre at the time. Fincham was one of the few geneticists who fully understood McClintock's complex publications. Fincham and Harrison began to collaborate on an investigation of instability at the pallida locus in Antirrhinum. A normal wild type Antirrhinum flower is fully pigmented and has magenta colour. Antirrhinum flowers with the unstable mutant allele pallida (pal) lack the overall magenta colour and have randomly distributed red spots, stripes or flakes representing cells or cell lineages in which reversion to wild type has taken place. Fincham and Harrison take
advantage of the existence of illuminated, controlled-temperature rooms at Bayfordbury to show in the first of a series of papers (1964) that the level of instability is extremely sensitive to the temperature at which the plants are growing at the time of bud initiation and that the temperature effect on instability is also manifested in the germline. Between 1964 and 1968 their studies of Antirrhinum will establish important features of genetic instability and they identify a single gene unlinked to pal as responsible for the difference between ‘low’ and ‘high’ unstable lines (1968).

Fincham and Harrison discuss their findings in the light of McClintock’s (1956, 1965) studies of maize, finding many similarities to the controlling elements she described (elements that had the capacity to move from one location in the genome to another). The importance of their work on Antirrhinum in the 1960s is only fully realised 20 years later when molecular techniques introduced at JII enable the transposable elements responsible for the observed instabilities to be isolated.

See also:


Information on Barbara McClintock’s work on what we now call transposable elements, for which she received a Nobel Prize in 1982, is available at:
http://www.osti.gov/accomplishments/mcclintock.html

Rosemary Carpenter’s historical summary of research on genetic instability in Antirrhinum majus (part of her claim for the Degree of Doctor of Science, University East Anglia, 1998) is available in the John Innes Centre archives.

1964-1965 Staff unrest at plans to move to Norwich

Director Kenneth Dodds’ Annual Report for 1964 acknowledges that the planned move has resulted in ‘lively’ discussion among the staff and he reports that ‘it was accepted with good grace’. Behind the scenes, however, there is considerable staff unrest not least because of months of uncertainty about whether the proposed move will take place. In April 1965 Bayfordbury and grounds are advertised for sale and a decision is reached at ARC headquarters to reduce JII to only two departments: Genetics and Cell Biology will transfer to the University of East Anglia to form part of the School of Biological Sciences while the other departments will be discontinued. Anger is expressed about the prospect of the ‘complete disappearance of the John Innes Institute as an independent research establishment with its own special facilities, traditions and research programme’. Critics also complain of an ARC plot to divert funds from research to education. The senior staff mount an active campaign to reverse the decision. From May to July 1965 the removal is
discussed in the House of Commons, *Sunday Telegraph, Gardeners’ Chronicle, the Grower, The Times, the Observer* and the *Eastern Daily Press*. In June twenty-five senior members of the Institute’s staff circulate a protest to the ARC, John Innes Trustees and Governing Council, MPs and leading scientists about what they see as a ‘proposed closure’ or break-up of the Institute. In response, the Genetical Society pass a resolution at their AGM saying that they are ‘gravely disturbed’ by these reports and urging that this ‘unique centre for genetic research’ be maintained in its integrity.

During the summer and autumn Cyril Darlington at Oxford (former Director of JIHI) helps mobilise university professors of genetics and fellows of the Royal Society to protest, and musters support from the President of the Royal Horticultural Society, the Director of Kew, and the Principal of Wye College. Meanwhile Dan Lewis tries to speed up reform measures at the University of London that would have fostered better relationships between it and JII, in the hope that this might remove one of the justifications for the move. The uncertainty about the Institute’s future results in considerable staff turnover, including the loss of Heads of Department John Fincham, Norman Simmonds, and Henry Harris. By September 1965 new proposals for JII at Norwich are agreed; these include the establishment of a Chair and Department of Applied Genetics in addition to the two departments already planned. Colonel James Innes, Chairman of Governing Council, announces that the following principles are being adhered to: first, that JII will ‘remain as an identifiable entity’ and secondly, that fundamental and applied work ‘should be and be seen to be interdependent’.

**1965 John Fincham publishes Genetic Complementation**

Shortly before joining JII John Fincham and his student John Pateman at the University of Leicester working with *am* mutants of *Neurospora crassa* found to their surprise that some mutants deficient in the enzyme GDH, and therefore presumably in the same gene, when combined in a heterozygote would regain their enzyme activity; in other words they were ‘complementing’ each other. Allelic complementation occurs when the active enzyme consists of a pair of, normally identical, polypeptide chains – ‘a dimer’. Certain pairwise combinations of mutant forms can make good each other’s defect and give a partially active enzyme.

Fincham had obtained indirect evidence that such allelic complementation occurred at the protein level during his year at the Massachusetts Institute of Technology (1960) where he also worked out methods for purifying wild-type and mutant enzymes. Fincham continued to work on complementation at JII with post-doctoral colleague Alan Coddington (a biochemist); their first results were published in 1963. At the time their research on genetic complementation posed a challenge to gene theory because mutations in the same gene were supposed to affect the same polypeptide and never to complement each other. That they could demonstrate complementation raised questions of great importance concerning the definition of the gene and the relation between the polypeptide chains, presumed to be the primary products of genetic translation,
and finished proteins. Fincham's research and interest in complementation encourages him to write this comprehensive review of the genetics and biochemistry of all types of complementation. His summary concludes that allelic complementation is basically irrelevant to primary gene action (‘except in so far as it confuses the investigator!’) but that it is of considerable importance in providing an insight into protein structure and function. The book becomes a ‘citation classic’.

For Fincham's reflections on the origin and impact of his book see:  

1965 Closure of Potato Genetics Department

Head of Department, Norman W. Simmonds leaves in September to become Director of the Scottish Plant Breeding Station in Edinburgh where the potato work will continue. Dr R. K McKee also leaves to take up a post in the Ministry of Agriculture and the Chair of Plant Pathology at Queen’s University, Belfast, Northern Ireland. The remaining members of JII’s Potato Genetics Department are transferred to Applied Genetics. The Commonwealth Potato Collection, which was being maintained by the Department, is transferred to the Scottish Plant Breeding Station. Between 1954 and 1965 the Potato Genetics Department has contributed to the classification of wild and cultivated potatoes, furthering understanding of variability, incompatibility relationships and cultivar evolution. Expeditions made by Kenneth Dodds and Norman Simmonds to study cultivated potato origins in South America have added to the stock of biological material in the collection. The Department has also undertaken biochemical pigment research and disease resistance studies (common scab, late blight and virus Y) with a view to breeding improved and disease-resistant varieties, together with other investigations of problems associated with potato improvement.

1965 Unit of Nitrogen Fixation founded at University of Sussex

The Unit of Nitrogen Fixation, which became one of the largest of the Agricultural Research Council’s Units, originated in a report commissioned for the multinational petrochemical company Shell in 1961 on state of the art research on nitrogen fixation. Shell decided that commercial prospects for such research were too remote but passed the report (by K. R. Butlin) on to the Agricultural Research Council which was interested in its proposals for a dedicated research group to investigate the basic chemical processes in nitrogen fixation. Biological nitrogen fixation represented a chemical enigma and there was no centre in Britain in a position to pick up on the lead given in this field by the US industrial giant, Dupont. Joseph Chatt, a leading
inorganic chemist, was chosen to direct the new Unit, and John Postgate, a chemist turned microbiologist, was appointed Assistant Director to take charge of the biological side of the research. The plan was for the team to comprise equal numbers of chemists and microbiologists. The Unit started work in temporary accommodation in London with the chemists based at Queen Mary College where Chatt had been offered a professorship in chemistry, and the microbiologists at the Royal Veterinary College several miles away. Difficulties with the site at QMC led to the consideration of other options for expanding the Unit. Chatt accepted the offer of a professorship at the new University of Sussex which had plenty of room. A common research space was created at the University of Sussex in 1965, albeit in pre-fabricated huts initially. The Unit moved into purpose-built labs in the Chemistry building in 1968. Chatt and Postgate developed independent but interlocking research programmes and within a few years the Unit was widely admired for its interdisciplinary approach and its research on the fundamentals of nitrogen fixation.

The Unit of Nitrogen Fixation moved to Colney in 1987 as the Nitrogen Fixation Laboratory.

1966 John Fincham leaves for Professorship of Genetics at Leeds

Fincham’s extensive work on *Neurospora*, which included studies of glyoxylate metabolism (with student R. B. Flavell) as well as allelic complementation, resulted in his lab at the John Innes Institute becoming a leading laboratory for the study of this fungus. According to Flavell, Fincham also ‘helped establish and sustain fungal genetics in Europe to balance the larger interest in the topic in the USA. His book with Peter Day, *Fungal genetics*, was the most comprehensive and influential in the world’ (Holliday and Flavell 2006, p. 89). However, after these few highly successful years, fungal genetics at JII began to unravel. Peter Day left to take up a position at Ohio State University in 1963; Fincham announced his decision to leave in 1964, when he secured the Professorship of Genetics at Leeds, but he did not take up the post until August 1966 because temporary buildings had to be constructed to house his new department. In September 1965 Robin Holliday left for a post at the Division of Microbiology, National Institute for Medical Research in London, and Alan Coddington went to the University of East Anglia as Lecturer in the new School of Biological Sciences. Fincham, Holliday and Coddington’s decisions to leave were directly related to the anticipated disruption and political upheaval of JII’s planned move to Norwich.

1966 Scientists in USA crack the Genetic Code

Over the course of several years, Marshall Nirenberg, Har Khorana and Severo Ochoa and their colleagues have elucidated the genetic code – showing how triplet mRNA codons specify each of the twenty kinds of amino acids in proteins. In 1968 Khorana and Nirenberg share the Nobel Prize in Physiology or Medicine with Robert Holley for their interpretation of the genetic code and its function in protein synthesis.

See also:
http://www.genome.gov/25520300
http://nobelprize.org/nobel_prizes/medicine/laureates/1968/

1966 Resignation of K S Dodds

In February, Kenneth Dodds takes up a post in Turkey under the Food and Agricultural Organization of the United Nations. As an interim measure, the Governing Council arranges for Dr E. E. Cheesman of the Agricultural Research Council to help administer the Institute. Cheesman continues as Acting Director until the appointment of a new Director in 1967.

1967 John Innes Institute moves to Norwich

The Institute’s move to Norwich is completed in June 1967, a year since building operations began. The temporary buildings at Colney were partially occupied in March, and the move proceeded in stages over the following months. Equipment was moved in between March and June and all the scientific staff have transferred to Norwich by October. The Bayfordbury estate is taken over by Hertfordshire County Council in July, with provision for JII staff to return until the end of the year to remove plants, trees and shrubs of scientific or botanical interest needed at the Institute’s new home in Norwich. The original plan following the move to Norwich is for JII’s permanent laboratories to be built on the University Plain a mile away from the Colney site. It is intended that Colney will be used as temporary accommodation and later for the plant work and to house the Department of Applied Genetics, an arrangement that if carried out will split up the ‘pure’ and ‘applied’ sections of the Institute.

The Agricultural Research Council (ARC) remains unwilling to specify the extent of their financial support to JII after the next five-year period. They wish to see how the association with the University of East Anglia develops but at this stage their commitment to the Genetics Department looks most at risk. In the long-term (and particularly after 1977) the ARC envisages a re-assessment of its contribution to JII with some of its responsibilities transferring to the University Grants Committee. The exception to this general proposal is Applied Genetics which, subject to an agreed programme, will remain the responsibility of the ARC and receive substantial funding.
1967 Roy Markham appointed Director and John Innes Professor of Cell Biology at UEA

Dr Roy Markham, FRS takes up his new appointments on 1st October 1967; he brings with him the Agricultural Research Council Virus Research Unit (VRU) which he has directed since 1960. VRU originated as the 'Potato Virus Research Station’, founded as part of Cambridge University’s School of Agriculture in 1927 with help from the Ministry of Agriculture. The founding director R. N. Salaman had been a friend of William Bateson and Sir Daniel Hall and under him the work of the Institute involved the development of virus-free potato varieties and general plant virus studies, especially those relating to potatoes (including Potato Virus X). In 1939 Kenneth M. Smith succeeded Salaman as director of the Institute which was later taken over by the ARC in 1947 and re-named the 'Plant Virus Research Unit’ to reflect Smith’s wider interests in plant viruses. Smith’s interest in insect viruses engendered a further name change to ‘Virus Research Unit’. Markham first joined VRU in 1940 (with a first degree in biochemistry) as Smith’s assistant.

Markham’s early training consequently includes practical plant virological methods, for example, diagnostic work and routine monitoring of virus-free stocks of potatoes. He has since become an expert in biochemical and biophysical investigations of plant viruses including turnip yellow mosaic virus, among others. He is also by temperament an inventive engineer. At this stage in his career he is recognised as a distinguished virologist and since 1964 has been a keen and active member of the Governing Council of JII. Recently he has been working intensively on the ultrastructure of viruses (their detailed architecture revealed by electron microscopy) and has begun to explore diffraction techniques. Getting Markham to leave Cambridge and accept the appointment is a major triumph because as yet JII has little to offer by comparison. Newly settled at Norwich, the Institute has no permanent laboratories and in May 1967 the total senior staff, including the Librarian and Secretary, number only 17. Professor Sidney Elsden (first Director of the Food Research Institute at Colney and an old friend of Markham) later documented the decisions waiting on the start of Markham’s Directorship:

‘… on the location of the Institute, on its design and on the appointment of the John Innes Professors of Genetics and Applied Genetics. Markham realised that if the Institute was built on the University Campus the laboratories would be separated from the glasshouses which were at Colney Lane and that this would be extremely inconvenient for the staff. He persuaded the John Innes Council and the Trustees to build the Institute on the Colney Lane site and at the same time he persuaded the Trustees to provide funds for a much larger Institute than was originally planned and which would include substantial facilities for research on ultrastructure’ (Elsden 1982, p. 21).

In addition, Markham proposed (in 1970) a large lecture theatre and recreational facilities for the staff; these included a swimming pool ‘on the grounds that the founder, John Innes, like him, was a keen swimmer’. Integration of the Virus Research Unit (VRU) with JII has
to wait until the building of additional accommodation is completed in 1970-1. Once Markham’s plans are pushed through, Markham will preside over the best designed and equipped centre for research on plant and microbial science in the United Kingdom.


For archives relating to Kenneth Smith, Roy Markham and VRU see:

http://www.jic.ac.uk/corporate/services-and-products/library/significant-collections.pdf

1967-8 New Electron Microscopy Section

The decision to move the ARC Virus Research Unit from Cambridge to Norwich means that the John Innes Institute will possess three high resolution electron microscopes, two from Cambridge and one from Bayfordbury. Markham is keen to exploit this as an opportunity to open an electron microscopy section, capable of running postgraduate courses. He appoints R. W. Horne, formerly Senior Principal Scientific Officer at the ARC’s Institute of Animal Physiology at Babraham and before that a pioneer electron microscopist in the Cavendish Laboratory in Cambridge, to lead the section. A new electron microscopy and photographic building is planned to accommodate up to five electron microscopes and the vast amount of enlarging that will be needed for the electron microscopy work. The new building will have a large classroom for teaching embedding, sectioning and staining techniques as well as the interpretation of electron micrographs.

1968 David Hopwood appointed as Head of Genetics and John Innes Professor of Genetics at UEA

David Hopwood, formerly a lecturer in Genetics at the University of Glasgow (1961-68), takes up his new appointment as Head of Genetics in July 1968 and moves to Norwich on 1 September. He is an expert in Streptomyces coelicolor, which grows mycelial colonies with sporulating aerial hyphae. Streptomycetes are also of interest because they are important natural antibiotic-producers. When Hopwood first took up the study of S. coelicolor as a Ph.D. student in the Botany School at Cambridge nobody else in the world was known to be working on Streptomyces genetics. Indeed, bacterial genetics was still in its infancy and ‘appeared bizarre compared with the genetics of plants and animals’ (Hopwood 2007, p.51). Pioneering work by Hopwood in the 1950s and 1960s has established S. coelicolor A3 (2) as the model system for the genus. His work has involved developing the basic genetics of S. coelicolor A3 (2) and devising a novel method of linkage analysis (1959), a procedure that later proved useful for genetic studies of other microbes. Hopwood had had a productive
collaboration with Giuseppe Sermonti and his wife Isabella Spada-Sermonti in Rome and had spent sabbatical periods there in 1960 and 1961. They continued to collaborate after Hopwood’s move to Glasgow, but Sermonti gradually lost interest in practical science and moved to philosophical studies, eventually becoming Italy’s strongest advocate of creationism.

In 1967 Hopwood, still working with a very small group, has just established a detailed circular linkage map of more than 100 S. coelicolor genes. A recent sabbatical at New York University with Werner Maas, who since 1956 has been investigating the regulation of arginine biosynthesis in Escherichia coli, has provided him with a comfortable grounding in biochemistry and skills that will be of use in the more molecular aspects of genetics in the next decade. Though still only 34, Markham recognises in him the ability to establish a more substantial group and to shape the future of genetics at JII. Hopwood will go on to develop an exceptionally successful blend of plant and bacterial genetics over the next three decades though not without a struggle. Hopwood has to contend with the difficulty that the Governing Council of JII has little understanding of microorganisms and with Agricultural Research Council fears that they will be paying only for a topic - Streptomyces – that they believe will have no relevance to agriculture. There are also challenges associated with continuing uncertainty about the long-term future of genetics at JII; the ARC has not made an ongoing commitment to fund it after the move to Norwich and it still faces the possibility of being detached to join biological sciences at UEA.

When Hopwood joins JII he brings four members of his Glasgow group including Alan Vivian (postdoctoral fellow) and Helen Ferguson (later Wright and now Kieser) his young laboratory assistant. Helen had left school at 16 and joined the Department of Bacteriology at Glasgow, gaining a thorough grounding as a technician in the teaching laboratories. Hopwood had been fortunate enough to have her assigned to his laboratory when he applied to Glasgow University for a technician to assist him in his research in 1965 and valued her work so much that he persuaded her to move to Norwich with him. She will work alongside Hopwood for the next 30 years and much of the later development of Streptomyces genetics as an international field of study will be due to her skill and personality.

See also Keith Chater, ‘David Hopwood and the emergence of Streptomyces genetics’, International Microbiology, 2 (1999): 61-68.

http://www.im.microbios.org/06june99/03%20Chater.pdf


1968 D. Roy Davies joins as Head of Applied Genetics and John Innes Professor of Applied Genetics at UEA

D. Roy Davies comes from the UK’s Atomic Energy Research Establishment at Harwell where his group were initially concerned to establish the feasibility of exploiting induced mutations for crop improvement. As many claims proved to be over-optimistic, the group’s work changed to studies of the induction and repair of radiation damage in a range of biological systems, notably Chlamydomonas, a genus of green algae. His primary concern on taking over Applied Genetics is to put together a research programme that will satisfy the Agricultural Research Council in the long term. In particular he must define those plant breeding problems that exist in the horticultural industry and which are not being catered for elsewhere by State-supported research organisations. This will mean scaling down some of the existing fruit-breeding work. Future programmes in Applied Genetics will centre on the exploitation of leafless and semi-leafless peas since there is no State-supported work on this crop; physiological and pathological studies will be supplemented by biochemical investigations as opportunities arise. In the interim Davies also hopes to fill other gaps in research in the horticultural industry by including the production of certain commercially important flower crops (including Carnation, Chrysanthemum, Poinsettias, Freesias, Anemones and F1 Antirrhinums).

1969 First evidence for a fertility system controlling mating in Streptomyces

Studies of genetic recombination in the bacterium Streptomyces coelicolor by David Hopwood, Richard Harold, Alan Vivian and Helen Ferguson strongly suggest that some kind of mating is involved. At this time the only precedent for bacterial conjugation is the system discovered by Joshua Lederberg and Edward Tatum in Escherichia coli (1946). It was Lederberg who between 1946 and 1952 launched bacterial genetics by showing that certain strains of bacteria reproduce by mating, combining their genetic material. His experiments overturned conventional opinion that bacteria were primitive organisms not suitable for genetic analysis. Since then Bill Hayes at the London Postgraduate Medical School, whose work and personality especially inspired Hopwood as a young PhD student, Luca Cavalli-Sforza in the Lederbergs’ laboratory at Stanford University, USA and other researchers around the world had made significant advances in the study of fertility in bacteria.

The most pressing problem for Hopwood’s group on arriving at Norwich is to try and make sense of the mating system of Streptomyces. Hopwood’s team have recently (1969) identified a class of fertility variants in S. coelicolor A3 (2) called ‘ultra-fertile’ (UF). These variants differ strikingly in their sexual capabilities from the strains that they have previously worked with. Fertility variants in the better-known bacterium E. coli have led to the elucidation of its sexual process. Using these insights, Hopwood’s team devise methods for attacking this problem in Streptomyces.
By 1969 they are able to present the first firm evidence for a fertility system controlling mating in *Streptomyces*.

See also:


On Joshua Lederberg’s experiments see:


On the history of bacterial genetics:


For a summary of early work on bacterial conjugation:

[http://www.mun.ca/biochem/courses/3107/Lectures/Topics/conjugation.html](http://www.mun.ca/biochem/courses/3107/Lectures/Topics/conjugation.html)
1970s – Present Timeline
1970s

1970 – A new virology department established. JII now had four departments: Applied Genetics, Genetics, Virus Research, and Ultrastructural Studies

1970s – The first registered ‘semi-leafless’ pea varieties produced from research and breeding work at JII. The improved crop productivity and standing ability led to the use of ‘semi-leafless’ worldwide

1972 - First John Innes Symposium on the ‘Generation of Subcellular Structures’

1974 – Second John Innes Symposium on ‘Modification of the Information Content of Plant Cells’, chosen for its current interest and ‘controversial nature’

1978 – ARC initiated a programme, involving several Institutes, designed to exploit advances in genetic manipulation techniques in the development of new varieties of crop plants and microorganisms of agricultural relevance

Gavin Brown was awarded the Veitch Memorial Gold Medal of the Royal Horticultural Society for his services to horticulture, particularly for his work in breeding fruit and flowering plants

1979 – Professor R Markham died in November. Professor D. Roy Davies appointed Acting Director

Professor D Hopwood was elected FRS in recognition of his pioneering genetic studies of streptomycetes, the soil bacteria that produce the great majority of medically- and agriculturally-important antibiotics

1980s

1980 – Professor Harold W Woolhouse appointed Director

John R Postgate became Director of ARC Unit of Nitrogen Fixation (Sussex) following J Chatt’s retirement

1982 – Head of Department of Ultrastructural Studies, Professor R W (Bob) Horne, retired in December; was succeeded by Dr Keith Roberts who established a new Department of Cell Biology in 1983

1983 - First edition of The Molecular Biology of the Cell, co-edited by Dr Keith Roberts, published. This became the leading cell biology textbook, lauded as ‘the most influential cell biology textbook of its time’ (5th edition, 2008)

1985 – Agricultural and Food Research Council’s Forward Policy proposed that its research institutes should be re-organised into eight ‘super’ institutes
The John Innes *Streptomyces* group described production of the first hybrid antibiotic by genetic engineering.

1987 – Plant Breeding Institute at Cambridge saw its applied research programmes, farm site and National Seed Development Corporation sold to a private company (Unilever) under the government’s privatisation policy. The non-privatised part of PBI was moved from Cambridge to Norwich and integrated into the AFRC’s new Institute of Plant Science Research (IPSR), which also included the John Innes Institute and the re-named Nitrogen Fixation Laboratory, which remained at Sussex.

The NFL’s director J R Postgate retired and was succeeded by Barry Smith.

Professor Woolhouse resigned as Director of JII to become Director of the IPSR; Richard Flavell, PBI plant molecular biologist, was appointed Director of JII.

The Sainsbury Laboratory was founded for research on molecular plant pathology, through the foresight of Sir David Sainsbury and the generosity of the Gatsby Charitable Foundation, a Sainsbury Family Charitable Trust. Dr Mike Daniels moved from the JII Genetics Department to be first head of the Sainsbury Laboratory with Drs David Baulcombe and Jonathan Jones as the other two founding senior scientists.

1989 – Formal opening of The Sainsbury Laboratory, occupying new buildings on the IPSR campus.

1990s

1990 – Majority of PBI’s scientific staff re-located to newly built facilities at IPSR where they formed the ‘Cambridge Laboratory’ under Dr Colin Law.

1992 – AFRC confirmed the move of AFRC Nitrogen Fixation Laboratory to Colney.

1993 – Dr Mike D Gale succeeded Dr C Law as Head of Cambridge Laboratory.

1994 – Merger of John Innes Institute, Cambridge Laboratory and Nitrogen Fixation Laboratory to form the new John Innes Centre. Professor R Flavell became first director of JIC.

Dr K Roberts established the first ‘Teacher Scientist Network’ in the UK, supported by The Gatsby Foundation with space provided by JIC.

BBSRC was established by Royal Charter by incorporation of the former AFRC with the biotechnology and biological sciences programmes of the former Science and Engineering Research Council (SERC).

Professor D Hopwood made Knight Bachelor in the Queen’s Birthday Honours for ‘services to genetics’.

1995 – Members of Nitrogen Fixation Laboratory staff moved to Colney. The Joseph Chatt Building and the conference centre complex were formally opened in October.
Professor M D Gale’s research on cereal genome structure revealed conservation in gene order (synteny) in all cereal species, enabling a step-change in breeding strategies and the cloning of genes from these species.

Professor Keith Chater elected FRS for his work demonstrating how the ability of streptomycetes to produce antibiotics is connected to unusual features of their growth.

1996 – Professor M D Gale elected FRS in recognition of his discovery that the organisation of genes in grasses, including the major crops, rice, maize and wheat, is so conserved that predictions can be made from one crop to another.

1998 – Professor R Flavell elected FRS for his research and leadership in plant molecular genetics. He was among the first to investigate plant genomes at the level of DNA sequence.

Professor R Flavell resigned on joining the biotechnology company Ceres in California, USA; Professor M D Gale appointed acting Director of JIC.

Royal Society awards Professor M D Gale and Graham Moore the prestigious Darwin Medal in recognition of their research on cereal genetics.

Professor Enrico Coen elected FRS for his outstanding research into how flowers are formed. Amongst other important genes that control flowering, he discovered the genes that switch growing shoots to produce flowers.

A £1.3 million controlled environment facility opened. The new facility is important to several of JIC’s main research programmes, including work on rice and studies on the sensitivity of plants to day-length.

1999 – Professor Chris Lamb appointed Director.

Dr Nick Harberd’s team identified and isolated the dwarfing gene that was central to the ‘Green Revolution’ through their research on synteny and the model plant species, Arabidopsis.

Professor E Coen’s team solved 250 year mystery of peloric or ‘monster’ flowers in toadflax (Linaria vulgaris). They showed that the abnormal toadflax flowers are caused by a naturally occurring mutation of a single gene that controls flower symmetry.

An international research group of over 200 scientists, from 35 laboratories, published the complete DNA sequence for chromosomes 2 and 4 of the tiny weed Arabidopsis thaliana (thale cress), two of this plant’s five chromosomes. Professor Mike Bevan oversaw the co-ordination of chromosome 4 sequencing work.

Professor Ray Dixon elected FRS for his major contributions to understanding the genetic basis of nitrogen fixation. He created the first ‘engineered’ nitrogen-fixing microbe.
2000s

2000 – Dr Caroline Dean’s team identified and isolated a plant gene (FRIGIDA) that controls whether or not a plant needs a winter period before it will flower.

2001 – Professor David Baulcombe of The Sainsbury Laboratory elected FRS for his outstanding contribution to the inter-related areas of plant virology, gene silencing and disease resistance.

Professor E Coen elected member of USA’s National Academy of Science; only 18 scientists worldwide and from all branches of science are elected as Foreign Associates each year.

2002 – Professor Sir D Hopwood’s group together with the Wellcome Trust Sanger Institute, Cambridge, publish the complete genome sequence of *Streptomyces coelicolor*, a member of the group of soil-inhabiting microbes that are the source of over half of the antibiotics in current use and many other drugs. Their achievement features on the cover of the international science journal *Nature*.

Major departmental restructuring implemented including the creation of two new research departments in Biological Chemistry and Molecular Microbiology. This brought JIC’s departments to six, the other departments being Crop Genetics, Cell and Developmental Biology, Metabolic Biology, and Disease and Stress Biology.

Genome Centre established – housing the John Innes Centre Genome Laboratory and the Norwich Bio-Incubator.

2003 – Professor Sir D Hopwood was awarded the first Ernst Chain Prize. The prize is for a career scientist who has made an original and substantive contribution in any field of science which has furthered, or is likely to further, understanding or management of human disease.

2004 – Professor C Dean elected FRS (and awarded OBE) for her outstanding contributions in the study of developmental timing in plants. Her work revealing the mechanism by which plants remember they have experienced winter demonstrated novel RNA processing mechanisms controlling flowering. Dean’s pivotal role in the development of *Arabidopsis* as a model for plant genetics was also recognized.

2005 – Merger of appropriate administration and support services of JIC with those of the neighbouring Institute of Food Research announced.

2006 – Dr G Moore’s group at JIC sequenced a gene complex that controls how chromosomes pair (Ph1). A major advance in wheat genetics, this knowledge could allow breeders to cross commercially grown varieties with wild varieties to give increased tolerance to drought and other desirable characteristics.
Professor Phil Dale (plant genetics) and Dr Alison Smith (plant biochemistry) were both awarded OBEs.

2007 – Professor K Roberts awarded OBE in recognition of services to cell biology and to science communication.

Computational and Systems Biology Department founded.

2008 – Professor Cathie Martin’s group expressed genes from snapdragon in tomatoes to grow purple tomatoes high in health-protecting anthocyanins. Sue Bunnewell and Andrew Davis’s image of the tomatoes was selected by *Nature* as one of the ‘Images of the Year’.

Fifth edition of *The Molecular Biology of the Cell* (co-editor Professor K Roberts) published. This book has now been read by over 1 million people.

Bioimaging team moves into purpose-built facility with a new Transmission Electron Microscope.

Professor Chris Lamb elected FRS for his major contributions to our understanding of the molecular basis of plant defence.

Professor C Dean, OBE, FRS elected member of USA’s National Academy of Science.

2009 – The story continues...