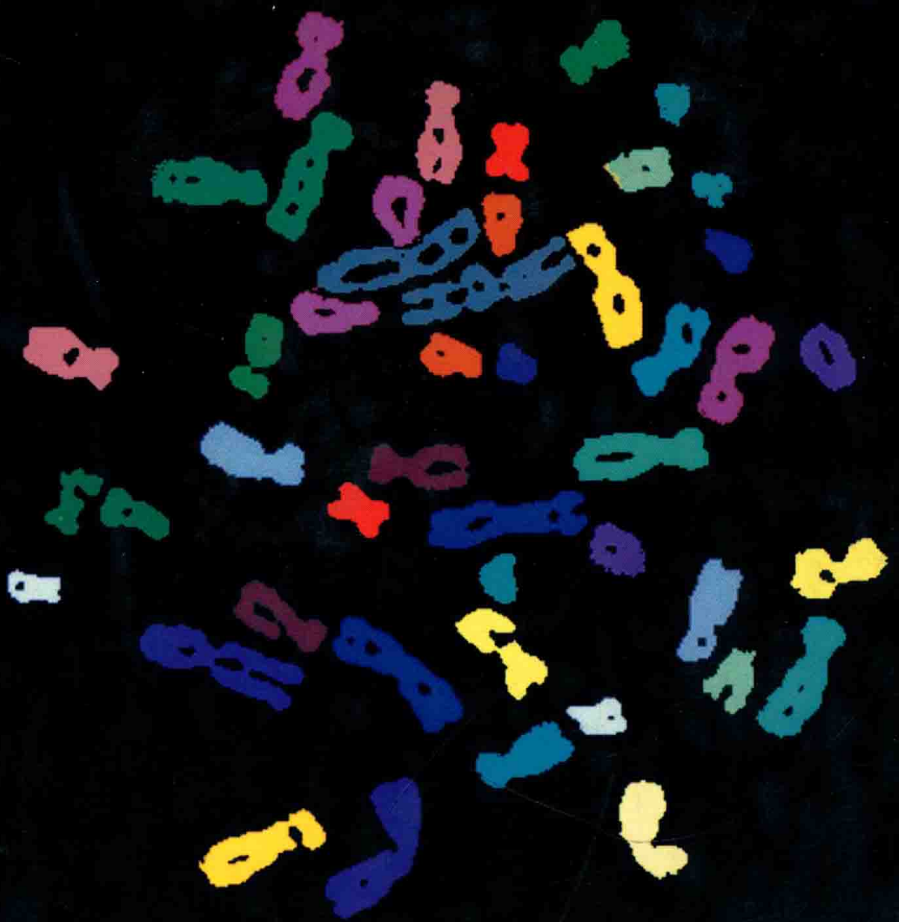
GENETICS MANUAL

CURRENT THEORY, CONCEPTS, TERMS

GEORGE P. RÉDEI



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♥

TO PAIGE AND GRACE

♥

PREFACE

The primary goal of this Manual is the facilitation of communication and understanding across the wide range of biology that is now called genetics. The emphasis is on recent theoretical advances, new concepts, terms and their applications. The book includes about 18 thousand concepts and over 650 illustrations (graphs, tables, equations and formulas). Most of the computational procedures are illustrated by worked-out examples. A list of about 900, mainly recent, books is provided at the end of the volume, and additional references are located at many entries and illustrations. The most relevant databases are also listed.

The cross-references following the entries connect to a network within the book, so this is not just a dictionary or glossary. By a sequential search, comprehensive, integrated information can be obtained as you prepare for exams, or lectures, or develop or update a course, or need to review a manuscript, or just wish to clarify some problems. In contrast to encyclopedias, I have used relatively short but greater variety of entries in order to facilitate rapid access to specific topics.

This Manual was designed for students, teachers, scientists, physicians, reviewers, environmentalists, lawyers, administrators, and to all educated persons who are interested in modern biology. Concise technical information is available here on a broad range of topics without a need for browsing an entire library. This volume can always be at your fingertips without leaving the workbench or desk. Despite the brevity of the entries, the contents are clear even for the beginner.

Herbert Macgregor made the remarkable statement that in 1992 about 7,000 articles related just to chromosomes were scattered among 627 journals. Since then, the situation has become worse. Many publications — beyond a person's specialization — are almost unreadable because of the multitude of unfamiliar acronyms and undefined terms. Students and colleagues have encouraged me to undertake this effort to facilitate reading of scientific and popular articles and summarize briefly the current status of important topics.

According to Robert Graves (a good poem) "makes complete sense and says all that it has to say memorably and economically". I hope you will appreciate the sense and economy of this Manual.

I will be much indebted for any comment, suggestion and correction.

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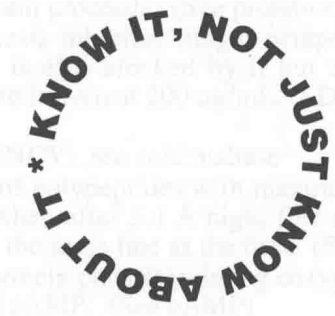
"I almost forgot to say that genetics will disappear as a separate science because, in the 21st century, everything in biology will become gene-based, and every biologist will be a geneticist."

Sydney Brenner, 1993

FIRST TO READ

The material in this book is in alphabetical order. There are different styles of alphabetization, however. Numbers involved with the entries do not affect the order. Words standing alone precede the hyphenated or compounded terms, e.g. *in vivo* precedes *inactive*. Hyphenated words are ordered as if they would not be hyphenated but single words. The spelling of some terms varies because some are used frequently with or without hyphenation (as one word) any many words are spelled either with a *c* or *k*. In the literature some technical terms are spelled either with an *e* or *ae*. Here the most common usage is favored. Certain terms are in plural and that may affect the relative order of the entry. Some entries are qualified by another word added after and in others the qualifier comes first. An attempt was made to guide the reader to the entry sought by both ways when this appeared important. If the case sought after appears missing, try to use synonyms or related terms or concepts and you may find the one that was hiding at the first attempt. Thanks for your patience.



A

A: adenine, a purine base of nucleic acids. (See adenine)

2,5-A (adenine) oligonucleotides: are generated by 2,5-A synthethase from double-stranded RNA. These oligonucleotides activate RNase L which attacks infecting viruses of vertebrates. If the two genes encoding these two enzymes are transformed into plants, they provide resistance against RNA viruses. (See host - pathogen relationship. RNase)

Å (ångstrom): unit of length, 1/10 of a 1 nm; 10^{-7} mm.

A6: *Agrobacterium tumefaciens* strain with a Ti plasmid coding for octopine production in the plant cell. (See *Agrobacterium*, opines, octopine)

α: average inbreeding coefficient, $\alpha = \Sigma p_i F_i$ where p_i is the relative frequency of inbred individuals with F_i coefficient of inbreeding. This value in most human populations is less than 0.001 while in isolated human groups it may exceed 0.02 or 0.04. (See inbreeding coefficient)

A BOX: an internal control region of genes (5S ribosomal RNA and tRNA) transcribed by DNA-dependent RNA polymerase III; the consensus is 5'-TGGCNNAGTGG-3'. The tRNA genes have also an essential *intermediate segment* of about a dozen bases that has no consensus yet its length is necessary for function. Also there is nearby another regulatory consensus, the B box 5'-GGTTCGAANNC-3'. The matrix attachment region (MAR) is also an A box (with a consensus of AATTAAA/CAAA). (See MAR)

***A* CHROMOSOME**: member of the regular chromosome set in contrast to a B or supernumerary chromosome. (See also B chromosome, accessory chromosome)

α COMPLEX: one of the alternate chromosome translocation complexes in *Oenothera.* (See β complex, translocation, *Oenothera*)

A DNA: see DNA

A MEDIUM for *E. coli*, g/L: K_2HPO_4 10.5, KH_2PO_4 4.5, $(NH_4)_2$ SO_4 1.0, Na-citrate.2 H_2O, 0.5 plus glucose 0.4%, thiamin 1 mg/L, $MgSO_4$ 1 mM, and an appropriate antibiotic

α PARTICLES: see alpha particles

α SATELLITE: the centromeric DNA that is normally heterochromatic but it may have important role in controling chromosome segregation and other centromere functions. (See centromere, satellite DNA, heterochromatin, segregation, meiosis)

A SITE: is a compartment on the ribosome; at the beginning of the translation process the first codon, Met or fMET lands at the P site and the next amino acid is delivered to the A site. Then the elongation of the peptide chain proceeds. (See protein synthesis)

α-AMANITIN: a protein synthesis inhibitor fungal octapeptide. It blocks RNA pol II (0.1 μg/mL); RNA polymerase III is also blocked by it but at much higher concentrations (20 μg/mL) but pol I is insensitive to it even at 200 μg/mL. LD_{50} in albino mice is 0.1 mg/kg. (See RNA polymerase, pol, LD_{50})

α-1,4-GLUCOSIDASE DEFICIENCY: see acid maltase

α-HELIX: a secondary structure of polypeptides with maximal intrachain hydrogen bonding. A most common conformation, when after 5.4 Å high, five right turns of an amino acid chain, every 18th amino acids occupy the same line as the first. (See pitch, protein structure)

A-KINASES: cAMP-dependent protein phosphorylating enzymes; the phosphorylation is dependent on sufficiently high level of cAMP. (See cAMP)

α-LACTOSE: milk sugar is converted into allolactose by the β-galactosidase gene of the *Lac* operon of *E. coli* and the latter then becomes the inducer of the operon. (See *Lac* operon)

α MATING TYPE FACTOR OF YEAST: is responsible for the secretion of the α factor (a pheromone), composed of 13 amino acids and it acts on *a* type cells. (See mating type determination)

AAA PROTEINS: are ATPases, enzymes cleaving off phosphates from ATP. (See ATP)

AAF: see alpha accessory factor

AARI: see TUP1

AARSKOG SYNDROME (Aarskog-Scott syndrome): autosomal dominant, autosomal recessive X-linked (Xq12) recessive short stature, hypertelorism (increased distance between organs or parts), scrotum (the testis bag) anomaly, pointed hairline (Widow's peak), broad upper lip, floppy ears, etc. The basic defect involves the RHO/RAC member of the RAS family of GTP-binding proteins. (See stature in humans, head/face/brain defects, RAS)

AATAAA: a consensus of 10 - 30 bp upstream from a CA dinucleotide at the site where cleavage, then polyadenylation of the mRNA commonly take place. This consensus may also be a signal for transcription termination although normally RNA polymerase II continues to work after passing it. (See polyadenylation signal, mRNA tail, transcription termination)

AATDB: *Arabidiopsis thaliana* database provides general information on all aspects of the plant, including genes, scanned images of mutants, nucleotide sequences, genetic and physical map data, cosmid and YAC clones, bibliographical information, etc. Access is available without password through <http://www.weeds.mgh.harvard.edu/index.html> or by e-mail <curator@frodo.mgh.harvard.edu>. (See also AIMS, *Arabidopsis thaliana,* databases)

AAUAAA: is a consensus for polyadenylation of the mRNA. Apparently the poly-A RNA polymerase enzyme and associated protein attach to this sequence before cleavage of the transcript and post-transcriptional polyadenylation takes place. Yeast does not have this consensus. (See also AATAAA consensus's role in polyadenylation)

αβ T cells: recognize the major histocompatibility complex-bound peptide antigens. (See MHC, γδ T cells, T cell)

ABA (abscisic acid (3-methyl-5-[1'-hydroxy-4'-oxo-2'-cyclyhexen-1'-yl]-cis-2,4-pentadienoic acid): is a terpenoid, synthesized from mevalonate and xanthins, apparently through two pathways. It has multiple physiological functions in concert with other plant hormones, particularly with gibberellins and cytokinins by regulating seed dormancy, germination, leaf abscission, etc. Some *aba* genes have been cloned. In the ABA signal transduction farnesyl transferase may be involved. (See prenylation, farnesyl pyrophosphate, plant hormones)

ABASIC SITES: in the DNA where glycosylases have removed bases by cleaving the glycosylic bond. (See glycosylases, DNA repair)

ABAXIAL: not in the axis of body or of an organ.

ABC EXCINUCLEASE: is a 260,000 M_r protein complex containing the subunits coded for by the *uvrA, uvrB* and *uvrC* genes of *E. coli.* UvrA is an adenosine triphosphatase and also brings into position UvrB which after attaching to the DNA cuts it at the 3' position and that provides the opportunity for UvrC to incise at the 5' position. UvrD, a helicase releases the damaged oligomer along with UvrC. Following these events, DNA polymerase fills in the correct nucleotides. In yeast the RAD1, 2, 3, 4, 10, 14, carry out the same tasks as the ABC excinucleases of bacteria. In humans, the XPA (a damage recognition protein, comparable to UvrA), binds to the XPF-ERCC1 (**e**xcision **r**epair **c**ross-**c**omplementing protein) heterodimer and to the human single strand binding replication protein, HSSB. XPF (3' cut) and XPG (5' cut) are nucleases. The gap-filling polymerases are polδ and polε. XPB and XPD are helicase subunits of the TFIIH transcription factor. The excinuclease complex is released at the end of the process with the aid of the proliferating cell nuclear antigen (PCNA). This complex is capable of excision of cyclobutane pyrimidine dimers, 6 - 4 photoproducts (adjacent pyrimidines cross linked through C^6- C^4), nucleotide adducts (molecules with added groups) formed by mutagenic agents. (See excision repair, adduct, DNA polymerases, DNA ligase, helicase, transcription factors, PCNA, cyclobutane)

ABC TRANSPORTERS (ATP-binding cassette transporters): constitute a large family of proteins which hydrolyze ATP and mediate transfers through membranes. These are usually called now TAP. (See TAP, protein-conducting channel, TRAM, signal hypothesis, SRP, translocon, translocase)

ABCD MODEL: is an environmental matrix for the study of the performance of species. (See box)

The ABCD Model

	Environment 1	Environment 2
Genotype 1	A	B
Genotype 2	C	D

ABDOMEN IN *DROSOPHILA*: the body segment between the thorax and telson. (See *Drosophila)*

ABELSON MURINE LEUKEMIA VIRUS oncogene (*abl*): is the mammalian homolog of the avian Rous sarcoma virus. It codes for a plasma membrane tyrosine kinase. (See oncogenes, Rous sarcoma)

ABERRANT GENETIC RATIOS: occur when the chromosomes carrying the wild type or mutant allele of a gene have reduced transmission through meiosis or the viability of the gametes is diminished. Depending on the chromosomal location of the defect, either the one (wild type) or the other (recessive) allele may appear in excess of expectation of normal phenotypic ratios.

ABERRATION CHROMOSOMAL: see chromosome breakage

ABETALILIPOPROTEINEMIA: involves very low levels of the very low density (VLDL), low density (LDL) and high density (HDL) of these lipoproteins. The rare recessive anomaly is accompanied by excretion of lipoproteins, malabsorption of fat, acanthocytosis (thorny type erythrocytes), retinitis pigmentosa (sclerosis [hardening], pigmentation and atrophy [wasting away]) of the retina of the eye and irregular coordination of the nerves (ataxia). (See neuromuscular disease)

ABH ANTIGENS: in humans are secreted in the saliva and other glycoprotein-containing mucus in the presence of the *Se* (dominant allele, human chromosome 19cen-q13.11), and the gene codes for the α2L-fucosyltransferase enzyme. The secreted glycoproteins, A and B are about 85% carbohydrate and about 15% protein. Approximately 75-80% of Caucasoids are secretors (homozygous or heterozygous for *Se*). The precursors of the antigens are Galactose(β1-3)*N*-acetyl-D-glucosamine-R and Gal(β1-4)*N*-acetyl-glucosamine-R (where R stands for the extension of the carbohydrate chain).

Fucose
|

Antigen H has the critical structure of Galactose(β1-3,4)*N*-acetyl-D-glucosamine-R. Antigenic determinant A is formed by *N*-acetylgalactosamine, and the B antigen by galactose addition at non-terminal position to the H antigen. Thus the A, B, and H antigens are different from each other by these carbohydrates and in some variants by the number of fucose molecules. The A and B alleles are codominant. The recessive O blood group lacks a fucosidase activity that places a fucose, by an α1-2 linkage on a galactose. The Lewis blood group (Le [Les], 19p13.1-q13.11) is distinguished on the basis that its dominant allele Le places fucose in an α-1,4 linkage to the *N*-acetylglucosamine. Individuals that have no secretor activity but are Le belong to the Lewis blood group Le^a whereas when both Se and Le are expressed they represent the Le^b type. (See also ABO blood group, Bombay blood type).

ABIOGENESIS: spontaneous generation of life, origin of living cells from organic material during the early history of the earth. (See spontaneous generation, origin of life)

abl: B cell lymphoma (Abelson leukemia) oncogene encoding a non-receptor protein tyrosine kinase. This oncogene is activated by ionizing radiation and alkylating agents. In its absence the JNK/SAP kinases (Jun kinase) are not stimulated. (See leukemia, lymphoma. JUN, JNK/SAP)

ABL: see abetalipoproteinemia

ABL (Abelson murine leukemia virus oncogene): located to human chromosome 9q34.1 and mouse chromosome 2. When translocated to human chromosome 22 it may transcribe a fusion protein with an abnormal protein tyrosine kinase activity and this is probably the cause of

ABL continued
chronic myeloid leukemia. Acute lymphocytic leukemia is also associated with a similar translocation, the Philadelphia chromosome, but it appears that tyrosine kinase activation is different from that of the fusion protein. The ABL gene has an about 300 kb intron downstream from the first exon. This intron appears to be the target of the translocations and causes acute lymphocytic leukemia. Insertion of DNA sequence into the *abl* gene of mouse results in several morphological alterations and death. (See oncogenes, ARG, Philadelphia chromosome, leukemia)

ABLATION: mechanical removal of cells or tissues of stem cells or plant meristems to study the role of those cells in differentiation and development. The purpose can be achieved also by obtaining genetic deletions in these areas, heterozygous for appropriate marker genes. The deletion of the dominant allele reveals the function of the recessives and permits tracing cell lineages on the basis of the visible sectors formed. Familial retina ablation may occur in animals as a hereditary abnormality. (See also gene fusion, pseudodominance, deletion, cell lineages)

ABM PAPER: see diazotized paper

ABO BLOOD GROUP: is represented by three major type of alleles (human chromosome 9q34) displaying codominance. These blood types are extremely important because inappropriate mixing (in blood transfusion) results in agglutination that prevents the flow of blood through the veins and oxygen transfer, and it is potentially lethal. These antigens are actually carbohydrates (attached to polypeptides), and the genes A and B specify α-D-*N* - acetylgalactosaminyltransferase and α-D- galactosyltransferase enzymes, respectively. Gene O is not active as an enzyme. The A and B enzymes (M_r about 100,000) are dimeric and structurally similar to each other. The A and B molecules are identified as A and B antigens. The clinical characteristics

:

Blood Group (frequency in caucasoids*)	Genotype	Antigens Formed	Antibodies Formed	Clumping With	Blood Type Acceptable for Transfusion
O (0.45)	i^Oi^O	neither	anti-A anti-B	A, B AB	O
A (0.44)	i^Ai^A or i^Ai^O	A	anti-B	B, AB	A, O
B (0.08)	i^Bi^B i^Bi^O	B	anti-A	A, AB	B, O
AB (0.03)	i^Ai^B	A, B	neither	neither	A, B, O

*The frequency of these alleles vary in different populations. For the calculation of frequencies see gene frequencies. Actually the A type exists in A_1 and A_2 forms and in about 1 - 2 % of the A_2 and in about 25% of the A_2B individuals anti-A_1 antigens occur.

Occasionally maternal antibodies against the A and B antigens may enter, through the placenta, the fetal blood stream and affect adversely the erythrocytes causing anemia and hyperbilirubinemia. In such cases medical treatment may be required. The ABO system has also a limited use in forensic medicine in paternity suites, in typing blood stains, semen and saliva in criminal cases. Immunologically active forms may be recovered in old human remains and can be used also in archeological research. This blood group provided some correlative information in cancer research, e.g. in O individuals afflicted with carcinomas A antigen may be detected in 10-20% of the cases. It appears, changes in glycosyltransferase activity is not uncommon in several types of tumors. The frequency of the various ABO alleles varies a great deal in the world's population. It has been shown that the O blood type provided some protection against the most severe form of syphilis (*Treponema pallidum*) but somewhat higher susceptibility to diarrhea caused by some viral and bacterial infections. The B blood group may have afforded

some protection against smallpox, plague and cholera. (See also ABH antigen, Lewis blood group, blood groups, forensic genetics)

ABORIGINE: the first group of inhabitants, humans, animals or plants.

ABORTION, SPONTANEOUS: is frequently caused by disease, chromosomal aberrations. Various types of chromosomal defects were cytologically detected in 30-50% of the aborted fetuses. About 15-20% of the verified human pregnancies are aborted spontaneously and an estimated 22% of the abortions occur before pregnancy is clinically detected. (See selective abortion, trisomy, chromosomal rearrangements, chromosome breakage)

ABORTIVE INFECTION: bacteria are infected with a phage capsule that carries bacterial rather than phage DNA and thus cannot result in the liberation of phage particles.

ABORTIVE TRANSDUCTION: the transduced DNA is not incorporated into the bacterial genome and in the absence of a replicational origin it can be transmitted but it cannot be propagated. Therefore the transduced fragment is contained in a decreasing proportion of the bacteria. (See transduction, transduction abortive [diagram])

ABRIN: agglutinin, a toxic lectin and hemagglutinin extracted from the seed of the tropical leguminous plant jequirity (*Abrus precarius*). Abrins A, B, C, D are glycoproteins of two polypeptide chains. The small A chain is an inhibitor of aminoacyl-tRNA binding and has nothing to do with agglutination. Abrin is more toxic to a variety of cancer cells (ascites, sarcomas) than to normal cells. (See aminoacyl tRNA synthetase, lectins, hemagglutinin)

ABRINE: N-methyl-L-tryptophan (α-methylamino-β-[3-indole]propionic acid), and is unrelated to abrin.

ABSCISIC ACID: a plant hormones regulating a variety physiological processes, including modification of the action of other plant hormones. Originally it was detected as a substance involved in the abscission of leaves. (See also ABA, plant hormones, formula below)

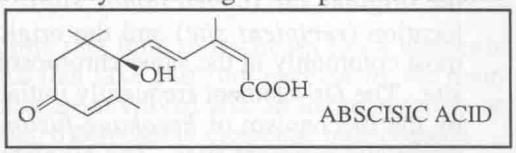
ABSCISSION ZONE: the thin-walled tissue layer (low in lignin and suberin) formed at the base of the plant organs before abscission takes place. (See abscisic acid)

ABSOLUTE LINKAGE: there is no recombination between (among) the genes in a chromosome. (See recombination, linkage)

ABSOLUTE WEIGHT: the mass of 1000 seeds or kernels after appropriate cleaning.

ABSORPTION: uptake of compounds through cell membranes or through the intestines into the bloodstream.

ABSORPTION SPECTRUM: the characteristic absorption peaks of a compound at various wavelengths of light; e.g. guanine has maximal absorption at about 278 nm at pH 9 but its maximum at pH 6.8 is at ca. 245 nm ultraviolet light; chlorophyll-a has an absorption maximum in benzene at ca. 680 and 420 nm visible light whereas chlorophyll-b maxima are at ca. 660 and 460 nm, respectively. These characteristics vary according to the pH and solvents used and are determined by spectrophotometers.)



ABSCISIC ACID

ABUNDANCE: average number of molecules in cells.

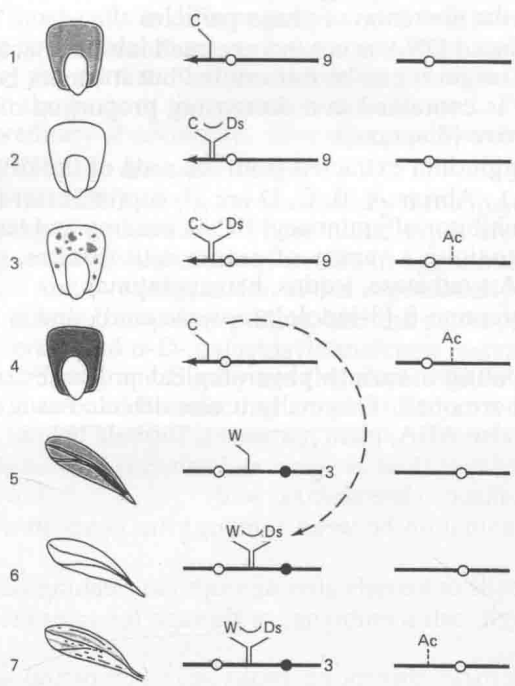
ABUNDANT mRNAs: a small number of RNAs that occur with great numbers in the cells. (See mRNA)

ABZYMES: monoclonal antibodies with enzyme-like properties. If these antibodies can recognize the transition state analogs of enzyme-substrate reactions, they might have enzymatic properties. These abzymes would have numerous chemical and pharmaceutical applications. (See monoclonal antibody, antibody)

Ac—Ds (*Activator -Dissociator*): the first transposable element system recognized on the basis of its genetic behavior in maize. It contains 4563 bp and bordered by 11 bp imperfect, inverted repeats. The independently discovered *Mp* (*Modulator* of *p1* [pericarp color]) is basically the same transposon. *Ac* is an autonomous element and can move by its own transposase function. The *Ac/Mp* element makes a 3.5 kb transcript, initiated at several sites upstream, and a 2,421 base mRNA. A defective (deleted) version of it, *Ds* (*Dissociator*), is non-autonomous and requires the presence of *Ac* for transposition. *Ds* was originally discovered on the basis of frequ-

Ac - Ds continued

ent chromosome breakage associated with it. The *Ds* elements are quite varied in size but practically identical at the terminal sections to *Ac*. These elements have been identified first on the basis of mutation at known loci *(a, Adh, sh, wx, etc.)* upon insertion and reversions when the inserted element is evicted. More recently it has been shown that many of the insertions do not lead to observable change in the expression of the genes or their effect is minimal and their presence may be then revealed only by sequencing of the target loci.



The possible phenotypic expression of genes in the presence of the *Ac - D s* elements in maize. (1) The expression of the *C* allele in chromosome 9 in the absence of the transposable elements. (2) If *Ds* is introduced into the locus the function of *C* is disrupted and the kernel becomes colorless. (3) If *Ac* (transposase) is introduced into any other location of the genome, it may cause the movement of the transposable element and colored spots appear. (4) In case *Ds* is entirely dislodged from the germline, in the following generation full or partial function of the *C* gene is restored, depending whether the original site was completely restored or some modifications took place, and only diluted color appears. (5) The *W* allele in chromosome 3 controls the development of green leaf color. (6) If *Ds* moves into the gene it may disrupt its function and albinism is observed. (7) In case *Ac* is introduced by crossing, *Ds* may move as indicated by the green stripes. Remember, *Ds* lacks transposase function although it may be moved by *Ac* which carries the transposase.

The *Ac* element is transposed by a non-replicative manner and after meiosis only one of the sister chromatids displays *Ac/Mp* at the original site (called *donor site*). In the other chromatid the element may be at another location (*recipient site*) and the original location becomes "empty". The recipient sites are most commonly in the same chromosome and quite frequently within the vicinity of the donor site. The *Ds* element frequently initiates a series of events resulting in chromosomal breakage by the mechanism of *breakage-fusion-bridge cycles* and duplications between the original donor and recipient sites. The *Ds* element may move in an inverted manner to the vicinity of a locus and thus the revertants may still contain a *Ds* element.

In the control of transposition the 11 bp inverted terminal repeats and, in addition, sequences 0.05 to 0.18 kb have importance. The *Ac-Ds* target sites display 8 bp duplication which remains even after the removal of the element. The empty target sites may show internal deletions and rearrangements.

The transposition is mediated by a *transposase* enzyme that can mobilize the *Ac* element which codes for it but it may act on the *Ds* elements too (which are transposase-defective *Ac* elements). It appears that an increase in the number of *Ac* elements results in proportionally smaller revertant sectors, and the genetic background, developmental specificities (e.g., somatic or germline tissues) and physiological factors may influence the timing and frequency

Ac - Ds continued
of transposition. There is evidence in favor of methylation being one of the factor(s) affecting *Ac* expression. This family of transposable elements has additional members such *MITE* (miniature transposable element) that has the same termini but it is very short. The *Ds1* element is similar to *Ds* but it carries retrotransposons within its sequences.
Ac has been successfully transfered to other species such as tobacco and *Arabidopsis.* (See controlling elements, transposable elements, hybrid dysgenesis, insertional mutation)

ACANTHOCYTOSIS: see abetalilipoproteinemia, elliptocytosis

ACANTHOSIS NIGRICANS: a hyperkeratosis and hyperpigmentation of the skin that may accompany the Crouzon syndrome. (See Crouzon syndrome)

AcAP: an anticoagulant protein isolated from *Ancylostoma caninum* hookworm.

ACAT: see sterol

ACATALASEMIA: a rare autosomal recessive trait involving the deficiency of the enzyme catalase. This enzyme has a protective role in the tissues by removing the H_2O_2. Symptoms include small painful ulcers around the neck, gangrenes in the mouth and atrophy of the gum and very low catalase activity in the blood and other tissues. The heterozygotes have intermediate levels of catalase activity. Acatalasemia may be classified into different groups according to the clinical symptoms, both in humans and in animals.

ACATALASIA: the same as acatalasemia

ACC (1-aminocyclopropane-1-carboxylic acid): is a precursor of the plant hormone ethylene.

ACCEPTOR SPLICING SITE: the junction between the right end of one exon and the left end of the next exon. (See introns, splicing)

ACCEPTOR STEM: part of the tRNA, including the site (5'CCA3') where amino acids are attached. (See aminoacyl-tRNA)

ACCESS TIME: the time interval between calling in a piece of information from a storage source to the actual delivery of that information to the caller. (See also real time)

ACCESSIBILITY: the genetically determined ability of the genome to provide access for the V(D)J recombinase to rearrange the immunoglobulin genes. (See V(J)D recombinase, RAG, immunoglobulins, CDR, RSS)

ACCESSION NUMBER: see BankIt

ACCESSORY CELLS (called also companion cells): are epidermal cells next to the guard cells around the plant stomata, that appear different from the usual epidermal cells.

ACCESSORY CHROMOSOME: see B chromosome

ACCESSORY DNA: product of DNA amplification in the cell. (See amplification)

ACCESSORY PIGMENTS: complement chlorophylls in absorbing light (carotenoids, xanthophyll, phycobilins)

ACCESSORY PROTEINS: such as transcription factors that bind to upstream DNA elements for controling transcription and other binding proteins that take part (not necessarily the main part) in a particular function. Accessory host proteins are involved also in the orientation or directionality of transposons. (See transcription factors, transposable elements, transposons)

ACCESSORY SEXUAL CHARACTERS: the structures and organs of the genital tract including accessory glands and external genitalia, but not the gonads, that are the primary sexual characters. (See sex determination, gonad, sex phenotypic)

ACCURACY: the percentage of correct identification of carcinogens and non-carcinogens on the basis of mutagenicity tests. The mutagenicity tests are much faster and much less expensive than direct carcinogenicity assays but it is important to know how well these simpler tests reveal the carcinogenic (or non-carcinogenic) properties of the chemicals tested. (See sensitivity, specificity of mutagen assays, predictability, bioassays in genetic toxicology)

ACCURACY OF DNA REPLICATION: see DNA replication error

ACE (affinity capillary electrophoresis): is a procedure to test the binding strength of ligands.

ACEDB: *Caenorhabditis elegans* (a nematode, useful for genetic analyses) database. (See

Caenorhabditis elegans)

ACENAPHTENE: a spindle fiber poison and thus polyploidization agent; it is also a fungicide and insecticide. (See polyploid, colchicine, spindle)

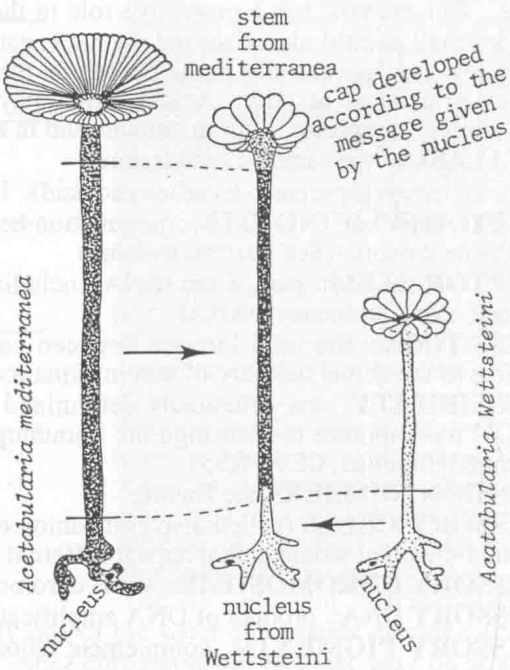
ACENTRIC (CHROMOSOME) FRAGMENT: lacks centromere and its distribution to daughter cells is at random, and it is frequently lost during meiosis. (See centromere, chromosome morphology)

ACENTRIC FRAGMENT: a broken off piece of a chromosome that lacks centromere and therefore its distribution to the poles during nuclear divisions is random and commonly it is lost.

ACERVULUS: a disk-like conidia-bearing reproductive structure of fungi. (See conidia)

ACETABULARIA: single-celled green alga that may reach the size of 2-3 cm and may be differentiated into rhizoids, stem and cap. It can survive enucleation for several months. The rhizoids, containing the nucleus, may regenerate into complete plants; x ≈ 10. (See enucleate)

Acetabularia species are useful object for developmental genetic studies and show dramatically the role of the cell nucleus. Grafting of the nucleus-containing section of the cell of *A. wettsteinii* to *A. mediterrania* caused *A. mediterranea* to develop a cap according to the instructions of the nucleus donor species.
Experiment of J. Hämmerling during the 1940s. (Modified after Goldschmidt, R.B. 1958 Theoretical Genetics. Univ. California Press. Berkeley, CA, USA)



ACETO-CARMINE: see stains

ACETONITRILE (methyl cyanide): a highly poisonous liquid with ether-like odor, flash point 12.8° C (beware of the vapors) a polar solvent used (among others) for the separation of oligonucleotides by reverse-phase chromatography on silica gels.

ACETO-ORCEIN: see stains

ACETOSYRINGONE:(4-acetyl-2,6-dimethoxyphenol) and hydroxyacetosyringone are produced in plant cells (tobacco) and are one group of the compounds that induce the *vir* gene system of the *Agrobacterium* Ti plasmid. (See *Agrobacterium*, transformation [plants], virulence genes of agrobacteria)

ACETYL COENZYME A: see acetyl-CoA

ACETYL GROUP ($R—\overset{\overset{O}{\|}}{C}—CH_3$) : is derived from acetic acid CH_3COOH; the R stands for different chemical groups. (See acyl group)

ACETYL-CoA (acetyl coenzyme A, ACoA): is a heat-stable cofactor involved in the transfer of acetyl groups in many biological reactions (citric acid cycle, fatty acid metabolism, etc.). It has three major domains: the β-mercapto ethylamine unit, the panthothenate unit and adenylic acid. (See epinephrine)

ACETYL-CoA CARBOXYLASE DEFICIENCY (ACAC): recessive, in human chromosome 17q21. It causes multiple interference with gluconeogenesis, fatty acid and the branched-chain amino acid metabolism. (See branched-chain amino acids)

ACETYLCHOLINE (M_r 149): the acetylcholine receptor provides the connection between synapsing neurons and it is thus a signal transmitter. When acetyl choline binds to a receptor a Na^+/K^+ channel opens. The muscarinic acetylcholine receptors are activated by the fungal alkaloid, muscarine, whereas the nicotinic acetylcholine receptors are operating in the nerve and muscle cells. Acetylcholine receptors are diffusely distributed on the embryonic myotubes but become highly concentrated in a minute area in the post-synaptic membrane and they tether the synaptic cytoskeletal complex. (See ion channels, synapse, cytoskeleton, rapsyn, myotube, neuregulin, agrin, neurotransmitters, acetylcholine receptors, muscarinic acetylcholine receptors)

ACETYLCHOLINE RECEPTORS: are acetylcholine regulated cation (Na^+, K^+ and Ca^{++}) channels between the motor neurons and the skeletal muscles. The receptor in the skeletal muscle contains five transmembrane polypeptides, encoded by four separate yet similar genes. When acetylcholine attaches to the receptor a conformational change ensues resulting in a brief opening of the channel. They are easily isolated from the electric organs of some fishes. (See also muscarinic acetylcholine receptors, nicotinic acetylcholine receptors, ion channels, agrin)

ACETYLCHOLINESTERASE (ACHE) is encoded in human chromosome 3q25.2 by codominant alleles. (See acetylcholine, acetylcholine receptors, pseudocholinesterase deficiency)

***achaete-scute* COMPLEX**: of *Drosophila* is a complex X-chromosomal locus regulating bristle formation and nerve differentiation. (See complex locus)

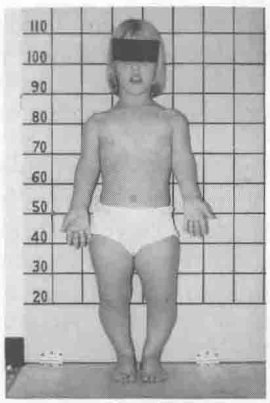
ACHENE: a single-seed dry fruit.

ACHIASMATE: nuclear division without the formation of chiasmata. (See meiosis, chiasma, distributive pairing)

ACHILLES' HEEL TECHNIQUE: is a technique applicable to systems where there is abundant sequence information, and it permits the cleavage of only a small set of restriction sites. It works this way: DNA sequences around the site or set of sites are synthesized and added to the genomic DNA along with RecA, and a methylase. After deproteinization a restriction enzyme is added. All the (methylated) restriction sites are protected from cleavage except those that were covered by the RecA-DNA complex. (See DNA sequencing, Rec, methylase, methylation of DNA, restriction enzyme)

ACHONDROGENESIS: has been described in two or more autosomal recessive forms involving deficiency in bone formation at the hip area and large head, short limbs, still-birth or neonatal death. The phenotypes show variations and clear-cut differentiation of the symptoms is difficult. (See achondroplasia, hypochondroplasia, stature in humans, collagen)

ACHONDROPLASIA: a rather common chromosome 4p16.3 dominant (homozygous perinatal lethal) type of human dwarfness that was observed e.g. in Denmark at a frequency of 1.1×10^{-4}. Its mutation frequency was estimated to be within the range 4.3 to 7×10^{-5}.



AN AUTOSOMAL DOMINANT TYPE ACHONDROPLASIAC ADOLESCENT. (Courtesy of Dr. D.L. Rimoin, Harbor General Hospital, Los Angeles, CA, and Dr. Judith Miles)

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The proximal bones in the limbs are most reduced. Large head with disproportionally small mid-face, abnormal hip and hands are characteristic. The heterozygotes are generally plagued by heart, respiratory and other problems. Hypochondroplasia appears to be allelic to achondroplasia. The so-called Swiss type achondroplasia is recessive and the afflicted individuals show reduced amount of leukocytes (lymphopenia) and agammaglobulinemia. Pseudoachondroplastic dysplasias (spondyloepiphyseal dysplasia) are autosomal recessive but some ambiguities were noted regarding the pattern of inheritance because of apparent gonadal mosa-

Achondroplasia continued
icism. The different forms do not have clear phenotypic distinctions within the group and from the dominant achondroplasia. Some of the skeletal reductions and defects are aggravated by face, eye defects, cleft palate and muscle weakness. Achondroplasia is caused by defects in the fibroblast growth factor receptor 3 (FGFR-3), located in human chromosome 4p16.3. A recurrent missense mutation in a CpG doublet of the transmembrane domaine of FGFR-3 caused an arginine substitution for glycine. Achondroplasiacs usually display normal intelligence. (See stature in humans, hypochondroplasia, pseudoachondroplasia, achondrogenesis, agammaglubulinemia, cleft palate, fibroblast growth factor, dwarfism)

ACHROMATIC: parts of the cell nucleus which are not stained by nuclear stains. A microscope lens that does not refract light into different colors.

ACID BLOB: a sequence of acid amino acids (negatively charged), responsible for activation of a transcription factor. (See transcription factors)

ACID FUCHSIN: a histological stain used to detect connective tissue and secretion granules (Mallory's acid fuchsin, orange G and aniline blue, and in the Van Gieson's solution of trinitrophenol staining of connective tissue of mammals). (See stains)

ACID MALTASE DEFICIENCY: is type II glycogen storage disease involving defect(s) in α-1,4-glucosidase activity. The disease causes accumulation of glycogen in most tissues, including the heart. The first symptoms appear by 2 months after birth and by 5-6 months death results due cardiorespiratory (heart and lung) failures. Although it is classified as an autosomal recessive trait in humans (GAA, 17q25.2-q25.3), the heterozygotes may be distinguished clinically. (See glucosidase, Gaucher diseases, glycogen storage diseases)

ACID PHOSPHATASE: cleaves phosphate linkages at low pH. Its levels are increased in most lysosomal storage diseases, particularly in Gaucher's diseases involving glucosyl ceramide lipidosis (defect in lipid metabolism involving cerebrosides, a complex of basic amino alcohols [sphingosine], fatty acids and glucose). Other diseases may also cause increase of acid phosphatase. In plants only acid phosphatases are found in appreciable quantities. Yeast has at least 4 genes with acid phosphatase function; one of them is constitutive, others are repressed by inorganic phosphate. ACP1 is in human chromosome 2p25, ACP2 in 11p12-p11. (See alkaline phosphatase)

ACIDIC DYES: stain basic residues.

ACIDIC SUGARS: see sialic acids

ACIDOSIS: a reduction of buffering capacity of the body resulting in lower pH of fluids.

ACINAR CELLS: are exocrine cell such as the mammary gland cells that secrete milk, lacrimal cells that secrete tears, etc.

AcMNPV (*Autographa californica* nuclear polyhedrosis virus): can be used for the construction of insect and mammalian transformation vector. (See baculovirus)

ACNE: inflammation of the sebaceous glands (that secrete oily stuff on the skin). It does not appear to be under strict genetic control but rather various environmental conditions, including bacterial infections, mechanical irritation, cosmetics, etc. cause it. It usually appears in puberty and disappears after but may leave behind permanent scars. Occasionally it occurs on infants. (See skin diseases)

ACONITASE: an enzyme controling the dehydration of citrate to cis-aconitate and the hydration of the latter to isocitrate. This enzyme has also an important role in the transport of iron. Iron-containing proteins regulate many processes in both prokaryotes and eukaryotes. In eukaryotic cells the level of the storage protein ferritin increases when soluble iron level increases in the cytosol. The control of the process is mediated by a 30-nucleotide *iron-response element* to what aconitase binds and then blocks the downstream translation of RNA. Aconitase is an iron-binding protein, and the increasing level of iron within the cell dissociates it from the ferritin mRNA resulting in about two order of magnitude increase of ferritin by releasing the translation suppressor from the ferritin mRNA. The increased level of iron also decreases the stability of several mRNAs encoding the receptor that binds the iron-transporting transferrin