# GLOSSARY OF TERMS COMMONLY USED IN BIOTECHNOLOGY

The following glossary is not complete. We have tried to include the most commonly used terms that appear in reports about biotechnology and genetic engineering. We have also tried to keep the explanations as simple and free of jargon as possible.

**Abiotic Stress**
Outside (nonliving) factors which can cause harmful effects to plants, such as soil conditions, drought, extreme temperatures.

**Acclimatization**
Adaptation of an organism to a new environment.

**Active immunity**
A type of acquired immunity whereby resistance to a disease is built up by either having the disease or receiving a vaccine against it.

**Active site**
The part of a protein that must be maintained in a specific shape if the protein is to be functional, for example, the part to which the substrate binds in an enzyme.
The part of an enzyme where the actual enzymatic function is performed.

**Adaptation**
In the evolutionary sense, some heritable feature of an individual's phenotype that improves its chances of survival and reproduction in the existing environment.

**Adjuvant**
Insoluble material that increases the formation and persistence of antibodies when injected with an immunogen.

**Additive genetic variance**
Genetic variance associated with the average effects of substituting one allele for another.

**Aerobic**
Needing oxygen for growth.

**Affinity chromatography**
A technique used in bioprocess engineering and analytical biochemistry for separation and purification of almost any biomolecule, but typically a protein, on the basis of its biological function or chemical structure. The molecule to be purified is specifically and reversibly adsorbed by a complementary binding substance (ligand) that is immobilized on a matrix, the matrix usually being in the form of beads. The matrix then is washed to remove contaminants, and the molecule of interest is dissociated from the ligand and is recovered from the matrix in purified form by changing the experimental conditions.

**Agglutinin**
An antibody that, is capable of recognizing and binding to an immunological determinant on the surface of bacteria or other cells and causing them to clump. (agglutination)

**Agronomic Performance/Trait**
Pertains to practices of agricultural production and its costs and the management of crop land. Examples of agronomic traits include yield, input requirements, stress tolerance.

**Aldolase**
An enzyme, not subject to allosteric regulation, that catalyzes in a reversible reaction the cleavage of fructose 1,6-biphosphate to form dihydroxyacetone phosphate and glyceraldehyde 3-phosphate. The enzyme catalysing the fourth reaction in the glycolytic pathway, which splits a monosaccharide into two three-carbon units.

**Agrobacterium tumefaciens**
A bacterium normally responsible for production of crown gall disease in a variety of plants. A plasmid has been isolated from this bacterium that is useful in plant genetic engineering. This plasmid, called the *Ti* plasmid, has been modified so that it does not cause disease but can carry foreign DNA into susceptible plant cells.

**Allelle**
Any of several alternative forms of a given gene.

**Allele frequency**
Often called gene frequency. A measure of how common an allele is in a population; the proportion of all alleles at one gene locus that are of one specific type in a population.

**Allelic exclusion**
A process whereby only one immunoglobulin light chain and one heavy chain gene are transcribed in any one cell; the other genes are repressed.

**Allogenic**
Of the same species, but with a different genotype.

**Allopolyploid**
Polyploid produced by the hybridization of two species.

**Allopolyploid Plants**
Plants having more than two sets of haploid chromosomes inherited from different species.

**Allotype**
The protein product (or the result of its activity) of an allele which may be detected as an antigen in another member of the same species.(eg histocompatibility antigens, immunoglobulins), obeying the rules of simple Mendelian inheritance.

**Allosteric Regulation**
Regulation of an enzyme's activity by binding of a small molecule at a site that does not overlap the active site region.

**Alternative splicing**
Various ways of splicing out introns in eukaryotic pre-mRNAs resulting in one gene producing several different mRNAs and protein products.

**Alu family**
A dispersed intermediately repetitive DNA sequence found in the human genome in about three hundred thousand copies. The sequence is about 300 bp long. The name Alu comes from the restriction endonuclease AluI that cleaves it.

**Ames test**
A widely used test to detect possible chemical carcinogens; based on mutagenicity in thebacterium Salmonella.

**Amino acids**
Building blocks of proteins. There are twenty common amino acids: alanine, arginine, asparagine, aspartic acid, cysteine, glutamic acid, glutamine, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, proline, serine, threonine, tryptophan, tyrosine, and valine.

**Amplification**
The process of increasing the number of copies of a particular gene or chromosomal sequence. This can also include amplification of the signal to improve detection as an alternative to amplification of the sequence.

**Amino acid**
The constituent subunits of proteins. Amino acids polymerize to form linear chains linked by peptide bonds; such chains are termed polypeptides (or proteins if large enough). There are twenty commonly occurring amino acids of which all proteins are made.

**Anaerobic**
Growing in the absence of oxygen.

**Anabolic**
That part of metabolism that is concerned with synthetic reactions.

**Aneuploid**
Having a chromosome number that is not an exact multiple of the haploid number, caused by one chromosome set being incomplete or chromosomes being present in extra numbers.

**Aneuploidy**
The condition of a cell or of an organism that has additions or deletions of a small number of whole chromosomes from the expected balanced diploid number of chromosomes.

**Annealing**
Spontaneous alignment of two complementary single polynucleotide (RNA, or DNA, or RNA and DNA) strands to form a double helix.

**Anti-oncogene**
A gene that prevents malignant (cancerous) growth and whose absence, by mutation, results in malignancy (eg retinoblastoma).

**Antibiotic**
Chemical substance formed as a metabolic byproduct in bacteria or fungi and used to treat bacterial infections. Antibiotics can be produced naturally, using microorganisms, or synthetically.

**Antibody**
A protein produced by the immune system in response to an antigen (a molecule that is perceived to be foreign). Antibodies bind specifically to their target antigen to help the immune system destroy the foreign entity.

**Anticodon**
Triplet of nucleotide cases (codon) in transfer RNA that pairs with (is complementary to) a triplet in messenger RNA. For example, if the codon is UCG, the anticodon might be AGC.

**Antigen**
A substance to which an antibody will bind specifically.

**Antigenic determinant**
*See* Hapten.

**Antihemophilic factors**
A family of whole-blood proteins that initiate blood clotting, such as Factor VIII and kidney plasminogen activator.

**Antinutrients**
Substances that act in direct competition with or otherwise inhibit or interfere with the use or absorption of a nutrient.

**Antisense RNA**
RNA produced by copying and reversing a portion of an RNA-encoding DNA, usually including a protein-specifying region, and placing it next to a transcription-control sequence. This cassette can be delivered to the target cell, resulting in genetic transformation and production of RNA that is complementary to the RNA that is produced from the original, not-reversed, DNA segment. This complementary, or antisense, RNA is able to bind to the complementary sequences of the target RNA, resulting in inhibition of expression of the target gene.

**Antiserum**
Blood serum containing specific antibodies against an antigen. Antisera are used to confer passive immunity to many diseases and as analytical and preparative reagents for antigens.

**Assay**
Technique for measuring a biological response.

**Attenuated**
Weakened; with reference to vaccines, made from pathogenic organisms that have been treated so as to render them avirulent.

**Autoimmune disease**
A disease in which the body produces antibodies against its own tissues.

**Autoimmunity**
A condition in which the body mounts an immune response against one of its own organs or tissues.

**Autosome**
Any chromosome other than a sex chromosome.

**Avirulent**
Unable to cause disease.

***Bacillus subtilis***
A bacterium commonly used as a host in recombinant DNA experiments. Important because of its ability to secrete proteins.

**Bactericide**
An agent that kills bacteria. Also called biocide or germicide.

**Bacteriophage**
Virus that reproduces in and kills bacteria. Also called phage.

**Bacterium**
Any of a large group of microscopic, single-cell organisms with a very simple cell structure. Some manufacture their own food from inorganic precursors alone, some live as parasites on other organisms, and some live on decaying matter.

**Base**
On the DNA molecule, one of the four chemical units that, according to their order, represent the different amino acids. The four bases are: adenine (A), cytosine(C), guanine (G), and thymine(T). In RNA, uracil (U) substitutes for thymine.

**Base pair**
Two nucleotide bases on different strands of a nucleic acid molecule that bond together. The bases generally pair in only two combinations; adenine with thymine (DNA) or uracil (RNA), and guanine with cytosine.

**Bacillus thuringiensis (Bt)**
A naturally occurring microorganism that produces a toxin protein that only kills organisms with alkalineing stomachs, namely such as insect larvae. As a When delivered as a part of the whole killed organism, this toxin protein has been used for biological control for decades. The genetic information that encodes the toxin protein was identified and moved into plants to make them insect tolerant.

**Batch processing**
Growth in a closed system with a specific amount of nutrient medium. In bioprocessing, defined amounts of nutrient material and living matter are placed in a bioreactor and removed when the process is completed. **Cf**. Continuous processing.

**Bioassay**
Determination of the effectiveness of a compound by measuring its effect on animals, tissues, or organisms, usually in comparison with a standard preparation.

**Biocatalyst**
In bioprocessing, an enzyme that activates or speeds up a biochemical reaction.

**Biochemical**
The product of a chemical reaction in a living organism.

**Biochip**
Electronic device that uses biologically derived or related organic molecules to form a semiconductor.

**Biocide**
An agent capable of killing almost any type of cell.

**Bioconversion**
Chemical restructuring of raw materials by using a biocatalyst.

**Biodegradable**
Capable of being broken down by the action of microorganisms, usually by microorganisms and under conditions generally in the environment.

**Bioinformatics**
The discipline encompassing the development and utilization of computational facilities to store, analyze and interpret biological data.

**Biological oxygen demand (BOD)**
The amount of oxygen used for growth by organisms in water that contains organic matter, in the process of degrading that matter.

**Biologic response modulator**
A substance that alters the growth or functioning of a cell. Includes hormones and compounds that affect the nervous and immune systems.

**Biomass**
The totality of biological matter in a given area. As commonly used in biotechnology, refers to the use of cellulose, a renewable resource, for the production of chemicals that can be used generate energy or as alternative feedstocks for the chemical industry to reduce dependence on nonrenewable fossil fuels.

**Bioprocess**
A process in which living cells, or components thereof, are used to produce a desired end product.

**Bioreactor**
Vessel used for bioprocessing.

**Biosynthesis**
Production of a chemical by a living organism.

**Biotechnology**
Development of products by a biological process. Production may be carried out by using intact organisms, such as yeasts and bacteria, or by using natural substances (e.g. enzymes) from organisms.

**Biosynthetic**
Relating to the formation of complex compounds formed from simple substances by living organisms.

**Biotechnology**
The integration of natural sciences and engineering sciences, particularly recombinant DNA technology and genetic engineering, in order to achieve the application of organisms, cells, parts thereof and molecular analogues for

products and services. (Modified from: European Federation of Biotechnology, as endorsed by the Joint IUFOST/IUNS Committee on Food, Nutrition and Biotechnology, 1989).

**Biotic Stress**
Living organisms which can harm plants, such as viruses, fungi, and bacteria, and harmful insects. See Abiotic stress.

**B lymphocytes (B-cells)**
A class of lymphocytes, released from the bone marrow and which produce antibodies

**Bovine somatotropin**
(also called bovine growth hormone) A hormone secreted by the bovine pituitary gland. It has been used to increase milk production by improving the feed efficiency in dairy cattle.

**Callus**
A cluster of undifferentiated plant cells that can, for some species, be induced to form the whole plant.

**Calvin Cycle**
A series of enzymatic reactions, occurring during photosynthesis, in which glucose is synthesized from carbon dioxide.

**Carcinogen**
Cancer-causing agent.

**Catalyst**
An agent (such as an enzyme or a metallic complex) that facilitates a reaction but is not itself changed at completion of the reaction.

**Catabolic**
That part of metabolism that is concerned with degradation reactions.

**Cell**
The smallest structural unit of living organisms that is able to grow and reproduce independently.

**Cell Cycle**
The term given to the series of tightly regulated steps that a cell goes through between its creation and its division to form two daughter cells.

**Cell culture**
Growth of a collection of cells, usually of just one genotype, under laboratory conditions.

**Cell fusion**
*See* Fusion.

**Cell line**
Cells which grow and replicate continuously in cell culture outside the living organism.

**Cell-mediated immunity**
Acquired immunity in which T lymphocytes play a predominant role. Development of the thymus in early life is critical to the proper development and functioning of cell-mediated immunity.

**Chemostat**
Growth chamber that keeps a bacterial or other cell culture at a specific volume and rate of growth by continually adding fresh nutrient medium while removing spent culture.

**Chimera**
An individual (animal, plant, or lower multicellular organism) composed of cells of more than one genotype. Chimeras are produced, for example, by grafting an embryonic part of one species onto an embryo of either the same of a different species.

**Chloroplast**
A chlorophyll-containing photosynthetic organelle, found in eukaryotic cells, that can harness light energy.

**Chromosomes**
Subcellular structures which convey the genetic material of an organism. Threadlike components in the cell that contain DNA and proteins. Genes are carried on the chromosomes.

**Cistron**
A length of chromosomal DNA representing the smallest functional unit of heredity, essentially identical to a gene.

**Clone**
A group of genes, cells, or organisms derived from a common ancestor. Because there is no combining of genetic material (as in sexual reproduction), the members of the clone are genetically identical or nearly identical to the parent.

**Codon**
A sequence of three nucleotide bases that in the process of protein synthesis specifies an amino acid or provides a signal to stop or start protein synthesis (translation).

**Coenzyme**
An organic compound that is necessary for the functioning of an enzyme. Coenzymes are smaller than the enzymes themselves and may be tightly or loosely attached to the enzyme protein molecule.

**Cofactor**
A nonprotein substance required for certain enzymes to function. Cofactors can be coenzymes or metallic ions.

**Colony-stimulating factors**
A group of lymphokines which induce the maturation and proliferation of white blood cells from the primitive cell types present in bone marrow.

**Comparative Genomics**
The comparison of genome structure and function across different species in order to further understanding of biological mechanisms and evolutionary processes.

**Composition Analysis**
The determination of the concentration of compounds in a plant. Compounds that are commonly quantified are proteins, fats, carbohydrates, minerals, vitamins, amino acids, fatty acids and antinutrients.

**Conventional Breeding**
Breeding of plants carried out by controlled transfer of pollen from one plant to another followed by selection of progeny through multiple generations for a desireable phenotype. This method has also often included irradiation or mutaiton of plants or seeds to induce extra variation in the donor material.

**Complementarity**
The relationship of the nucleotide bases on two different strands of DNA or RNA. When the bases are paired properly (adenine with thymine [DNA] or uracil [RNA] and guanine with cytosine), the strands are said to be "complementary."

**Complementary DNA (cDNA)**
DNA synthesized from an expressed messenger RNA through a process known as reverse transcription. This type of DNA is used for cloning or as a DNA probe for locating specific genes in DNA hybridization studies.

**Conjugation**
Sexual reproduction of bacterial cells in which there is a one-way exchange of genetic material between the cells in contact.

**Continuous processing**
A method of bioprocessing in which new materials are added and products removed continuously at a rate that maintains the volume at a specific level and usually maintain the composition of the mixture as well. *Cf.* Batch processing and chemostat.

**Coumarins**
White vanilla-scented crystalline esters used in perfumes and flavorings and as an anticoagulant. Formula: C9H6O2.

**Crossbreeding**
Interbreeding to breed (animals or plants) using parents of different races, varieties, breeds, etc.

**Crossing over**
Exchange of genes between two paired chromosomes.

**Culture**
As a noun, cultivation of living organism in prepared medium; as a verb, to grow in prepared medium.

**Culture medium**
Any nutrient system for the artificial cultivation of bacteria or other cells; usually a complex mixture of organic and inorganic materials.

**Cyto**
A prefix referring to cell or cell plasm.

**Cytogenetics**
Study of the cell and its heredity-related components, especially the study of chromosomes as they occur in their "condensed" state, when not replicating.

**Cytokines**
Intercellular signals, usually protein or glycoprotein, involved in the regulation of cellular proliferation and function.

**Cytoplasm**
Cellular material that is within the cell membrane and surround the nucleus.

**Cytotoxic**
Able to cause cell death A cytotoxic substance usually is more subtle in its action than is a biocide.

**Defensin**
A natural defense protein isolated from cattle. It may prove effective against shipping fever, a viral disease that attacks cattle during transport, causing an estimated $250 million in losses each year.

**Deoxyribonucleic acid (DNA)**
The molecule that carries the genetic information for most living systems. The DNA molecule consists of four bases (adenine, cytosine, guanine, and thymine) and a sugar-phosphate backbone, arranged in two connected strands to form a double helix. *See also* Complementary DNA; Double helix; Recombinant DNA; Base pair.

**Diagnostic**
A product used for the diagnosis of disease or medical condition. Both monoclonal antibodies and DNA probes are useful diagnostic products.

**Diet**
A specific allowance or selection of food or feed that a person or animal regularly consumes.

**Differentiation**
The process of biochemical and structural changes by which cells become specialized in form and function as the organism develops.

**Diploid**
A cell with two complete sets of chromosomes. *Cf.* Haploid.

**DNA**
*See* Deoxyribonucleic acid.

**DNA probe**
A molecule (usually a nucleic acid) that has been labeled with a radioactive isotope, dye, or enzyme and is used to locate a particular nucleotide sequence or gene on a DNA or RNA molecule.

**DNA Sequencing**
Technologies through which the order of base pairs in a DNA molecule can be determined.

**Dose-Response Assessment**
The determination of the relationship between the magnitude of exposure (dose) to a chemical, biological or physical agent and the severity and/or frequency of associated adverse health effects (response).

**Double helix**
A term often used to describe the configuration of the DNA molecule. The helix consists of two spiraling strands of nucleotides (a sugar, phosphate, and base), joined crosswise by specific pairing of the bases. *See also* Deoxyribonucleic acid; Base; Base pair.

**Downstream processing**
The stages of processing that take place after the fermentation or bioconversion stage, includes separation, purification, and packaging of the product.

**Drug Delivery**
The process by which a formulated drug is administered to the patient. Traditional routes have been orally or by intravenous perfusion. New methods that are being developed are through the skin by application of a transdermal patch or across the nasal membrane by administration of a specially formulated aerosol spray.

**Electrophoresis**
A technique for separating different types of molecules in a gel (or liquid), ion-conducting medium, based on their differential movement in an applied electrical field.

**Enterotoxins**
Toxin affecting the cells of the intestinal mucosa.

**Endonuclease**
An enzyme that breaks nucleic acids at specific interior bonding sites; thus producing nucleic acid fragments of various lengths. *Cf.* Exonuclease.

**Enzyme**
A protein catalyst that facilitates specific chemical or metabolic reactions necessary for cell growth and reproduction. *Cf* Catalyst.

**Epitope**
A site on the surface of a macromolecule capable of being recognized by an antibody. An epitope may consist of just a few amino-acid residues in a protein or a few sugar residues in a polysaccharide. A synonym is "immunological determinant."

**Erythropoietin**
(also abbreviate EPO) A protein that boosts production of red blood cells. It is clinically useful in treating certain types of anemias.

**Escherichia coli (E. coli)**
A bacterium that inhabits the intestinal tract of most vertebrates. Much of the work using recombinant DNA techniques has been carried out with this organism because it has been genetically very well characterized.

**Eukaryote**
A cell or organism containing a true nucleus, with a well-defined membrane surrounding the nucleus. All organisms except bacteria, archebacteria, viruses, and blue-green algae are eukaryotic. *Cf.* Prokaryote.

**Event**
The term used to describe a plant and its offspring that contain a specific insertion of DNA. Such events will be distinguishable from other events by their unique site of integration of the introduced DNA.

**Exon**
In eukaryotic cells, the part of the gene that is transcribed into messenger RNA and encodes a protein. *See also* Intron; Splicing.

**Exonuclease**
An enzyme that breaks down nucleic acids only at the ends of polynucleotide chains, thus releasing one nucleotide at a time, in sequential order. *Cf*. Endonuclease.

**Exposure Assessment**
The qualitative and/or quantitative evaluation of the likely exposure to biological, chemical and physical agents via different sources.

**Expression**
In genetics, manifestation of a characteristic that is specified by a gene. With hereditary diseases, for example, a person can carry the gene for the disease but not actually have the disease. In this case, the gene is present but not expressed. In molecular biology and industrial biotechnology, the term is often used to mean the production of a protein by a gene that has been inserted into a new host organism.

**Expressed sequence tags (ESTs)**
Expressed sequence tag (EST) A unique DNA sequence derived from a cDNA library (therefore from a sequence which has been transcribed in some tissue or at some stage of development). The EST can be mapped, by a combination of genetic mapping procedures, to a unique locus in the genome and serves to identify that gene locus.

**Factor VIII**
A large, complex protein that aids in blood clotting and is used to treat hemophilia. *See also* Antihemophilic factors.

**Feedstock**
The raw material used in chemical or biological processes.

**Fermentation**
An anaerobic process of growing microorganisms for the production of various chemical or pharmaceutical compounds. Microbes are normally incubated under specific conditions in the presence of nutrients in large tanks called fermentors.

**Flavonoids**
Any of a group of organic compounds that occur as pigments in fruit and flowers.

**Food Additive**
Any substance not normally consumed as a food by itself and not normally used as a typical ingredient of food, whether or not it has nutritive value, the intentional addition of which to a food for a technological (including organoleptic) purpose in the manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food results, or may be expected to result (directly or indirectly), in it or its byproducts becoming a component of or otherwise affecting the characteristics of such foods. The term does not include "contaminants" or substances added to food for maintaining or improving nutritional qualities.

**Frameshift**
Insertion or deletion of one or more nucleotide bases such that incorrect triplets of bases are read as codons.

**Fructan**
A type of polymer of fructose, present in certain fruits.

**Functional Foods**
The Institute of Medicine's Food and Nutrition Board defined functional foods as "any food or food ingredient that may provide a health benefit beyond the traditional nutrients it contains."

**Functional Genomics**
The development and implementation of technologies to characterize the mechanisms through which genes and their products function and interact with each other and with the environment.

**Fusion**
Joining of the membrane of two cells, thus creating a new, fused cell that contains at least some of the nuclear material from both parent cells. Used in making hybridomas.

**Fusion protein**
A protein with a polypeptide chain derived from two or more proteins. A fusion protein is expressed from a gene prepared by recombinant DNA methods from the portions of genes encoding two or more proteins.

**Gas Chromatography**
Analytical technique in which compounds are separated based on their differential movement in a stream of inert gas through a (coated) capillary at elevated temperature. This technique is suitable for the analysis of volatile compounds or compounds that can be made volatile by derivatization reactions and that are also stable at higher temperatures.

**Gel Electrophoresis**
Analytical technique by which usually large biomolecules (proteins, DNA) are separated through a gel within by application of an electric field. Separation may depend on, for example, charge and size of the molecules. Separated biomolecules may be visualized as separate bands at different positions within the gel.

**Gene Expression**
The process through which a gene is activated at particular time and place so that its functional product is produced.

**Gene Silencing**
A method usually performed by the expression of an mRNA of complementary or the same nucleotide sequence in a cell such that the expression of the mRNA causes the down regulation of the protein which is being targeted.

**Gene Transfer**
The transfer of genes to an organism. Usually used in terms of transfer of a gene to an organism other that the original organism, through the tools of biotechnology.

**Gene**
A segment of chromosome that encodes the necessary regulatory and sequence information to direct the synthesis of a protein or RNA product. *See also* Operator; Regulatory g.; Structural g.; Suppressor g.

**"Gene machine"**
A computer controlled, solid-state chemistry device for synthesizing oligodeoxyribonucleotides by combining chemically-activated precursors of deoxyribonucleotides (bases) sequentially in the proper order.

**Gene mapping**
Determination of the relative locations of genes on a chromosome.

**Gene sequencing**
Determination of the sequence of nucleotide bases in a strand of DNA.

**Gene therapy**
The replacement of a defective gene in an organism suffering from a genetic disease. Recombinant DNA techniques are used to isolate the functioning gene and insert it into cells. Over three hundred single gene genetic disorders have been identified in humans. A significant percentage of these may be amenable to gene therapy.

**Genetic code**
The mechanism by which genetic information is stored in living organisms. The code uses sets of three nucleotide bases (codons) to make the amino aids that, in turn, constitute proteins.

**Genetic engineering**
A technology used to alter the genetic material of living cells in order to make them capable of producing new substances or performing new functions.

**Genetic Map**
A map showing the positions of genetic markers along the length of a chromosome relative to each other (genetic map) or in absolute distances from each other (physical map).

**Genetic screening**
The use of a specific biological test to screen for inherited diseases or medical conditions. Testing can be conducted prenatally to check for metabolic defects and congenital disorders in the developing fetus as well as post-natally to screen for carriers of heritage diseases.

**Genome**
The total hereditary material of a cell, comprising the entire chromosomal set found in each nucleus of a given species.

**Genomics**
Science that studies the genomes (i. e., the complete genetic information) of living beings. This commonly entails the analysis of DNA sequence data and the identification of genes.

**Genotype**
Genetic make-up of an individual or group. *Cf*. Phenotype.

**Germ cell**
Reproductive cell (sperm or egg). Also called gamete or sex cell.

**Germicide**
*See* Bactericide.

**Germplasm**
The total genetic variability, represented by germ cells or seeds, available within a particular population of organisms.

**Gene pool**
The total genetic information contained within a given population.

**Glycoalkaloid Toxins**
Steroid-like compounds produced by plant members of the botanical family Solanaceae, most notably "solanine" present in potato tubers.

**Golden Rice**
In 1999, Swiss and German scientists announced the development of a genetically engineered rice crop that produces beta-carotene, a substance which the body converts to Vitamin A. This improved nutrient rice was developed to treat individuals suffering from vitamin A deficiency, a condition that afflicts millions of people in developing countries, especially children and pregnant women.

**Growth hormone**
(also called somatotropin) A protein produced by the pituitary gland that is involved in cell growth. Human growth hormone is clinically used to treat dwarfism. Various animal growth hormones can be used to improved milk production as well as producing a leaner variety of meat.

**Haploid**
A cell with half the usual number of chromosomes, or only one chromosome set. Sex cells are haploid. Cf. Diploid.

**Hapten**
A small molecule which, when chemically-coupled to a protein, acts as an immunogen and stimulates the formation of antibodies not only against the two-molecule complex but also against the hapten alone.

**Hazard Characterization**
The qualitative and/or quantitative evaluation of the nature of the adverse health effects associated with biological, chemical and physical agents. For chemical agents, a dose-response assessment should be performed if the data are obtainable.

**Hazard Identification**
The identification of biological, chemical, and physical agents capable of causing adverse health or environmental effects.

**Hazard**
A biological, chemical, or physical agent, or condition, with the potential to cause an adverse health or environmental effect.

**Hemagglutination**
Clumping (agglutination) of red blood cells, for example by antibody molecules or virus particles.

**Hereditary**
Capable of being transferred as genetic information from parent cells to progeny.

**Heterozygote**
With respect to a particular gene at a defined chromosomal locus, a heterozygote has a different allelic form of the gene on each of the two homologous chromosomes.

**Histocompatibility**
Immunologic similarity of tissues such that grafting can be done without tissue rejection.

**Histocompatibility antigen**
An antigen that causes the rejection of grafted material from an animal different in genotype from that of the host animal.

**Homologous**
Corresponding or alike in structure, position, or origin.

**Homozygote**
With respect to a particular gene at a defined chromosomal locus, a homozygote has the same allelic form of the gene on each of the two homologous chromosomes.

**Hormone**
A chemical that acts as a messenger or stimulatory signal, relaying instructions to stop or start certain physiological activities. Hormones are synthesized in one type of cell and then released to direct the function of other cell types.

**Host**
A cell or organism used for growth of a virus, plasmid, or other form of foreign DNA, or for the production of cloned substances.

**Host-vector system**
Combination of DNA-receiving cells (host) and DNA-transporting substance (vector) used for introducing foreign DNA into a cell.

**Humoral immunity**
Immunity resulting from circulating antibodies in plasma protein.

**Hybridization**
Production of offspring, or hybrids, from genetically dissimilar parents. The process can be used to produce hybrid plants (by cross-breeding two different varieties) or hybridomas (hybrid cells formed by fusing two unlike cells, used in producing monoclonal antibodies). The term is also used to refer to the binding of complementary strands of DNA or RNA.

**Hybrid**
The offspring of two parents differing in at least one genetic characteristic (trait). Also, a heteroduplex DNA or DNA-RNA molecule.

**Hybridoma**
The cell produced by fusing two cells of different origin. In monoclonal antibody technology, hybridomas are formed by fusing an immortal cell (one that divides continuously) and an antibody-producing cell. *See also* Monoclonal antibody; Myeloma.

**Immune serum**
Blood serum containing antibodies.

**Immune system**
The aggregation of cells, biological substances (such as antibodies), and cellular activities that work together to provide resistance to disease.

**Immunity**
Nonsusceptibility to a disease or to the toxic effects of antigenic material. *See also* Active i., Cell-mediated i.; Humoral i.; Natural active i.; Natural passive.; Passive i.

**Immunoassay**
Technique for identifying substances based on the use of antibodies.

**Immunodiagnostics**
The use of specific antibodies to measure a substance. This tool is useful in diagnosing infectious diseases and the presence of foreign substances in a variety of human and animal fluids (blood, urine, etc.) It is currently being investigated as a way of locating tumor cells in the body.

**Immunofluorescence**
Technique for identifying antigenic material that uses antibody labeled with fluorescent material. Specific binding of the antibody and antigen can be seen under a microscope by applying ultraviolet light rays and noting the visible light that is produced.

**Immunogen**
Any substance that can elicit an immune response, especially specific antibody production.. An immunogen that reacts with the elicited antibody may be called an antigen.

**Immunoglobulin**
General name for proteins that function as antibodies. These proteins differ somewhat in structure, and are grouped into five categories on the basis of these differences: immunoglobulin G (IgG) IgM, IgA, IgD and IgE.

**Immunology**
Study of all phenomena related the body's response to antigenic challenge (i.e., immunity, sensitivity, and allergy).

**Immunomodulators**
A diverse class of proteins that boost the immune system. Many are cell growth factors that accelerate the production of specific cells that are important in mounting an immune response in the body. These proteins are being investigated for use in possible cures for cancer.

**Immunotoxins**
Specific monoclonal antibodies that have a protein toxin molecule attached. The monoclonal antibody is targeted against a tumor cell and the toxin is designed to kill that cell when the antibody binds to it. Immunotoxins have also been termed "magic bullets."

**Inbred**
Progeny produced as a result of inbreeding.

**Inducer**
A molecule or substance that increases the rate of enzyme synthesis, usually by blocking the action of the corresponding repressor.

**Inserted DNA**
The segment of DNA that is introduced into the chromosome, plasmid or other vector using recombinant DNA techniques.

**Interferon**
A class of lymphokine proteins important in the immune response. The are three major types of interferon: alpha (leukocyte), beta (fibroblast), and gamma (immune). Interferons inhibit viral infections and may have anticancer properties.

**Interleukin**
A type of lymphokine whose role in the immune system is being extensively studied. Two types of interleukin have been identified. Interleukin 1 (IL-1), derived from macrophages, is produced during inflammation and amplifies the production of other lymphokines, notably interleukin 2 (IL-2). IL-2 regulates the maturation and replication of T lymphocytes.

**Introgressed**
Backcrossing of hybrids of two plant populations to introduce new genes into a wild population.

**Intron**
In eukaryotic cells, a sequence of DNA that is contained in the gene but does not encode for protein. The presence of introns divides the coding region of the gene into segments called exons. *See also* Exon; Splicing.

**Inulins**
A fructose polysaccharide present in the tubers and rhizomes of some plants. Formula: (C6H10O5)n.

**In vitro**
Literally, "in glass." Performed in a test tube or other laboratory apparatus.

**In vivo**
In the living organism.

**Invertase Activity**
Enzyme activity occurring in the intestinal juice of animals and in yeasts, that hydrolyses sucrose to glucose and fructose.

**Isoflavones**
Water-soluble chemicals, also known as phytoestrogens, found in many plants and so named because they cause effects in the mammalian body somewhat similar to those of estrogen. The most investigated natural isoflavones, genistein and daidzen, are found in soy products and the herb red clover.

**Isoenzyme (isozyme)**
One of the several forms that a given enzyme can take. The forms may differ in certain physical properties, but function similarly as biocatalysts.

**Isogenic**
Of the same genotype.

**Kidney plasminogen activator**
A precursor to the enzyme urokinase that has bloodclotting properties.

**Knock-out**
A technique used primarily in mouse genetics to inactivate a particular gene in order to define its function.

**Lectins**
Agglutinating proteins usually extracted from plants.

**Leukocyte**
A colorless cell in the blood, lymph, and tissues that is an important component of the body's immune system; also called white blood cell.

**Library**
A set of cloned DNA fragments. A collection of genomic or complementary DNA sequences from a particular organism that have been cloned in a vector and grown in an appropriate host organism (e.g., bacteria, yeast).

**Ligase**
An enzyme used to join DNA or RNA segments together. They are called DNA ligase of RNA ligase, respectively.

**Linkage**
The tendency for certain genes to be inherited together due to their physical proximity on the chromosome.

**Linkage map**
An abstract map of chromosomal loci, based on recombinant frequencies.

**Linkage group**
A group of gene loci known to be linked; a chromosome. There are as many linkage groups as there are homologous pairs of chromosomes. See synteny.

**Linker**
A fragment of DNA with a restriction site that can be used to join DNA strands.

**Lipoproteins**
A class of serum proteins that transport lipids and cholesterol in the blood stream. Abnormalities in lipoprotein metabolism have been implicated in certain heart diseases.

**Liquid Chromatography**
Analytical technique in which substances are separated based on their differential movement within a liquid stream. A common form of liquid chromatography is column chromatography in which the dissolved substances may bind from the liquid differentially to a column of solid material with different affinities and subsequently be released thus be carried from the column into the at different speeds by the liquid through the columnliquid, thus creating a basis for separation.

**Locus(Plural loci)**
The position of a gene, DNA marker or genetic marker on a chromosome. See gene locus

**Lymphocyte**
A type of leukocyte found in lymphatic tissue in the blood, lymph nodes, and organs. Lymphocytes are continuously made in the bone marrow and mature into antibody-forming cells. *See also* B lymphocytes; T lymphocytes.

**Lymphokine**
A class of soluble proteins produced by white blood cells that play a role, as yet not fully understood, in the immune response. *See also* Interferon; Interleukin.

**Lymphoma**
Form of cancer that affects the lymph tissue.

**Lysis**
Breaking apart of cells.

**Lysozyme**
An enzyme present in, for example, tears, saliva, egg whites and some plant tissues that destroys the cells of certain bacteria.

**Macronutrient**
Any substance, such as carbon, hydrogen, or oxygen, that is required in large amounts for healthy growth and development.

**Macrophage**
A type of white blood cell produced in blood vessels and loose connective tissues that can ingest dead tissue and cells and is involved in producing interleukin 1. When exposed to the lymphokine "macrophage-activating factor," macrophages also kill tumor cells. *See also* Phagocyte.

**Marker**
Any genetic element (locus, allele, DNA sequence or chromosome feature) which can be readily detected by phenotype, cytological or molecular techniques, and used to follow a chromosome or chromosomal segment during genetic analysis. See centromere marker; chromosome marker; DNA marker; genetic marker; inside marker; outside marker.

**Macrophage-activating factor**
An agent that stimulates macrophages to attack and ingest cancer cells.

**Mass Spectrometry**
Analytical technique by which compounds in a vacuum compartment are ionized, eventually fragmented, accelerated, and detected based upon the mass-dependent behavior of the ionized compounds or their fragments in response to the application of a magnetic or electric field in a vacuum.

**Medium**
A liquid or solid (gel) substance containing nutrients needed for cell growth.

**Meiosis**
Process of cell reproduction whereby the daughter cells have half the chromosome number of the parent cells. Sex cells are formed by meiosis. *Cf.* Mitosis

**Messenger RNA (mRNA)**
Nucleic acid that carries instructions to a ribosome for the synthesis of a particular protein.

**Metabolism**
All biochemical activities carried out by an organism to maintain life.

**Metabolite**
A substance produced during or taking part in metabolism.

**Metabolomics**
"Open-ended" analytical techniques that generate profiles of the metabolites, i.e., chemical substances within a biological sample. Commonly differences between profiles of different (groups of) samples are determined and the identity of the associated metabolites elucidated. Contrary to targeted analysis, these techniques are indiscriminate in that they do not require prior knowledge of every single substance that is present.

**Microarray**
A microscopic, ordered array of nucleic acids, proteins, small molecules, cells or other substances that enables parallel analysis of complex biochemical samples. There are many different types of microarrays both from a biological and production system perspective. The generic terms "DNA array", "GeneChipTM", or "hybridization array" are used to refer broadly to all types of oligonucleotide-based arrays. The two most common are cDNA arrays and genomic arrays. cDNA array: A microarray composed of grid of nucleic acid molecules of known composition linked to a solid substrate, which can be probed with total messenger RNA from a cell or tissue to reveal changes in gene expression relative to a control sample.

**Microbial herbicides/pesticides**
Microorganisms that are toxic to specific plant/insects. Because of their narrow host range and limited toxicity, these microorganisms may be preferable to their chemical counterparts for certain pest control applications.

**Microbiology**
Study of living organisms and viruses, which can be seen only under a microscope.

**Micronutrient**
Any substance, such as a vitamin or trace element, essential for healthy growth and development but required only in minute amounts.

**Microorganism**
Any organism that can be seen only with the aid of a microscope. Also called microbe.

**Mitochondria**
Cellular organelles present in eukaryotic organisms which enable aerobic respiration, which generates the energy to drive cellular processes. Each mitochondrion contains a small amount of DNA encoding a small number of genes (approximately 50).

**Mitosis**
Process of cell reproduction whereby the daughter cells are identical in chromosome number to the parent cells. *Cf.* Meiosis.

**Molecular Biology**
The study of biological processes at the molecular level.

**Molecular genetics**
Study of how genes function to control cellular activities.

**Monoclonal antibody**
Highly specific, purified antibody that is derived from only one clone of cells and recognizes only one antigen. *See also* Hybridoma; Myeloma

**mRNA**
Messenger RNA.

**Multigenic**
Of hereditary characteristics, one that is specified by several genes.

**Mutagen**
A substance that induces mutations.

**Mutant**
A cell that manifest new characteristics due to a change in its DNA.

**Mutation**
A structural change in a DNA sequence resulting from uncorrected errors during DNA replication.

**Mutation Breeding**
Genetic change caused by natural phenomena or by use of mutagens. Stable mutations in genes are passed on to offspring; unstable mutations are not.

**Muton**
The smallest element of a chromosome whose alteration can result in a mutation or a mutant organism.

**Myeloma**
A type of tumor cell that is used monoclonal antibody technology to form hybridomas.

**Nanoscience**
The study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a larger scale.

**Nanotechnology**
The production and application of structures, devices and systems by controlling shape and size at nanometre scale.

**Natural active immunity**
Immunity that is established after the occurrence of a disease.

**Natural killer (NK) cell**
A type of leukocyte that attacks cancerous or virus-infected cells without previous exposure to the antigen. NK cell activity is stimulated by interferon.

**Natural passive immunity**
Immunity conferred by the mother on the fetus or newborn.

**Nitrogen fixation**
A biological process (usually associated with plants) whereby certain bacteria convert nitrogen in the air to ammonia, thus forming a nutrient essential for growth.

**Nuclease**
An enzyme that, by cleaving chemical bonds, breaks down nucleic acids into their constituent nucleotides. *See also* Exonuclease.

**Nucleic acid**
Large molecules, generally found in the cell's nucleus and/or cytoplasm, that are made up of nucleotide bases. The two kinds of nucleic acid are DNA and RNA.

**Nuclear Magnetic Resonance**
Analytical technique by which compounds are brought exposed to into a magnetic field, which induces magnetic dipoles within the nucleus of particular atoms inside these compounds. The magnetic energy conveyed to these atoms is subsequently released as radiofrequency waves, whose frequency spectrum provides information on the structure of the compounds.

**Nucleotides**
The building blocks of nucleic acids. Each nucleotide is composed of sugar, phosphate, and one of four nitrogen bases. If the sugar is ribose, the nucleotide is termed a "ribonucleotide," whereas deoxyribonucleotides have deoxyribose as the sugar component (i. e. adenine, cytosine, guanine and thymine in the case of DNA). The sequence of the nucleotides within the nucleic acid determines, for example, the amino acid sequence of an encoded protein.

**Nucleus**
In eukaryotic cells, the centrally-located organelle that encloses most of the chromosomes. Minor amounts of chromosomal substance DNA are found in some other organelles, most notably the mitochondria and the chloroplasts.

**Nutritionally Improved**
Improving the quantity, ratio and/or bioavailability of essential macro and micronutrients and other compounds for which the clinical and epidemiological evidence is clear that they play a significant role in maintenance of optimal health and are limiting in diets.

**Nutraceutical**
The term was coined by the Foundation for Innovation in Medicine in 1991 and is defined as "any substance that may be considered a food or part of a food and provides medical or health benefits, including the prevention and treatment of disease."

**Organoleptic**
Able to perceive a sensory stimulus such as taste.

**Oligodeoxyribonucleotide**
A molecule consisting of a small number (about two to a few tens) of nucleotides linked sugar to phosphate in a linear chain.

**Oncogene**
Any of a family of cellular DNA sequences which possess the potential to become malignant by undergoing alteration. There are 4 groups of viral and non-viral onc genes: protein kinases, GTPases, nuclear proteins, and growth factors.

**Oncogenic**
Cancer causing

**Oncology**
Study of tumors.

**Open reading frame**
A nucleotide sequence beginning with a start (AUG) codon, continuing in register with amino acid-encoding codons, and ending with a stop codon.

**Operator**
A region of the chromosome, adjacent to the sequences encoding the gene product, where a repressor protein binds to prevent transcription.

**Operon**
Sequence of genes responsible for synthesizing the enzymes needed for biosynthesis of a molecule. An operon is controlled by an operator gene and a repressor gene.

**Opsonin**
An antibody that renders bacteria and other antigenic material susceptible to destruction by phagocytes.

**Organic compound**
A compound containing carbon.

**Passive immunity**
Immunity acquired from receiving preformed antibodies.

**Pathogen**
Disease-causing organism.

**Peptide**
Two or more amino acids joined by a linkage called a peptide bond.

**Pesticide**
Any substance intended for preventing, destroying, attracting, repelling or controlling any pest including unwanted species of plants or animals during the production, storage, transport, distribution and processing of food, agricultural commodities, or animal feeds, or which may be administered to animals for the control of ectoparasites. The term includes substances intended for use as a plant-growth regulator, defoliant, desiccant, fruit-thinning agent, or sprouting inhibitor, and substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport. The term normally excludes fertilizers, plant and animal nutrients food additives and animal drugs.

**Phage**
*See* Bacteriophage.

**Phagocyte**
A type of white blood cell that can ingest invading microorganisms and other foreign material. *See also* Macrophage.

**Pharmacogenomics**
The identification of the genes whichgenes that influence individual variation in the efficacy or toxicity of therapeutic agents, and the application of this information in clinical practice.

**Phenotype**
Observable characteristics, resulting from interaction between an organism's genetic make-up and the environment. *Cf*. Genotype

**Phenylpropanoids**
Especially the derivatives of the cinnamyl alcohols and of cinnamic acids, isolated from medicinal plants due to the interest as the source for the preparation of the remedies.

**Photosynthesis**
Conversion by plants of light energy into chemical energy, which is then used to support the plants' biological processes.

**Phytate (Phytic Acid)**
A phosphorus-containing compound in the outer husks of cereal grains that, in addition to limiting the bioavailability of phosphorous itself, binds with minerals and inhibits their absorption.

**Phytochemicals**
Small molecule chemicals unique to plants and plant products.

**Plasma**
The fluid (noncellular) fraction of blood.

**Plasmapheresis**
A technique used to separate useful factors from blood.

**Plasmid**
Circular extra-chromosomal DNA molecules present in bacteria and yeast. Plasmids replicate autonomously each time the organism a bacterium divides and are transmitted to the daughter cells. DNA segments are commonly cloned using plasmid vectors.

**Plasticity**
The quality of being plastic or able to be molded, changed.

**Plastid**
Any of various small particles in the cytoplasm of the cells of plants and some animals that contain pigments (see chromoplast), starch, oil, protein, etc.

**Pleiotropic**
Genes or mutations that result in the production of multiple effects at the phenotypic level. It is the consequence of the fact that biochemical pathways starting from different genes intersect in many places, inhibiting, deflecting, and variously modifying each other. Introduced genes may also insert into sites that effect phenotypic changes other than the one desired.

**Polyclonal**
Derived from different types of cells.

**Polymer**
A long molecule of repeated subunits.

**Polymerase**
General term for enzymes that carry out the synthesis of nucleic acids.

**Polymerase chain reaction (PCR)**
A technique used for enzymatic in vitro amplification of specific DNA sequences without utilizing conventional procedures of molecular cloning. It allows the amplification of a DNA region situated between two convergent primers and utilizes oligonucleotide primers that hybridize to opposite strands. Primer extension proceeds inward across the region between the two primers. The product of DNA synthesis of one primer serves as a template for the other primer; repeated cycles of DNA denaturation, annealing of primers, and extension result in an exponential increase in the number of copies of the region bounded by the primers. The process mimics in vitro the natural process of DNA replication occurring in all cellular organisms, where the DNA molecules of a cell are duplicated prior to cell division. The original DNA molecules serve as templates to build daughter molecules of identical sequence.

**Polypeptide**
Long chain of amino acids joined by peptide bonds.

**Post-transcriptional Modification**
A series of stepsprocess through which protein molecules are biochemically modified within a cell following their synthesis by translation of messenger RNA. A protein may undergo a complex series of modifications in different cellular compartments before its final functional form is produced.

**Profiling**
Creation of indiscriminate patterns of the substances within a sample with the aid of analytical techniques, such as functional genomics, proteomics, and metabolomics. The identity of the compounds detectable within the pattern need not be known.

**Probe**
*See* DNA probe.

**Prion**
This is the protein that makes up the infectious agent claimed by a large number of groups now to be the infectious particle that transmits the disease from one cell to another and from one animal to another. It is made from the normal protein PrPc (the c stands for chromosomal) that is produced in small quantities on many cells and especially the lymphoid and nervous tissue cells.

**Prion rods**
The microscopic rods that appear when prions, that have been broken up with proteinase K but then allowed to come back together into crystalline forms.

**PrP**
The prion protein. It can exist in various forms. One is called PrPc and is the normal type of the protein that is found in a cell (i.e. chromosomal PrP). One is called PrPsc (or PrPscrapie) that is found in the infected cells. It may be called PrP-res, indicating that it is difficult to break down with proteinases. PrP27-30 is the designantion of the prion protein fragments following cleavage by protease K.

**Prokaryote**
A cellular organism (e.g., bacterium, blue-green algae) whose DNA is not enclosed within a nuclear membrane. *Cf.* Eukaryote.

**Promoter**
A DNA sequence that is located near or even partially within encoding nucleotide sequences and which controls gene expression. Promoters are required for binding of RNA polymerase to initiate transcription.

**Prophage**
Phage nucleic acid that is incorporated into the host's chromosome but does not cause cell lysis.

**Protease K**
This is the enzyme that breaks down proteins very Effectively... proteins that are resistant to protease cleavage such as prions receive special attention!

**Protein**
Proteins are biological effector molecules encoded by an organism's genome. A protein consists of one or more polypeptide chains of amino acid subunits. The functional action of a protein depends on its three dimensional structure, which is determined by its amino acid composition and any post-transcriptional modifications.

**Protein A**
A protein produced by the bacterium *Staphylococcus aureus* that specifically binds antibodies. It is useful in the purification of monoclonal antibodies.

**Proteomics**
The development and application of techniques used to investigate the protein products of the genome and how they interact to determine biological functions. This is an "oOpen ended" analytical techniques that generate profiles of the proteins within a biological sample. Commonly that is used to find differences between profiles of different (groups of) samples are and determined and the identity of the associated proteins elucidated. Contrary to targeted analysis, these this techniques are is indiscriminate in that they it does not require prior knowledge of every single substance protein present that is analyzed beforehand.

**Protoplast Fusion**
The fusion of two plant protoplasts. that each consist of the living parts of a cell, including the protoplasm and cell membrane but not the vacuoles or the cell wall.

**Protoplast**
The cellular material that remains after the cell wall has been removed. A plant cell from which the cell wall has been removed by mechanical or enzymatic means. Protoplasts can be prepared from primary tissues of most plant organs as well as from cultured plant cells.

**Pure culture**
In vitro growth of only one type of microorganism.

**Quantitative Trait Loci**
The locations of genes that together govern a multigenic trait, such as yield or fruit mass.

**Radioimmunoassay**
A technique for quantifying a substance by measuring the reactivity of radioactively labeled forms of the substance with antibodies.

**Reagent**
Substance used in a chemical reaction, often for analytical purposes.

**Recombinant DNA (rDNA)**
The DNA formed by combining segments of DNA from two or more different sources or different regions of a genome.

**Recombinant DNA Technology**
The term given to some techniques of molecular biology and genetic engineering which were developed in the early 1970s. In particular, the use of restriction enzymes, which cleave DNA at specific sites, allow to manipulate sections of DNA molecules to be inserted into plasmid or other vectors and cloned in an appropriate host organism (e. g. a bacterial or yeast cell).

**Recombinant DNA**
DNA formed by combining segments of DNA from different types of organism. Any A DNA molecule formed by joining DNA segments from different sources (not necessarily different organisms). Also This may also could be a strand of include DNA synthesised in the laboratory by splicing together selected parts of DNA strands from different organic species, or by adding a selected part to an existing DNA strand.

**Regeneration**
Laboratory technique for forming a new plant from a clump of plant cells.

**Regulatory gene**
A gene that acts to control the protein-synthesizing activity of other genes.

**Regulatory Sequence**
A DNA sequence to which specific proteins bind to activate or repress the expression of a gene.

**Regulon**
A protein, such as a heat-shock protein, that exerts an influence over growth.

**Reproductive Cloning**
Techniques carried out at the cellular level aimed at the generation of an organism with an identical genome to an existing organism.

**Replication**
Reproduction or duplication, as of an exact copy of a strand of DNA.

**Replicon**
A segment of DNA (e.g., chromosome or plasmid) that can replicate independently.

**Repressor**
A protein that binds to an operator adjacent to a structural gene, inhibiting transcription of the gene.

**Restriction enzyme**
An enzyme that recognizes a specific DNA nucleotide sequence, usually symmetrical, and cuts the DNA within or near the recognized sequence. This may create a gap into which new genes can be inserted.

**Restriction Fragment Length Polymorphism**
The variation that occurs in the pattern of fragments obtained by cleaving DNA with restriction enzymes, because of differences between inherited amino nucleic acid sequences changes in the DNA of individuals of a population.

**Reticuloendothelial system**
The system of macrophages, which serves as an important defense system against disease.

**Retrovirus**
An animal virus that contains the enzyme reverse transcriptase. This enzyme converts the viral RNA into DNA which can combine with the DNA of the host cell and produce more viral particles.

**Rheology**
Study of the flow of matter such as fermentation liquids.

**Rhizobium**
A class of microorganisms that converts atmospheric nitrogen into a form that plants can utilize for growth. Species of this microorganism grow symbiotically on the roots of certain legumes such as peas, beans, and alfalfa.

**RIA (Radioimmunoassay)**
A diagnostic test using antibodies to detect trace amounts of substances. Such tests are useful in biomedical research to study how drugs interact with their receptors.

**Ribonucleic acid (RNA)**
A molecule similar to DNA that functions primarily to decode the instructions for protein synthesis that are carried by genes. *See also* Messenger RNA; Transfer RNA.

**Ribosome**
A cellular component, containing protein and RNA, that is involved in protein sythesis.

**Ribozyme**
Any of the RNA molecules possessing catalytic activity and acting as biological catalysts.

**Risk**
A function of the probability of an adverse health effect and the severity of that effect, consequential to a hazard(s).

**Risk Analysis**
A process consisting of three components: risk assessment, risk management and risk communication.

**Risk Assessment**
A scientific based process consisting of the following steps: (i) hazard identification, (ii) hazard characterization, (iii) exposure assessment, and (iv) risk characterization.

**Risk Characterization**
The qualitative and/or quantitative estimation, including attendant uncertainties, of the probability of occurrence and severity of known or potential adverse health

effects in a given population based on hazard identification, hazard characterization and exposure assessment.

**Risk Communication**

The interactive exchange of information and opinions throughout the risk analysis process concerning hazards and risks, risk-related factors and risk perceptions, among risk assessors, risk managers, population, industry, the academic community and other parties, including the explanation of risk assessment findings and the basis of risk management decisions.

**Risk Management**

The process, distinct from risk assessment, of weighing policy alternatives, in consultation with all interested parties, considering risk assessment and other factors relevant for the health protection of population and for the promotion of fair practices, and if needed, selecting appropriate prevention and control options.

**RNA (Ribonucleic Acid)**

A single stranded nucleic acid molecule comprising a linear chain made up from four nucleotide subunits (A, C, G, and U). There are three types of RNA: messenger, transfer and ribosomal. (Actually there are also ribosomes etc.)

**Scale-up**

Transition from small-scale production to production of large industrial quantities.

**Secondary Metabolites**

Chemical substances within a biological organism that are not necessary for primary cellular functions. Secondary metabolism proceeds by modification of the primary metabolites of photosynthesis, respiration, etc. by four main pathways. The malonate/polyketide pathway leads to the production of fatty acids and naphthoquinones. The mevalonate/isoprenoid pathway leads to the various terpenes (such as menthol), carotenoids and steroids. The shikimate pathway leads to aromatic amino acids and the phenolics and the final group of metabolites is a non-specific mix of amino-acid derivatives including the alkaloids (such as solanine) and others of mixed biogenesis.

**Selective medium**

Nutrient material constituted such that it will support the growth of specific organisms while inhibiting the growth of others.

**Sequence Homology**

The measurable likenesses or degree of identity or similarity between two nucleotide or amino acid sequences.

**Sequence tagged site (STS)**

Short (200 to 500 base pairs) DNA sequence that has a single occurrence in the human genome and whose location and base sequence are known. Detectable by polymerase chain reaction, STSs are useful for localizing and orienting the mapping and sequence data reported from many different laboratories and serve as landmarks on the developing physical map of the human genome. Expressed sequence tags (ESTs) are STSs derived from cDNAs.

**Serology**

Study of blood serum and reaction between the antibodies and antigens therein.

**Sera-Binding Tests**

Immunological assays that evaluate for the presence of antigen-specific IgE in blood serum obtained from individuals allergic to food, pollen, or other environmental antigens. Sera-binding tests include assays such as western blotting, ELISA, ELISA-inhibition, RAST and RAST-inhibition techniques.

**Shikimate Pathway**

Pathway in micro-organisms and plants involved in the biosynthesis of the aromatic amino acid family (phenylalanine, tyrosine, tryptophan) with a requirement for chorismate as well as shikimate. Secondary metabolites such as lignin, pigments, UV light protectants, phenolic redox molecules and other aromatic compounds such as folic acid and ubiquinone are postscript products of the shikimate pathway.

**Signal Transduction**

The molecular pathways mechanism through which a cell senses changes in its external environment and changes its gene expression patterns in response.

**Single Nucleotide Polymorphism (SNP)**

A chromosomal locus at which a single base variation exists stably within populations (typically defined as each variant form being present in at least 1-2% of individuals).

**Signal sequence**

The N-terminal sequence of a secreted protein, which is required for transport through the cell membrane.

**Single-cell protein**

Cells or protein extracts from microorganisms, grown in large quantities for use as protein supplements. Single cell protein is expected to have a nutritionally favorable balance of amino acids.

**Site-specific recombination**

A crossover event, such as the integration of phage lambda, that requires homology of only a very short region and uses an enzyme specific for that recombination. Recombination occurring between two specific sequences that need not be homologous; mediated by a specific recombination system.

**snRNP**

Small nuclear ribonucleoprotein (RNA plus protein) particle. Component of the spliceosome, the intron-removing apparatus in eukaryotic nuclei .

**Somaclonal Selection**

Epigenetic or genetic changes, sometimes expressed as a new trait, resulting from in vitro culture of higher plant cells. Somatic (vegetative non-sexual) plant cells can be propagated in vitro in an appropriate nutrient medium. The cells which multiply by division of the parent somatic cells are called somaclones and, theoretically, should be genetically identical with the parent. Occasionally in vitro cell culture generates cells and plants which are significantly different, epigenetically and/or genetically, from the parent. Such progeny are called somaclonal variants and may provide a useful source of genetic variation.

**Southern Analysis/Hybridization (Southern Blotting)**
A procedure in which DNA restriction fragments are is transferred from an agarose gel to a nitrocellulose filter, where the denatured DNA is denatured and then hybridized to a radioactive probe (blotting). (See Hybridization.)

**Somatic cells**
Cells other than sex or germ cells.

**Splicing**
The removal of introns and joining of exons to form a continuous coding sequence in RNA.

**Stem Cell**
A cell that has the potential to differentiate into a variety of different cell types depending on the environmental stimuli it receives.

**Stilbenes**
A colorless or slightly yellow crystalline water-insoluble unsaturated hydrocarbon used in the manufacture of dyes; trans-1,2-diphenylethene. Formula: C6H5CH:CHC6H5. It forms the backbone structure of several compounds with estrogenic activity. Trans-3,4',5-trihydroxy-stilbene, also known as resveratrol, has been found in some experiements to inhibit cell mutations, stimulate at least one enzyme that can inactivate certain carcinogens, and may contribute to a low incidence of cardiovascular disease.

**Strain**
A pure-breeding lineage, usually of haploid organisms, bacteria, or viruses.

**Stringent response**
A translational control mechanism of prokaryotes that represses tRNA and rRNA synthesis during amino acid starvation.

**Structural gene**
A gene that codes for a protein, such as an enzyme.

**Substantial Equivalence**
In the report of the 1996 FAO/WHO Expert Consultation, substantial equivalence was identified as being "established by a demonstration that the characteristics assessed for the genetically modified organism, or the specific food product derived therefrom, are equivalent to the same characteristics of the conventional comparator. The levels and variation for characteristics in the genetically modified organism must be within the natural range of variation for those characteristics considered in the comparator and be based upon an appropriate analysis of data." In the Codex Guideline for the Conduct of Food Safety Assessment of Foods Derived from Recombinant-DNA Plants (2003), the concept of substantial equivalence is described as "a key step in the safety assessment process. However, it is not a safety assessment in itself; rather it represents the starting point which is used to structure the safety assessment of a new food relative to its conventional counterpart. This concept is used to identify similarities and differences between the new food and its conventional counterpart. It aids in the identification of potential safety and nutritional issues and is considered the most appropriate strategy to date for safety assessment of foods derived from recombinant-DNA

plants. The safety assessment carried out in this way does not imply absolute safety of the new product; rather, it focuses on assessing the safety of any identified differences so that the safety of the new product can be considered relative to its conventional counterpart."

**Substrate**

Material acted on by an enzyme.

**Suppressor gene**

A gene that can reverse the effect of a mutation in other genes.

**Synteny**

All loci on one chromosome are said to be syntenic (literally on the same ribbon). Loci may appear to be unlinked by conventional genetic tests for linkage but still be syntenic.

**Synteny test**

A test that determines whether two loci belong to the same linkage group (ie are syntenic) by observing concordance (occurrence of markers together) in hybrid cell lines.

**Tannins**

Any of a class of yellowish or brownish solid compounds found in many plants and used as tanning agents, mordants, medical astringents, etc. Tannins are derivatives of gallic acid with the approximate formula C76H52O46.

**T-DNA**

In this reportk, tThe segment of the Ti plasmid of A. tumefaciens that is transferred to the plant genome following infection.

**Template**

A molecule that serves as the pattern for synthesizing another molecule.

**Therapeutics**

Compounds that are used to treat specific diseases or medical conditions.

**Thymus**

A lymphoid organ in the lower neck, the proper functioning of which in early life is necessary for development of the immune system.

**Ti Plasmid**

A plasmid containing the gene(s) responsible for inducing plant tumor formationtransfer of genes from A.tumefaciens to plant cells.

**Tissue culture**

In vitro growth in nutrient medium of cells isolated from tissue.

**Tissue plasminogen activator (tPA)**

A protein produced in small amounts in the body that aids in dissolving blood clots.

**T lymphocytes (T-cells)**

White blood cells that produced in the bone marrow but mature in the thymus. They are important in the body's defense against certain bacteria and fungi, help B lymphocytes make antibodies, and help in the recognition and rejection of foreign tissues. T lymphocytes may also be important in the body's defense against cancers.

**Toxin**
A poisonous substance produced by certain microorganisms.

**Transcription**
The process through which a gene is expressed to generate a complementary messenger RNA molecule. Synthesis of messenger (or any other) RNA on a DNA template.

**Transcriptome**
The total messenger RNA expressed in a cell or tissue at a given point in time.

**Transduction**
Transfer of genetic material from one cell to another by means of a virus or phage vector.

**Transfection**
Infection of a cell with nucleic acid from a virus, resulting in replication of the complete virus.

**Transfer RNA (tRNA)**
RNA molecules that carry amino acids to sites on ribosomes where proteins are synthesized.

**Transgene**
A gene from one source that has been incorporated into the genome of another organism.

**Transgenic Plant**
A fertile plant that carries an introduced gene(s) in its germ-line.

**Transformation**
Change in the genetic structure of an organism by the incorporation of foreign DNA.

**Transgenic organism**
An organism formed by the insertion of foreign genetic material into the germ line cells of organisms. Recombinant DNA techniques are commonly used to produce transgenic organisms.

**Translation**
Process by which the information on a messenger RNA molecule is used to direct the synthesis of a protein.

**Transmissible spongiform encephalopathy**
A disease that can be transmitted from one animal to another and will produce changes in the brain that are appear similarly to a sponge (i.e. some of the cells are clear when seen down the microscope)

**Transposon**
A segment of DNA that can move around and be inserted at several sites in the genome of a cell possibly altering expression. The first to be described was the Ac/Ds system in maize shown by McClintock to cause unstable mutations.

**tRNA**
*See* transfer RNA.

**Trypsin Inhibitors**
Antinutrient proteins present in plants such as soybeans that inhibit the digestive enzyme, trypsin if not inactivated by heating or other processing methods.

**Tumor necrosis factor**
A cytokine with many actions including the destruction of some types of tumor cells without affecting healthy cells. However hopes for there usefulness in cancer therapy have been dampened by toxic effects of the treatment. They are now being engineered for selective toxicity for cancer cells.

**Tumor suppressor gene**
Any of a category of genes that can suppress transformation or tumorigenicity (probably ordinarily involved in normal control of cell growth and division.

**Unintended Effect**
An effect that was not the purpose of the genetic modification or mutation. An unintended effect may be either predictable or unpredictable, based on the knowledge of, among other things, the function of the introduced DNA and of the native DNA affected by the genetic modification. A predicted unintended effect would be for example variations in metabolic intermediates and endpoints, an unpredicted effect might be turning on of unknown endogenous genes.

**Vaccine**
A preparation that contains an antigen consisting of whole disease-causing organisms (killed or weakened), or parts of such organisms, and is used to confer immunity against the disease that the organism cause. Vaccine preparation can be natural, synthetic, or derived by recombinant DNA technology.

**Vector**
The agent (e.g., plasmid or virus) used to carry new DNA into a cell.

**Virion**
An elementary viral particle consisting of genetic material and a protein covering.

**Virology**
Study of viruses.

**Virulence**
Ability to infect or cause disease.

**Virus**
A submicroscopic organism that contains genetic information but cannot reproduce itself. To replicate, it must invade another cell and use parts of that cell's reproductive machinery.

**White blood cells**
*See* Leukocytes.

**Wild type**
The form of an organism that occurs most frequently in nature.

**Yeast**
A general term for single-celled fungi that reproduce by budding. Some yeasts can ferment carbohydrates (starches and sugars), and thus are important in brewing and baking.

# CHRONOLOGY OF BIOTECHNOLOGY

| | |
|---|---|
| 8000 BC | Humans domesticate crops and livestock (Mesopotamia).<br>Potatoes first cultivated for food – (Andes) |
| 6500 BC | Encrusted residue in the shards of pottery unearthed in a Celtic hunter-gatherer camp in 1983 by Edinburgh archaeologist – remains of Neolithic heather beer |
| 4000 BC | Tigris-Euphrates cradle of civilization – viticulture established. Babylonia beer a more popular drink – climate more suited to growing grains than grapes. In Mesopotamia 40% of cereal production went into beer production. |
| 3000 BC | Celts independently discover the art of brewing – Pliny the elder notes: "Western nations intoxicate themselves by means of moistened grain"<br>Solom Katz, anthropologist suggests that these discoveries led to the transformation from hunting gathering to agricultural societies about 10,000 year. |
| 2000 BC | Babylonians control date palm breeding by selectively pollinating female trees with pollen from certain male trees. |
| 1750 BC | Oldest known recipe – for beer – is recorded on Sumerian tablets. |
| 600 BC | Olive trees, along with unknown microbes, are brought to Italy by Greek settlers. |
| 500 BC | The Chinese use moldy soybean curds as an antibiotic to treat boils. |
| 250 BC | Theophrastus writes of Greeks rotating their staple crops with broad beans to take advantage of enhanced soil fertility. |
| 100 A.D | Powdered chrysanthemum is used in China as an insecticide. |
| 1322 | An Arab chieftain first uses artificial insemination to produce superior horses. |
| 1346 | The nomadic Kipchaks from the Euro-Asian steppe, under Mongol de Mussis, catapult bubonic plague-infested bodies into the Genoese trading post Kaffa (modern Feodosia in the Crimea). |
| 1621 | Potatoes from Peru are planted in Germany, another example of foreign microbes' finding new homes. |
| 1665 | Robert Hooke's Micrographia describes cells – viewed in sections of cork – for the first time. He named them cells because they looked like monks' cells in monasteries. |
| 1675 | With a home-made microscope, Antonie van Leeuwenhoek discovers bacteria, which he calls "very little animalcules." |
| 1761 | Koelreuter reports successful crossbreeding of crop plants in different species. |

1770 Benjamin Franklin, the colony of Pennsylvania's ambassador, sends home from Europe seeds he calls "Chinese caravances" that turn out to be America's first soybeans.
1790 United States passes first patent law.
1795 Thomas Jefferson writes, "The greatest service which can be rendered any country is to add a useful plant to its culture, especially a bread grain"
1797 Jenner inoculates a child with a viral vaccine to protect him from smallpox.
1816 Tariff Act exempts foreign plants and trees from U.S. import duties. (Foreign garden seed is exempted in 1842.)
1802 German naturalist Gottfried Treviranus creates the term "biology." Organized bands of English handicraftsmen riot against the textile machinery displacing them, and the Luddite movement – led by a man they sometimes called King Ludd – begins near Nottingham, England.
1827 President John Quincy Adams instructs U.S. consular officers abroad to ship back to the United States any plant "as may give promise, under proper cultivation, of flourishing and becoming useful"
1830 Scottish botanist Robert Brown discovers a small dark body in plant cells. He calls it the nucleus or "little nut."
1830 Proteins discovered.
1833 First enzyme discovered and isolated
1835 Charles Cagniard de Latour's work with microscopes shows that yeast is a mass of little cells that reproduce by budding. He thinks yeast are vegetables.
1835 Schleiden and Schwann propose that all organisms are composed of cells, and Virchow declares, "Every cell arises from a cell."
1839 Congress puts $1,000 into the Congressional Seed Distribution Program, administered by the U.S. Patent Office, to increase the amount of free seeds mailed to anyone requesting them.
1840 The term "scientist" is added to the English language by William Whewell, an English polymath, scientist, Anglican priest, philosopher, theologian, historian of science and Master of Trinity College, Cambridge before they were known as "men of science".
1845 Late blight (*Phytophtera infestans*), a fungal disease afflicting potatoes, ravages Ireland's potato crop in 1845 and 1846; more than a million Irish die in the infamous potato famine.
1852 In Paris, an international "Corn Show" features corn varieties from many countries, including Syria, Portugal, Hungary and Algeria.
1852 The United States imports sparrows from Germany as defense against caterpillars.
1857 Louis Pasteur begins the experiments that eventually prove definitively that yeast is alive.
1859 *On the Origin of Species*, Charles Darwin's landmark book, is published in London. The concept of carefully selecting parents and culling the variable progeny greatly influences plant and animal breeders in the late 1800s despite their ignorance of genetics.

1862 The Organic Act establishes the U.S. Department of Agriculture (USDA) – formerly the Division of Agriculture in the Patent Office – and directs its commissioner "to collect new and valuable seeds and plants and to distribute them among agriculturalists"

1865 Augustinian monk Gregor Mendel, the father of modern genetics, presents his laws of heredity to the Natural Science Society in Brunn, Austria. But the scientific world, agog over Darwin's new theory of evolution, pays no attention to Mendel's discovery.

1869 DNA is discovered in the sperm of trout from the Rhine River by Swiss chemist Frederick Miescher, but Miescher does not know its function. other sources suggest it was from the bloody bandages of injured soldiers.

1869 *Hemileia vastatrix*, a disease deadly to coffee trees, wipes out the coffee industry in the British colony of Ceylon (now Sri Lanka) and England becomes a nation of tea totalers.

1870 The Navel orange is introduced into the United States from Brazil (obviously called navel to reflect its use in combating scurvy of the high seas).

1877 German chemist Robert Koch develops a technique whereby bacteria can be stained and identified.

1877 Louis Pasteur notes that some bacteria die when cultured with certain other bacteria, indicating that some bacteria give off substances that kill others; but it will not be until 1939 that Rene Jules Dubos first isolates antibiotics produced by bacteria.

1879 German biologist Walter Flemming discovers chromatin, the rod-like structures inside the cell nucleus that later came to be called chromosomes. Their function is not known.

1878 Ralph Waldo Emerson suggests that weeds are actually plants "whose virtues have not yet been discovered"

1879 In Michigan, Darwin devotee William James Beal makes the first clinically controlled crosses of corn in search of colossal yields.

1882 Swiss botanist Alphonse de Candolle writes the first extensive study on the origins and history of cultivated plants; his work later played a significant role in N.I. Vavilov's mapping of the world's centers of diversity.

1883 The term "germplasm" is coined by German scientist August Weismann.

American Seed Trade Association (ASTA) is founded.

1884 Father Gregor Mendel dies after 41 years studying, with no scientific acclaim, the hereditary "factors" of pea plants; he said not long before his death, "My time will come."

1884 In that very same year, Luther Burbank established his research gardens in Santa Rosa CA Luther Burbank produced enough new hybrids to offer the most important publication of his career, an 1893 catalog which he called "New Creations in Fruits and Flowers." The concept of a 52 page catalog listing over a hundred brand-new hybrid plants, all of which were produced by one man was looked upon with surprise, wonder and disbelief. Burbank's booklet was even denounced by some religious groups who claimed that only

God could "create" a new plant., In his working career Burbank introduced more than 800 new varieties of plants-including over 200 varieties of fruits many vegetables, nuts and grains, and hundreds of ornamental flowers. "I think of myself not as a Master whose work must die with him, but as a Pioneer who has mapped out certain new roads and looked down into the Promised Land of Plant Development"

1885 French chemist Pierre Berthelot suggests that some soil organisms may be able to "fix" atmospheric nitrogen.

1888 Dutch microbiologist Martinus Willem Beijerinck observes *Rhizobium leguminosarum* nodulating peas.

1889 The commissioner of Agriculture becomes secretary of same and a member of the president's Cabinet when the USDA is given executive status.

1889 The vedalia beetle – commonly known as the ladybird – is introduced from Australia to California to control cottony cushion scale, a pest that was ruining the state's citrus groves. This episode represents the first scientific use of biological control for pest management in North America.

1895 A German company, Hochst am Main, sells "Nitragin," the first commercially cultured *Rhizobia* isolated from root nodules.

1896 *Rhizabia* becomes commercially available in the United States.

1898 The USDA creates the "Section of Seed and Plant Introduction," which assigns its first Plant Introduction Number, PI#1, to a common Russian cabbage.

1900 The science of genetics is born when Mendel's work is rediscovered by three scientists Hugo DeVries, Erich Von Tschermak and Carl Correns – each independently checking scientific literature for precedents to their own "original" work. Drosophila (fruit flies) used in early studies of genes.

1901 Gottlieb Haberlandt stated "to my knowledge, no sytematically organized attempts to culture isolated vegetative cells from higher plants in simple nutrient solutions have been made. Yet the results of such culture experiemnts should give some interesting insight into the properties and potentialities which the cell, as an elementary organism, posses. Moreover it would provide information about the inter-relationships and complementary influences to which cells within the multicellular whole organism are exposed.

1902 The term immunology first appears.

1906 The term "genetics" is coined.

1909 Replacing Mendel's term "factors," geneticist Wilhelm Johannsen coins the terms "gene" to describe the carrier of heredity, "genotype" to describe the genetic constitution of an organism, and "phenotype" to describe the actual organism.

1911 The first cancer-causing virus is discovered by Rous.

1914 The first modern sewage plant, designed to treat sewage with bacteria, opens in Manchester, England.

1915 Phages, or bacterial viruses, are discovered.

1916 French-Canadian bacteriologist Felix-Hubert D'Herelle discovers viruses that prey on bacteria and names them "bacteriophages" or "bacteria eaters."

1916 George Harrison Shull, pioneering corn breeder and Princeton genetics professor, publishes inaugural issue of Genetics magazine.

1917 Stem rust attacks the U.S. wheat crop, destroying more than two million bushels and forcing Herbert Hoover's Food Administration to declare two "wheatless days" a week.

1918 Geneticist Donald Jones invents the "double-cross" (the crossing of two single crosses) moves hybrid corn from the lab into farmers' fields.

1919 Hungarian Kark Ereky coins the term "biotechnology" to describe the interaction of biology with technology.

1920 The human growth hormone is discovered by Evans and Long.

1923 More than 50,000 foreign plants have been introduced into the United States since 1862 by the USDA. Along with these plants came 90% of the pests that plague agriculture today; most are invisible microbes.

1925 Nikolai Vavilov leads Russian plant hunters on the first attempt to "cover the globe" in search of wild plants and primitive cultivars.

1926 Henry Agard Wallace, secretary of Agriculture during Franklin Roosevelt's first two terms and vice president during his third, starts the Hi-Bred Company – a hybrid corn-seed producer and marketer known today as Pioneer Hi-Bred International, Inc.

1928 Penicillin discovered as an antibiotic: Alexander Fleming. A small-scale test of formulated Bacillus thuringiensis (Bt) for corn borer control begins in Europe. Commercial production of this biopesticide begins in France in 1938. Karpechenko crosses radishes and cabbages, creating fertile offspring between plants in different genera. Laibach first uses embryo rescue to obtain hybrids from wide crosses in crop plants – known today as hybridization.

1930 Congress passes the Plant Patent Act, recognizing for the first time that plant breeder products do not exist in nature and thus should be patentable like other human-made products.

1933 Fewer than 1% of all the agricultural land in the Corn Belt has hybrid corn growing on it; by 1943, however, hybrids will cover more than 78% of the same land.

1933 American Wendell Stanley purifies a sample of tobacco mosaic virus (TMV) and finds crystals. This suggests, contrary to contemporary scientific opinion, that viruses are not just extremely small bacteria, for bacteria do not crystallize.

1934 White cultured tomato roots on a simple medium of inorganic salts, sucrose, and yeast extract.

Gautheret found the cambial tissue of *Salix capraea* and *Populas alba* could proliferate but growth was limited

1938 The term molecular biology is coined.

1939 With the addition of auxin and B vitamins, Gauthert reported first plant tissue culture of unlimited growth, a strain of carrots isolated two years earlier.

1936 The USDA's 1936 and 1937 Yearbooks of Agriculture not only sound the first alarm over the loss of important germplasm around the world, but also are the first – and last – major efforts to catalog the genetic diversity available in the United States.

1938 The bacterium *Bacillus popilliae* (Bp) becomes the first microbial product registered by the U.S. government. It kills Japanese beetles.

1939 Rene Dubos, who will later enjoy international acclaim as an environmentalist, isolate gramicidin, an antibiotic, from a common soil microbe. His discovery helps cure a mastitis outbreak in the Borden Company's cow herd, including the famed Elsie, at the 1939 World's Fair.

The first large-scale deliberate release of bacteria into the environment takes place when Bp is sprayed over Connecticut, New York, New Jersey, Delaware and Maryland in an effort to arrest the damaging effects of the Japanese beetle.

1940 Nikolai Vavilov, perhaps the leading plant geneticist in the world, is arrested while on a collecting expedition in the Ukraine and charged by the Soviet Union with agricultural sabotage. Initially sentenced to death, Vavilov's punishment is reduced and he is sent to Siberia (lucky dude).

Oswald Avery precipitates a pure sample of what he calls the "transforming factor"; though few scientists believe him, he has isolated DNA for the first time.

1941 Danish microbiologist A. Jost coins the term "genetic engineering" in a lecture on sexual reproduction in yeast at the Technical Institute in Lwow, Poland.

1942 The electron microscope is used to identify and characterize a bacteriophage – a virus that infects bacteria.

Penicillin mass-produced in microbes.

1943 The Rockefeller Foundation, in collaboration with the Mexican government, initiates the Mexican Agricultural Program – the first use of plant breeding as foreign aid.

Nikolai Vavilov dies of malnutrition in prison.

1944 DNA is proven to carry genetic information – Avery et al.

Waksman isolates streptomycin, an effective antibiotic for tuberculosis.

1945 At a meeting in Quebec, Canada, delegates from 37 countries sign the constitution establishing the U.N. Food and Agriculture Organization (FAO).

1946 Discovery that genetic material from different viruses can be combined to form a new type of virus, an example of genetic recombination.

1946 D.C. Salmon, a U.S. military adviser on duty in Japan, sends home Norin 10 – the source of the dwarfing gene that later will help produce Green Revolution wheat varieties.

Recognizing the threat posed by loss of genetic diversity, the U.S. Congress Research and Marketing Act establishes the National Cooperative Program, which provides funds for systematic and extensive plant collection, preservation and introduction, an effort to link U.S. state and federal governments in the preservation of germplasm and the first vestiges of today's National Plant Germplasm System (NPGS).

1947 Little-known geneticist Barbara McClintock issues her first report on "transposable elements" – known today as "jumping genes" – but the scientific community fails to recognize the significance of her discovery. ( she finally wins a noble prize for her work in 1983 – see Rosalind Franklin below!!!)

An FAO subcommittee recommends that the FAO become a clearinghouse for information and that it facilitate the free exchange of germplasm throughout the world.

1949 Pauling shows that sickle cell anemia is a "molecular disease" resulting from a mutation in the protein molecule hemoglobin.

1950 Aldrin, one of the deadliest chemicals available, is used by the U.S. government to attack the Japanese beetle in the midwest, replacing the bacterial insecticides that had been used earlier in the northeast.

The U.S. Army ten's the spread and survival of "simulants," which are actually *Serratia marcescens* bacteria, by spraying them over San Francisco. Within days, one San Franciscan is dead and many others are ill with unusual Serratia infections, but the Army calls this "apparently coincidental." Similar tests are conducted in New York City's subway system, at Washington's National Airport and elsewhere.

1951 American Joshua Lederberg shows that some bacteria can conjugate or come together and exchange part of themselves with one another. He calls the material exchanged the "plasmid." He also discovers that viruses that attack bacteria can transmit genetic material from one bacterium to another.

Artificial insemination of livestock using frozen semen is successfully accomplished.

1953 *Nature* publishes James Watson and Francis Crick's 900-word manuscript describing the double helical structure of DNA, the discovery for which they will share a Nobel Prize in 1962.

1954 Seymour Benzer at Purdue University devised an experimental setup to map mutations within a short genetic region of a particular bacterial virus. Over a five-year period, Benzer mapped recombinations of genetic material that distinguished mutational changes that had taken place at adjacent base pairs.

1955 An enzyme involved in the synthesis of a nucleic acid is isolated for the first time.

1956 Kornberg discovers the enzyme DNA polymerase I, leading to an understanding of how DNA is replicated.

Heinz Fraenkel-Conrat took apart and reassembled the tobacco mosaic virus, demonstrating "self assembly."

1957 Francis Crick and George Gamov worked out the "central dogma," explaining how DNA functions to make protein. Their "sequence hypothesis" posited that the DNA sequence specifies the amino acid sequence in a protein. They also suggested that genetic information flows only in one direction, from DNA to messenger RNA to protein, the central concept of the central dogma.

1957 Skoog and Miller demonstrate the relationship between the auxin-cytokinin balance of the nutrient media, and the pattern of redifferentiation of unorganized tobacco pith callus. Cytokinin≫Auxin results in shoots Auxin≫cytokinin results in roots.

As a result of plant breeding efforts begun in 1943, Mexico becomes self-sufficient in wheat for the first time.

The term "agribusiness" is coined by Harvard Business School's Ray Goldberg.

1957 Meselson and Stahl demonstrated the replication mechanism of DNA.

1958 Kornberg discovered and isolated DNA polymerase I, which became the first enzyme used to make DNA in a test tube.

Sickle cell anemia is shown to occur due to a change of a single amino acid.

DNA is made in a test tube for the first time.

1959 The National Seed Storage Laboratory (NSSL), the first long-term seed storage facility in the world, opens in Fort Collins, Colorado.

Francois Jacob and Jacques Monod established the existence of genetic regulation – mappable control functions located on the chromosome in the DNA sequence – which they named the operon. They also demonstrated the existence of proteins that have dual specificities.

Reinart regenerated plants from carrot callus culture.

The steps in protein biosynthesis were delineated.

Soviet leader Nikita Khrushchev visits the Iowa corn farm of seedsman Roswell Garst to verify for himself the impressive stories he has heard about hybrid corn. After his trip, Khrushchev welcomes hybrid corn in the Soviet Union.

Systemic fungicides were developed.

1960 The Rockefeller and Ford Foundations establish, with the Philippine government, the International Rice Research Institute (IRRI) – the first international agricultural research center.

Exploiting base pairing, hybrid DNA-RNA molecules are created.

Messenger RNA is discovered.

1961 As part of its World Seeds Year, the FAO holds a "Technical Conference on Plant Exploration and Introduction," marking the first time a major international agency focuses on plant germplasm.

UPOV, the International Union for the Protection of New Varieties of Plants, is negotiated in Paris, France; the goal of the "Convention of Paris"

is to make uniform the enactment and enforcement of Plant Breeders' Rights legislation around the world.

USDA registers first biopesticide: *Bacillus thuringiensis*, or Bt.

1962 Planting of high-yield wheat varieties (later known as Green Revolution grains) begins throughout Mexico and the seeds are released by the Mexican Agricultural Program to other countries.

1963 New wheat varieties developed by Norman Borlaug increase yields by 70 percent.

1964 The FAO, backed by the U.N. Special Fund, sets up the Crop Research and Introduction Centre at Izmir, Turkey, to assemble and study germplasm from that region.

Based on its success with IRRI, the Rockefeller Foundation initiates its second international research center, CIMMYT, the International Center for the Improvement of Maize and Wheat, in Mexico.

1965 Scientists noticed that genes conveying antibiotic resistance in bacteria are often carried on small, supernumerary chromosomes called plasmids. This observation led to the classification of the plasmids.

Harris and Watkins successfully fuse mouse and human cells.

1966 The genetic code was "cracked". Marshall Nirenberg, Heinrich Mathaei, and Severo Ochoa demonstrated that a sequence of three nucleotide bases (a codon) determines each of 20 amino acids.

Headline in the Manila Bulletin reads "MARCOS GETS MIRACLE RICE" – the first tin, the term "miracle rice" is used to describe varieties released by IRRI.

1967 The first automatic protein sequencer is perfected.

Arthur Kornberg conducted a study using one strand of natural viral DNA to assemble 5,300 nucleotide building blocks. Kornberg's Stanford group then synthesized infectious viral DNA.

The FAO and the International Biological Programme put on the second major conference on germplasm – marking the first time that the world's scientific community recognizes the need to conserve genetic resources.

The term "genetic resources" is coined by Sir Otto Frankel, a renowned plant breeder from Australia.

1968 Russia renames the Lenin All-Union Institute of Plant Industry the N.I. Vavilov All-Union Institute of Plant Industry in honor of the man who built it, during the 1920s and 30s, into the greatest collection of germplasm anywhere.

The FAO creates a Crop Ecology and Genetic Resources Unit to act as a clearinghouse for information on plant collecting expeditions.

The superlative "Green Revolution" is coined by William Gaud, an administrator for the Agency for International Development (AID).

1969 An enzyme is synthesized in vitro for the first time.

A survey by the FAO's Crop Ecology Unit reveals that only 28% of the approximately two million germplasm samples held worldwide are being stored properly.

The FAO's Crop Ecology Unit sponsors the first attempt to develop a standardized, computerized data bank for the world's genetic resources so that breeders can locate the germplasm they need.

1970 Howard Temin and David Baltimore, working independently, first isolated "reverse transcriptase" Their work described how viral RNA that infects a host bacteria uses this enzyme to integrate its message into the host's DNA.

Site specific restriction endonucleases are discovered by Hamilton Smith-*Hin*d III

The Southern Corn Leaf Blight (SCLB) sweeps across the South, destroying 15% of the US. corn crop.

Congress enacts the Plant Variety Protection Act (PVPA) to extend patent protection to plant varieties reproduced sexually, by seed.

Norman Borlaug becomes the first plant breeder to win the Nobel Prize, for his work on Green Revolution wheat varieties. CIMMYT and IRRI share UNESCO's Science Prize.

1971 First complete synthesis of a gene

Consultative Group on International Agricultural Research (CGIAR) is created under joint sponsorship of the World Bank, the U.N. Development Program (UNDP) and the FAO, which sets up a Technical Advisory Committee to assist the CGIAR.

Reflecting the increasing worldwide focus on natural resources, the FAO's *Plant Introduction Newsletter* is renamed *Plant Genetic Resources Newsletter*.

1972 Paul used restriction endonucleases, ligase and other enzymes to paste two DNA strands together to form a hybrid circular molecule. This was the first recombinant DNA molecule.

The DNA composition of humans is discovered to be 99 percent similar to that of chimpanzees and gorillas.

Initial work with embryo transfer.

National Academy of Sciences releases Genetic Vulnerability of Major Crops – a study prompted by the SCLB in 1970 – and the lack of genetic diversity in major crops briefly enjoys media attention and becomes a national issue.

The U.N. Conference on the Human Environment in Stockholm thrusts the-environmental movement into the international arena and, for a short time, draws worldwide attention to the urgent need to conserve the world's diminishing genetic resources, both plant and animal.

1973 The era of biotechnology begins when Stanley Cohen of Stanford University and Herbert Boyer of U.C. San Francisco successfully recombine ends of bacterial DNA after splicing a foreign gene in between. They call their handiwork "recombinant DNA," but the press prefers to call it "genetic engineering"

Molecular biologist Robert Pollack's early concern about the safety of certain recombinant DNA experiments results in the publication of his

*Biohazards in Biological Research* – the first book to warn the world of biotechnology's potential dark side.

The era of cheap energy ends when Arab nations suddenly start a 1000% increase in the price of oil, stunting world economic growth and the Green Revolution by driving up prices of fuel and fertilizer – the two keys to the productivity of high-yielding varieties.

1974 The National Institutes of Health forms a Recombinant DNA Advisory Committee to oversee recombinant genetic research.

The CGIAR and the FAO agree to establish the International Board for Plant Genetic Resources (IBPGR) as the lead agency in the coordination of efforts to preserve crop germplasm around the world.

In an attempt to bring order to the loosely structured state/federal new-crops research program, the National Plant Germplasm System is established under the USDA's Agricultural Research Service (ARS).

1975 Scientists gather at Asilomar, California, for the first international conference on the potential dangers of recombinant DNA, and recommend that regulatory guidelines be placed on their work – an unprecedented act of self-regulation by scientists.

The first monoclonal antibodies are produced.

The National Plant Genetic Resources Board is formed to guide both the NPGS and the USDA in setting national policy on crop genetic resources.

1976 The tools of recombinant DNA are first applied to a human inherited disorder.

Molecular hybridization is used for the prenatal diagnosis of alpha thalassemia.

Yeast genes are expressed in E. coli bacteria.

The sequence of base pairs for a specific gene is determined (A, C, T, G).

First guidelines for recombinant DNA experiments released: National Institutes of Health-Recombinant DNA Advisory Committee.

1977 Genetic engineering became a reality when a man-made gene was used to manufacture a human protein in a bacteria for the first time. Biotech companies and universities were off to the races, and the world of reproduction would never be the same again.

Procedures developed for rapidly sequencing long sections of DNA using electrophoresis.

Having inherited from the FAO's Crop Ecology Unit the project to develop a standardized computer system for germplasm, the IBPGR decides that the project is too costly and backs out.

1978 High-level structure of virus first identified.

Recombinant human insulin first produced.

North Carolina scientists show it is possible to introduce specific mutations at specific sites in a DNA molecule.

1979 Human growth hormone first synthesized.

Gene targeting.

RNA splicing.

Early concern over the dangers of recombinant DNA has waned and the NIH guidelines are relaxed.

Seeds of the Earth, a book by Canadian economist Pat Mooney, is the first publication to warn of potential control of germplasm resources by the private sector. Replete with controversial claims, it foments international debate over the control and use of genetic resources.

1980 U.S. congressional hearings on proposed amendments to expand the 1970 Plant Variety Protection Act turn into the first extended public discussion of patent protection for plants; opposition to plant patents is strong, but the amendments pass.

In *Diamond v. Chakrabarty*, the US. Supreme Court upholds by five to four the patentability of genetically altered micro-organisms, opening the door to greater patent protection for any modified life forms.

The U.S. patent for gene cloning is awarded to Cohen and Boyer.

Genentech, Inc. becomes the first recombinant DNA company to go public. Making Wall Street history, just 20 minutes after trading begins at $35 per share the price per share hits $89. It closes at $71.25.

The first gene-synthesizing machines are developed.

Researchers successfully introduce a human gene – one that codes for the protein interferon – into a bacterium.

Nobel Prize in Chemistry awarded for creation of the first recombinant molecule: Berg, Gilbert, Sanger.

1981 Scientists at Ohio University produce the first transgenic animals by transferring genes from other animals into mice.

Chinese scientist becomes the first to clone a fish – a golden carp.

Mary Harper and two colleagues mapped the gene for insulin. That year, mapping by in situ hybridization became a standard method.

At the 21st session of the FAO Conference in Rome, genetic resource conservation becomes an internationally politicized issue when many non-industrialized countries protest that it is done primarily by and for industrialized countries.

1982 Steve Lindow, UC Berkeley requested permission to test genetically engineered bacteria to control frost damage to potatoes and strawberries.

Applied Biosystems, Inc., introduces the first commercial gas phase protein sequencer, dramatically reducing the amount of protein sample needed for sequencing.

First recombinant DNA vaccine for livestock developed.

First biotech drug approved by FDA: human insulin produced in genetically modified bacteria.

First genetic transformation of a plant cell: petunia.

The EPA included GMOs in its policy of regulating microbial pest-control agents (MPCA, for the control of pests and weeds) as distinctive entities from chemicals

Michael Smith at the University of British Columbia, Vancouver, developed a procedure for making precise amino acid changes anywhere in a protein.

Diversity magazine, the first and only non-governmental periodical devoted exclusive!, to genetic resource issues, makes its debut.

The Plant Breeding Research Forum, the most extensive effort to educate Congress an the public on the need to preserve crop germplasm, holds the first of three annual meetings sponsored by Pioneer Hi-Bred International, Inc., a US. seed company operating in 90 countries.

Having lost, neglected, or eaten to extinction most of its local rice varieties during the recent war, Kampuchea (formerly Cambodia) requests nearly 150 samples of rice germplasm from IRRI, whose scientists had collected Cambodian rice varieties in 1973; IRRI obliges.

1983 The first genetic transformation of plant cells by TI plasmids is performed.

Syntex Corporation received FDA approval for a monoclonal antibody-based diagnostic test for Chlamydia trachomatis.

Jay Levy's lab at UCSF isolated the AIDS virus (human immunodeficiency virus, HIV) at almost the same moment it was isolated at the Pasteur Institute in Paris and at the NIH.

NIH unanimously approves Lindow test. 1983. The EPA approves release of Frost-Ban. Advanced Genetic Sciences, Inc. conducted a field trial of Lindow's recombinant microbe, Frost-Ban, on a Contra Costa County strawberry patch.

Science reported Cetus Corporation's GeneAmp polymerase chain reaction (PCR) technology. PCR, which uses heat and enzymes to make unlimited copies of genes and gene fragments, later becomes a major tool in biotech research and product development worldwide.

The first artificial chromosome is synthesized.

The first genetic markers for specific inherited diseases are found.

First whole plant grown from biotechnology: petunia.

First proof that modified plants pass their new traits to offspring: petunia.

U.S. patents were granted to companies genetically engineering plants.

First genetically engineered organism (to control crown gall of fruit trees) approved for sale, in Australia.

Law of the Seed, Pat Mooney's second book, is released and claims that, with patents to protect them, multinational corporations are taking over both the seed and biotechnology industries in an effort to control not only germplasm, but also the food the world eats. The book draws numerous angry responses around the world from plant breeders and administrators, both public and private.

At the 22nd session of the FAO, germplasm becomes a political football when, led by the Mexican delegation, a large bloc of Third World nations wins a vote to place the world's genetic resources under the "auspices and jurisdiction" of the FAO.

Marvin Carruthers at the University of Colorado devised a method to construct fragments of DNA of predetermined sequence from five to about 75 base pairs long. He and Leroy Hood at the California Institute of Technology invented instruments that could make such fragments automatically.

1984 The EPA publishes the recombinant-DNA testing guidelines.

1984 The DNA fingerprinting technique is developed.

Chiron Corp. announced the first cloning and sequencing of the entire human immunodeficiency virus (HIV) genome.

The wave of interest in agricultural biotechnology reaches Congress when a House-Senate conference committee agrees to allot $20 million for the USDA's biotechnology initiative almost twice the USDA's entire budget for all of its crop germplasm activities.

With little change in the budget for the U.S. National Plant Germplasm System in 1984 and 1985 and with none expected in 1986, the NPGS will be $30 million behind what it needs to operate effectively by 1987, according to its own "Long-Range Plan," published in 1981.

Federal District Court Judge John J. Sirica temporarily halts all federally funded experiments involving the deliberate release of recombinant DNA organisms, causing a scramble among many federal agencies to see which shall have regulatory responsibility over this heretofore-uncharted territory.

The takeover of Agrigenetics Corp., a leading agricultural biotechnology company, by Lubrizol Corp., the $800 million chemical manufacturer based in Wickliffe, Ohio, is one of the first example of the move toward concentration in the seed and biotech industries; indeed, over 100 seed and plant science companies have been bought out in the last 10 years.

California becomes the first state to launch its own "Genetic Resources Conservation Program:" at UC Davis. Designed to preserve germplasm vital to California's economy, the program's main function is to coordinate current conservation efforts within California, including those made by individuals as well as private and public institutions.

The USDA and the University of California announce plans to create the "Plant Gene Expression Center,' a research center that will answer basic questions about the control of gene expression in plants. The decision to locate this unique federal/state facility in California further bolsters that state's reputation as a world center for plant research.

The U.S. Patent Office stuns U.S. seed and biotech firms by announcing, in response to a questionnaire submitted by the Japanese Patent Association, that any plant that falls under either the 1930 Plant Patent Act or the 1970 Plant Variety Protection Act cannot also be patented under the general patent law – precisely the opposite of what was indicated by the Chakrabarty decision in 1980 and what more than a billion dollars of private money put into agricultural biotech research has been bet on.

Father Gregor Mendel, the father of modern genetic science, died 100 years ago; it's both fitting and ironic that, although he didn't live to see it, his work – all done with pea plants – started up the genetic train now roaring into new frontiers in plant science.

1985 Genetically engineered plants resistant to insects, viruses, and bacteria were field tested for the first time.

Cal Bio cloned the gene that encodes human lung surfactant protein, a major step toward reducing a premature birth complication.

Genetic markers found for kidney disease and cystic fibrosis.

Genetic fingerprinting entered as evidence in a courtroom.

The NIH approves guidelines for performing gene-therapy experiments in humans.

1986 First recombinant vaccine for humans: hepatitis B.

First anti-cancer drug produced through biotech: interferon.

Ribozymes and retinoblastomas identified.

The U.S. government publishes the Coordinated Framework for Regulation of Biotechnology, establishing more stringent regulations for rDNA organisms than for those produced with traditional genetic modification techniques.

A University of California Berkeley chemist describes how to combine antibodies and enzymes (abzymes) to create pharmaceuticals.

The Environmental Protection Agency approves the release of the first transgenic crop – gene-altered tobacco plants.

Scientists developed herbicide-resistant soybeans, which were to become the single mostimportant GM crop by the mid-1990s.

The Organization of Economic Cooperation and Development (OECD) Group of National Experts on Safety in Biotechnology states: "Genetic changes from rDNA techniques will often have inherently greater predictability compared to traditional techniques" and "risks associated with rDNA organisms may be assessed in generally the same way as those associated with non-rDNA organisms."

1987 Activase® is approved for treatment of heart attacks.

Infergen® is approved for treatment of hepatitis C

Calgene, Inc. received a patent for the tomato polygalacturonase antisense sequence. Inhibits production of the enzyme and extend the shelf-life of fruit.

First approval for field test of modified food plants: virus-resistant tomatoes.

Frostban, a genetically altered bacterium that inhibits frost formation on crop plants, is field-tested on strawberry and potato plants in California, the first authorized outdoor tests of a recombinant bacterium.

1988 Harvard molecular geneticists are awarded the first U.S. patent for a genetically altered animal – a transgenic mouse.

A patent for a process to make bleach-resistant protease enzymes to use in detergents is awarded.

Congress funds the Human Genome Project, a massive effort to map and sequence the human genetic code as well as the genomes of other species.

1989 First field trial of a recombinant viral crop protectant.

First approval for field test of modified cotton: insect-protected (Bt) cotton.

Plant Genome Project begins.

Recombinant DNA animal vaccine approved for use in Europe.

Use of microbes in oil spill cleanup: bioremediation technology.

UC Davis scientists developed a recombinant vaccine against rinderpest virus, which had wiped out millions of cattle in developing countries.

UC Davis scientists first to field test a genetically-engineered tree.

1990 Chy-Max™, an artificially produced form of the chymosin enzyme for cheese-making, is introduced. It is the first product of recombinant DNA technology in the U.S. food supply.

First food product of biotechnology approved in U.K.: modified yeast

First insect-protected corn: Bt corn.

First field test of a genetically modified vertebrate: trout.

UCSF and Stanford University were issued their 100th recombinant DNA patent license. By the end of fiscal 1991, both campuses had earned $40 million from the patent.

The first successful field trial of genetically engineered cotton plants was conducted by Calgene

Inc. The plants had been engineered to withstand use of the herbicide Bromoxynil.

The FDA licensed Chiron's hepatitis C antibody test to help ensure the purity of blood bank products.

Michael Fromm, molecular biologist at the Plant Gene Expression Center, reported the stable transformation of corn using a high-speed gene gun.

Mary Claire King, epidemiologist at UC-Berkeley, reported the discovery of the gene linked to breast cancer in families with a high degree of incidence before age 45.

GenPharm International, Inc. created the first transgenic dairy cow. The cow was used to produce human milk proteins for infant formula.

A four-year-old girl suffering from ADA deficiency, an inherited disorder that destroys the immune system, became the first human recipient of gene therapy. The therapy appeared to work, but set off a fury of discussion of ethics both in academia and in the media.

The Human Genome Project, the international effort to map all of the genes in the human body, was launched. Estimated cost: $13 billion.

1991 Biochips are developed for commercial use under the guidance of Affymetrix.

1992 The FDA declares that genetically engineered foods are "not inherently dangerous" and do not require special regulation.

American and British scientists unveil a technique for testing embryos in vitro for genetic abnormalities such as cystic fibrosis and hemophilia.

First European patent on a transgenic animal issued for transgenic mouse sensitive to carcinogens – Harvard's" Oncomouse".

The FDA declares that transgenic foods are "not inherently dangerous" and do not require special regulation.

Convention on Biological Diversity (CBD, negotiated under UNEP's auspices, was adopted on 22 May 1992 and entered into force on 29 December 1993. As of August 1998, there are 174 Parties to the Convention. Article 19.3 of the CBD provides for Parties to consider the need for and modalities of a protocol setting out procedures in the field of the safe transfer, handling and use of genetically modified organisms that may have an adverse effect on biodiversity and its components.

1993 Betaseron® is approved as the first treatment for multiple sclerosis in 20 years.

FDA approves bovine somatotropin (BST) for increased milk production in dairy cows.

Final rule notification by USDA in lieu of permit process for GEOs that are field tested in accordance with specific safety criteria.

1994 First FDA approval for a whole food produced through biotechnology: FLAVRSAVR™ tomato.

The first breast cancer gene is cloned.

Approval of recombinant version of human DNase, which breaks down protein accumulation in the lungs of CF patients.

BST commercialized as POSILAC bovine somatotropin.

1995 The first baboon-to-human bone marrow transplant is performed on an AIDS patient.

The first full gene sequence of a living organism other than a virus is completed, for the bacterium Hemophilus influenzae.

Gene therapy, immune system modulation and recombinantly produced antibodies enter the clinic in the war against cancer.

USDA introduces simplification of requirements and procedures for genetically engineered organisms. Allows most genetically engineered plants that are considered regulated articles to be introduced under the notification procedure, provided that the introduction meets certain eligibility criteria and performance standards.

A reduction in field test reporting requirements conducted under notification for which no unexpected or adverse effects are observed.

1996 The discovery of a gene associated with Parkinson's disease provides an important new avenue of research into the cause and potential treatment of the debilitating neurological ailment.

The EPA wanted to expand its federal regulatory powers over the characteristics of plants that help plants resist diseases and pests. The agency has coined a new term for these characteristics, calling them "plant-pesticides." All plants are able to prevent, destroy, repel or mitigate pests or diseases. That ability occurs naturally, and some crops have been bred for resistance

to specific pests. EPA proposes to single out for regulation those pest-resistant qualities that were transferred to the plant through recombinant DNA technology (genetic engineering).

Appropriate Oversight for Plants with Inherited Traits for Resistance to Pests A Report From 11 Professional Scientific Societies (July 1996).

Evaluation of the safety of substances in plants should be based on the toxicological and exposure characteristics of the substance and not on whether the substance confers protection against a plant pest.

1997 Scottish scientists, using DNA from adult ewe cells, report cloning a ewe named Dolly.

A new DNA technique combines PCR, DNA chips and a computer program providing a new tool in the search for disease-causing genes.

First weed- and insect-resistant biotech crops commercialized: Roundup Ready® soybeans and Bollgard® insect-protected cotton.

Biotech crops grown commercially on nearly 5 million acres worldwide: Argentina, Australia, Canada, China, Mexico and the United States.

A group of Oregon researchers claims to have cloned two Rhesus monkeys.

The EPA introduces "Microbial Products of Biotechnology; Final Regulations Under the Toxic Substances Control Act". Microbes subject to this rule are "new" microorganisms used commercially for such purposes as production of industrial enzymes and other specialty chemicals; agricultural practices (e.g., biofertilizers); and break-down of chemical pollutants in the environment.

The EPA claims to review each application on a case-by-case basis based on the product and the risk and not the means by which the organism was created. Yet it is interesting to note that no EUPs have been required for undirected mutagenesis, most transconjugants and plasmid-cured strains. Yet EUPs were required for all live recombinant DNA GEOs irrespective of product or risk.

1998 University of Hawaii scientists clone three generations of mice from nuclei of adult ovarian cumulus cells.

Human embryonic stem cell lines are established.

Scientists at Japan's Kinki University clone eight identical calves using cells taken from a single adult cow.

The first complete animal genome, for the C. elegans worm, is sequenced.

A rough draft of the human genome map is produced, showing the locations of more than 30,000 genes.

Five Southeast Asian countries form a consortium to develop disease-resistant papayas.

1999 First conviction using genetic fingerprinting in the U.K.

Genetically engineered rabies vaccine tested in raccoons.

Also in the 1990s.

Discovery that hereditary colon cancer is caused by defective DNA repair gene.

Biotechnology-based biopesticide approved for sale in the United States.

Patents issued for mice with specific transplanted genes.

2000 First complete map of a plant genome developed: Arabidopsis thaliana.

World's first litter of cloned piglets are born at PPL Therapeutics in Blacksburg, VA.

Biotech crops grown on 108.9 million acres in 13 countries.

"Golden Rice" announcement allows the technology to be available to developing countries in hopes of improving the health of undernourished people and preventing some forms of blindness.

First biotech crop field-tested in Kenya: virus-resistant sweet potato.

US President Bill Clinton and UK Prime Minister Tony Blair announce that Celera Genomics (a private enterprise) and the international Human Genome Project have both completed an initial sequence of the human genome "the Book of Life".

The Biggest Surprise about the Human Genome: The human genome contains only about 35,000 genes, just a fraction more than many 'lower' organisms and far fewer than numbers originally predicted for humans.

US President Bill Clinton signs executive order prohibiting federal employers from using genetic information in hiring or promoting workers.

2001 First complete map of the genome of a food plant completed: rice.

Chinese National Hybrid researchers report developing a "super rice" that could produce double the yield of normal rice.

Complete DNA sequencing of the agriculturally important bacteria, Sinorhizobium meliloti, a nitrogen-fixing species, and Agrobacterium tumefaciens, a plant pest and the original plant "genetic engineer".

A single gene from Arabidopsis inserted into tomato plants by UC Davis Scientist Edwardo Blumwald creates the first crop able to grow in salty water and soil.

Biosteel – recombinant spider silk is produced in goat milk. Spider drag line silk has 80 times the tensile strength of steel.

In his first address to the nation, Bush approves a compromise on stem cell funding. His decision allows for (a) full federal funding for research on adult and umbilical stem cells, (b) limited federal funding for research on human embryonic stem cells (hES cells) to pre-existing cell lines drawn from surplus embryos created for in-vitro fertilization, (c) no federal funding for research on hES cells from Donor Embryos created specifically for developing stem cells or for research in theraputic cloning (to obtain hES cells stem cells, tissues or organs that are genetically identical, and immunologically compatible, to the donor's).

2002 The first draft of a functional map of the yeast proteome, an entire network of protein complexes and their interactions, is completed. A map of the yeast genome was published in 1996.

International consortia sequence the genomes of the parasite that causes malaria and the species of mosquito that transmits the parasite.

The draft version of the complete map of the human genome is published, and the first part of the Human Genome Project comes to an end ahead of schedule and under budget.

Scientists make great progress in elucidating the factors that control the differentiation of stem cells, identifying over 200 genes that are involved in the process.

Biotech crops grown on 145 million acres in 16 countries, a 12 percent increase in acreage grown in 2001. More than one-quarter (27 percent) of the global acreage was grown in nine developing countries.

Researchers announce successful results for a vaccine against cervical cancer, the first demonstration of a preventative vaccine for a type of cancer.

Scientists complete the draft sequence of the most important pathogen of rice, a fungus that destroys enough rice to feed 60 million people annually. By combining an understanding of the genomes of the fungus and rice, scientists will elucidate the molecular basis of the interactions between the plant and pathogen.

Scientists are forced to rethink their view of RNA when they discover how important small pieces of RNA are in controlling many cell functions.

The Institute for Genomic Research (TIGR) announces the formation of two non-profit organizations: the Institute for Biological Energy Alternatives (IBEA), analyzing genomes of organisms that metabolize carbon or hydrogen for cleaner energy alternatives, and The Center for the Advancement of Genomics (TCAG), a bioethics think-tank, supported by the J. Craig Venter Science Foundation. "Our goal is to build a new and unique sequencing facility that can deal with the large number of organisms to be sequenced, and can further analyze those genomes already completed," said Venter, "and at such reduced cost that health care customized to one's own DNA would be feasible".

2003 Feb House Passes Ban on All Human Cloning: "The House bill bans all human cloning – for reproduction or research – and imposes a $1 million fine and a prison sentence of up to 10 years for violators. The Senate will consider s two competing bills: one by Senator Diane Feinstein (D-CA), that bans reproductive human cloning but permits the use of somatic cell nuclear transfer for therapeutic purposes (research on Alzheimers, Diabetes, Parkinson's, spinal cord injury, etc). and one by Senator Sam Brownback (R-KS) that would ban both forms of human somatic cell nuclear transfer. (Our new Senate Majority Leader Bill Frist, M.D. (R-TN) has stated support for banning reproductive human cloning but permitting the use of somatic cell nuclear transfer for therapeutic purposes.)

The Human Genome Project – fini – yeah right!! BETHESDA, Md., – "The International Human Genome Sequencing Consortium, led in the United States by the National Human Genome Research Institute (NHGRI) and the Department of Energy (DOE), today announced the successful completion of the Human Genome Project more than two years ahead of schedule

Happy Birthday Double Helix! On April 25, 1953, James Watson and Francis Crick published their landmark letter to Nature describing the DNA double helix. Nature marks the 50th anniversary of the event with a free Nature web focus "containing news, features and web specials celebrating the historical, scientific and cultural impacts of the discovery of the double helix."

A healthy mule named Idaho Gem is the first member of the horse family to be cloned, by Gordon Wood et al. at the University of Idaho. Since mules can't have babies the good old fashioned way, cloning may allow breeders to produce identical copies of champion mules. Idaho Gem is the brother of Taz, a champion racing mule, and the Idaho Gem will also be trained to race. A second mule clone, Utah Pioneer, was born June 9th.

Samuel Waksal, former CEO of ImClone, begins 87 months in prison without parole. Waksal was sentenced and fined over $4 million for insider trading and tax evasion eariler in the summer, stemming from the events surrounding the FDA decision to reject the approval of ImClone's cancer drug, Erbitux in late 2001.

The FDA approved use of Eli Lilly's growth hormone, Humatrope, for boosting the height of children who are short but in good health. Humatrope has been used since 1987 to treat children with growth-hormone deficiencies, but now, Lilly will be able to market Humatrope for short children with normal levels of growth hormone.

World's first cloned horse born to its genetic twin: Italian scientists created the world's first cloned horse from an adult cell taken from the horse who gave birth to her. Prometea, a healthy female. Prometea is the first animal known to be carried and born by the mother from which she was cloned. . .".

Chimp Genome Assembled the most closely related species to humans The sequence of the chimpanzee, Pan troglodytes, was assembled by NHGRI-funded teams led by Eric Lander, Ph.D., at The Eli & Edythe L. Broad Institute of the Massachusetts Institute of Technology and Harvard University, Cambridge, Mass.; and Richard K. Wilson, Ph.D., at the Genome Sequencing Center, Washington University School of Medicine, Saint Louis.

January 2004 Bio-computing. Biological Routes to Hybrid Electronic and Magnetic Nanostructured Materials. Angela Belcher MIT reports in the Jan 9 issue of Science that she used genetically engineered viruses that are noninfectious to humans to mass produce tiny materials for next-generation optical, electronic and magnetic devices.

Researchers at the Technion-Israel Institute of Technology have harnessed DNA to mold a nano-transister constructed of graphite nanotubes coated in silver and gold.

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| 12 February 2004 | Cloning Creates Human Embryos "Scientists in South Korea report he first human embryonic stem cell line produced with somatic cell nuclear transfer (cloning). Their goal, the scientists say, is not to clone humans but to advance understanding of the causes and treatment of disease. Patients with diseases like Parkinson's and diabetes have been waiting for the start of so-called therapeutic cloning to make embryonic stem cells that are an exact genetic match of the patient. Then those cells, patients hope, could be turned into replacement tissue to treat or cure their disease without provoking rejection from the body's immune system". |
| 26 February 2004 | FDA Approves Avastin, the first Anti-Angiogenesis drug for treating cancer "Genentech today announced the FDA approval of Avastin – the first FDA-approved therapy designed to inhibit angiogenesis, the process by which new blood vessels develop, which is necessary to support tumor growth and metastasis." Watch out, cancer cells! (Note: On August 13th, the FDA and Genetech released a warning that Avastin can increase the risk of clots that could cause a stroke or heart attack. Genentech shares fell nearly 6 percent on news of the warning (stay tuned). |
| 2 April 2004 | Sailing the Genome Seas: The Sorcerer II Expedition: J. Craig Venter, Ph.D., president of the Institute for Biological Energy Alternatives (IBEA), announced today in the journal Science (Environmental Genome Shotgun Sequencing of the Sargasso Sea, 2 April 2004) results from sequencing and analysis of samples taken from the Sargasso Sea off Bermuda. Using the whole genome shotgun sequencing and high performance computing developed to sequence the human genome, IBEA researchers sequenced over 1 billion bp of DNA, discovered at least 1,800 new species (mostly microbial) and more than 1.2 million new genes from the Sargasso Sea, all while sailing on Venter's 55-foot yacht. |
| 14 July 2004 | Woof! Dog Genome now available: "A team of scientists (MIT, Harvard, and Agencourt Bioscience) successfully assembled the genome of the domestic dog (Canis familiaris). The breed of dog was the boxer, one of the breeds with the least amount of variation in its genome and therefore likely to provide the most reliable reference genome sequence. Next mammals up: the orangutan, African elephant, shrew, the European hedgehog, the guinea pig, the lesser hedgehog , the nine-banded armadillo, the rabbit. and the domestic cat (each represents an important position on the mammalian evolutionary tree and is likely to by important in helping to interpret the human genome.)" |
| 30 July 04 | Francis Crick, DNA pioneer, dies at age 88 "Scientists around the world have paid tribute to British scientist Francis Crick, co-discover of the structure of DNA…" |

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| 12 August 2004 | Green light for stem cell clones: Newcastle University (Britain) is granted first U.K. licence to create to create embryonic stem cells from human embryos for research. The decision adds the U.K. (with Korea) to the forefront of global research in hES cell technology. |
| 23 August 2004 | Marathon Mouse: "California scientists Ron Evans et al. have genetically engineered an animal that has more muscle, less fat and more physical endurance than their littermates. Increasing the activity of a single gene – PPAR-delta, involved in regulation of regulate muscle development. The engineered mice ran 1,800 meters before quitting and stayed on the treadmill an hour longer than the natural mice, which were able to stay running for only 90 minutes and travel 900 meters. They also seem protected against the inevitable weight gain that follows a high fat, high calorie diet" Sign me up for the clinical trials! Published on-line Tuesday (for the October 2004 volume) of PLOS – Public Library of Science Biology. |
| November 2, 2004 | Stem cell initiative approved by California voters |
| January 2005 | Carlo Montemagno at the University of California, Los Angeles used rat muscle tissue to power tiny silicon robots, just half the width of a human hair, a development that could lead to stimulators that help paralyzed people breathe and "musclebots" that maintain spacecraft by plugging holes from micrometeorites. It was the first demonstration of muscle tissue being used to propel a microelectromechanical system. |
| February 2005 | Nanobacteria are real?? Kajander and Ciftcioglu were vindicated when patients with chronic pelvic pain – thought to be linked to urinary stones and prostate calcification – reported "significant improvement" after using an experimental treatment manufactured by NanoBac. In 2004 The Mayo study found that nanobacteria does indeed self-replicate and endorsed the idea that the particles are life forms. |
| March 2005 | In a project expected to cost $US1.35 billion over nine years, the United States Government's proposed "Human Cancer Genome Project", will open a new front in the battle against cancer, say US health officials. It is uncertain at present where the money will come from but the initiative is likely to start with some smaller pilot projects. The plan is to compile a complete catalogue of the genetic abnormalities that characterise cancer and will be greater in scale than the human genome project, which mapped the human genetic blueprint. It would seek to determine the DNA sequence of thousands of tumour samples, looking for mutations that give rise to cancer or sustain it. A databank of all these mutations, would be freely available to researchers and would provide invaluable clues for developing new ways to diagnose, treat and prevent cancer. |

April 2005 — By artificially initiating a DNA repair process known as homologous recombination, Dr. Matthew Porteus of UT Southwestern, working with scientists from Richmond, Calif.-based Sangamo Biosciences, was able to replace a mutated version of the gene that encodes a portion of the interleukin-2 receptor (IL-2R) in human cells, restoring both gene function and the production of the IL-2R protein. Mutations in the IL-2R gene are associated with a rare immune disease called severe combined immunodeficiency disease, or SCID.

May 2005 — By mid 2005 several classes of the wunderkind molecule RNAi-based drugs were making their way through the long and protracted clinical trial process. . One – a treatment for age-related macular degeneration (AMD) of the eye – is in Phase 1 clinical trials. Other RNAi-based drugs still in pre-clinical development target HIV, hepatitis C, Huntington disease, and various neurodegenerative disorders.

June 2005 — A research group headed by Dan Luo, Cornell assistant professor of biological engineering, has created "nanobarcodes" that fluoresce under ultraviolet light in a combination of colors that can be read by a computer scanner or observed with a fluorescent light microscope. This technology could make it as easy as a supermarket checkout to identify genes, pathogens, illegal drugs and other chemicals of interest by tagging them with this color-coded probes made out of synthetic tree-shaped DNA.

July 2005 — Nina Bissell, Lawrence Berkeley demonstrates that a key molecular pathway by which an enzyme that normally helps remodel tissues initiates the pathway to breast cancer. The same molecular pathway links both the loss of tissue organization in cancerous organs and the loss of genomic stability in individual cancer cells. This study demonstrates how structure and function in a tissue are intimately related, and how loss of structure could itself lead to cancer thus the unit of function in organs – which are made of tissues – is the organ itself. Matrix metalloproteinases (MMPs) are important during an organism's development and during wound healing, but they can also promote carcinogenesis. One type, MMP-3, causes normal cells to express a protein, Rac1b, that has previously been found only in cancers. Rac1b stimulates the production of highly reactive oxygen molecules, which promote cancer in two ways – by leading to tissue disorganization and by damaging genomic DNA.

September 2005 — The journal Science reported that The FANTOM Consortium for Genome Exploration Research Group, a large international collection of scientists that includes researchers at The Scripps Research Institute's Florida campus, the results of a massive multi-year project to map the mammalian "transcriptome". The transcriptome, or transcriptional landscape as it is sometimes called, is the totality of RNA transcripts produced from DNA, by the cell in any tissue at any given

time. It is a measure of how human genes are expressed in living cells, and its complete mapping gives scientists major insights into how the mammalian genome works. Antisense transcription was once thought to be rare, but the transcriptome reveals that it takes place to an extent that few could have imagined. This discovery has significant implications for the future of biological research, medicine, and biotechnology because antisense genes are likely to participate in the control of many, perhaps all, cell and body functions. If correct, these findings will radically alter our understanding of genetics and how information is stored in our genome, and how this information is transacted to control the incredibly complex process of mammalian development.

December 2005 Researchers led by a team at AntiCancer, Inc., in San Diego found that stem cells from hair follicles of mice can be used to rejoin severed nerves in mouse models. The hair follicle stem cells were used by the AntiCancer researchers to rejoin nerves in the legs of mice that were experimentally severed. After injection of the hair follicle stem cells, the nerves were rejoined and were able to regain function, enabling the mice to walk normally again.

December 2005 Amgen the world's largest biotechnology company, and Abgenix, a company specializing in the discovery, development and manufacture of human therapeutic antibodies, announced that they have signed a definitive merger agreement under which Amgen will acquire Abgenix for approximately $2.2 billion in cash plus the assumption of debt.

December 2005 BioE® , Inc., a biomedical company providing non-embryonic, human stem cells, announced that studies conducted by researchers at the University of Newcastle upon Tyne in the United Kingdom and the University of Minnesota in Minneapolis confirm the promise of the company's novel cord blood stem cell – the Multi-Lineage Progenitor Cell(TM) (MLPC(TM)) – for tissue engineering, bone marrow transplantation and regenerative medicine applications.

2006

January 2006 Dow AgroSciences received the world's first regulatory approval for a plant-made vaccine from the United States Department of Agriculture (USDA) Center for Veterinary Biologics. This approval represented an innovative milestone for the company and the industry.

January 2006 The Scripps Research Institute has revealed for the first time the structure of Sec13/31, a "nanocage" that transports a large body of proteins from the endoplasmic reticulum (ER), which makes up more than half the total internal cell membrane, to other regions of the cell. The newly uncovered structure of the cage reveals a self-assembling nanocage that to a significant degree helps shape basic human physiology from birth to death, and could one day lead to new treatment approaches to a number of diseases including diabetes and Alzheimer's disease. This new knowledge will allow further study of the structure's

function in building and maintaining membranes required for exporting key molecules such as insulin, involved in the onset of diabetes, and beta amyloid, associated with Alzheimer's disease. The new findings were published in the January 12, 2006 (Vol 439) issue of the journal Nature.

January 2006 ADVENTRX Pharmaceuticals, confirmed inhibition of influenza A virus by the Company's broad spectrum anti-viral drug, Thiovir(TM). The Company is conducting preclinical research on influenza A, which includes the H5N1 avian flu strain. The tests are being conducted in collaboration with Virapur, LLC., a virology specialty company in San Diego, and lead investigator Marylou Gibson, Ph.D. The Company filed a provisional patent application with the US Patent and Trademark Office on January 27, 2006 in connection with these findings. Thiovir is a broad spectrum anti-viral agent and non-nucleoside reverse transcriptase inhibitor (NNRTI) designed for oral delivery and as a component of highly active antiretroviral therapy (HAART) for HIV/AIDS.

January 2006 Agilent Technologies launched the industry's first dual-mode, one-color/two-color microarray platform, offering researchers unprecedented flexibility and performance for gene expression research. Gene expression profiling represents a majority of all DNA microarray experiments. Affymetrix launched the GeneChip® Human Tiling 1.0R Array Set and Mouse 1.1R Array Set, the only commercially available microarrays for whole-genome transcript mapping. According to Affy these new arrays look far beyond the known protein-coding genes to deliver the most detailed and unbiased view of the entire human and mouse genomes, enabling researchers to map transcription factors and other protein binding domains. Recent scientific publications using Affymetrix tiling arrays have uncovered broad transcriptional activity in large regions of the genome that were once considered "junk" DNA.

February 2006 Progenics Pharmaceuticals, announced that PRO 140 has been designated a fast track product by the FDA for the treatment of human immunodeficiency virus (HIV) infection. The FDA Fast Track Development Program facilitates development and expedites regulatory review of drugs intended to address an unmet medical need for serious or life-threatening conditions. PRO 140 belongs to a new class of HIV/AIDS therapeutics – viral-entry inhibitors – that are intended to protect healthy cells from viral infection. PRO 140, currently in phase 1b clinical trials in HIV-infected individuals, is a humanized monoclonal antibody directed against CCR5, a molecular portal that HIV uses to enter cells.

February 2006 Researchers from the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig have discovered that two areas in the human brain are responsible for different types of language processing requirements. They found that simple language structures are processed

in an area that is phylogenetically older, and which apes also possess. Complicated structures, by contrast, activate processes in a comparatively younger area which only exists in a more highly evolved species: humans. These results are fundamental to furthering our understanding of the human language faculty. (PNAS, February 6, 2006)

February 2006 Stem Cell Therapy International, reported the successful results of a case of stem cell transplantation performed November 2005 on a 42-year-old Irish man, who was diagnosed with progressive multiple sclerosis (MS) three years ago. Samuel Bonnar, a shop owner in Newtownabbey, Ireland, was experiencing increasing debilitation including difficulty speaking and the effects of poor circulation. He had received traditional treatment for MS at two hospitals in Ireland with little to no effect. SCTI arranged for Mr. Bonnar to be treated with injections of a stem cell biological solution. Within a few days, Mr. Bonnar's speech and mobility were vastly improved and after two weeks he had regained the ability to climb a full set of stairs without having to lift his left leg with his hand. Numbness in the fingertips of both hands subsided and occurs now only occasionally.

February 2006 NanoViricides announced that it has been informed of the initial test results of a nanoviricide compound used in its anti-influenza drug, FluCide-I(TM). The company is creating special purpose nanomaterials for anti-viral therapy. A nanoviricide(TM) is a specially designed, flexible, nanomaterial with or without an encapsulated active pharmaceutical ingredient and a targeting ligand to a specific type of virus, like a guided missile.

February 2006 Geron Corporation announced today the presentation of studies showing that cardiomyocytes differentiated from human embryonic stem cells (hESCs) survive, engraft and prevent heart failure when transplanted into an infarcted rat heart. The results provide proof-of-concept that transplanted hESC-derived cardiomyocytes show promise as a treatment for myocardial infarction and heart failure.

March 2006 Researchers at UC Irvine have found that a new compound not only relieves the cognitive symptoms of Alzheimer's disease, but also reduces the two types of brain lesions that are hallmarks of this devastating disease, thereby blocking its progression. Although drugs exist on the market today to treat the symptoms of Alzheimer's, AF267B represents the first disease-modifying compound, meaning it appears to affect the underlying cause and reduces the two signature lesions, plaques and tangles.

March 2006 Johns Hopkins scientists report the discovery of a protein 12.5 kDa cystatin, found only in cerebrospinal fluid can be used to diagnose MS, perhaps in its earliest stages, and also to monitor treatment by measuring its levels in CSF or identifying those at risk for the debilitating autoimmune disorder.

March 2006 Recombinomics issued a warning based on the identification of American sequences in the Qinghai strain of H5N1 isolated in Astrakhan, Russia. The presence of the America sequences in recent isolates in Astrakhan indicated H5N1 had already migrated to North America. They report that levels of H5N1 in indigenous species will be supplemented by new sequences migrating into North America in the upcoming months.

March 2006 CancerVax filed an Investigational New Drug (IND) application for D93, an investigatory, humanized, monoclonal antibody with a novel anti-angiogenic and tumor inhibitory mechanism of action. Preclinical studies with D93 have demonstrated its ability to reduce angiogenesis and inhibit tumor growth in in vivo models of several types of cancer.

March 2006 Researchers at Purdue University have discovered a molecular mechanism that may play a crucial role in cancer's ability to resist chemotherapy and radiation treatment and that also may be involved in Alzheimer's and heart disease. The scientists, using an innovative imaging technique invented at Purdue, have learned that a protein previously believed to be confined to the nucleus of healthy cells actually shuttles between the nucleus and cytoplasm, the region of the cell surrounding the nucleus. Moreover, the protein's shuttling is controlled by the presence of another protein in the nucleus and its attachment to that second protein. The experiments were done using a line of "teratocarcinoma" malignant tumor cells from mice called F9, which, when subjected to the right biochemical signals, have the ability to alter their properties and are considered to be "cancer stem cells." The hypothetical cancer-resistance role of cancer stem cells could explain why tumors return after treatment.

March 2006 Ina a not too unsurprising revelation, the vast differences between humans and chimpanzees are due more to changes in gene regulation than differences in individual genes themselves, researchers from Yale, the University of Chicago, and the Hall Institute in Parkville, Victoria, Australia, argued in the 9 March 2006 issue of the journal Nature. Not unsurprising since rather like Einstein's proof of the curvature of space was provided years later by the bending of light near a total eclipse, their work goes some way towards proving a 30-year-old theory, proposed in a classic paper from Mary-Claire King and Allan Wilson of Berkeley. That 1975 paper documented the 99-percent similarity of genes from humans and chimps and suggested that altered gene regulation, rather than changes in coding, might explain how so few genetic changes could produce the wide anatomic and behavioral differences between the two.

August 2006 Reporting in Nature the Haussler group at UC Santa Cruz, lead by Katie Pollard now at UC Davis, devised a ranking of regions in the human genome that show significant evolutionary acceleration. They showed that a gene termed 'human accelerated regions', HAR1, is part of a novel RNA (rather than protein) gene (HAR1F) that associates with a protein that is expressed specifically in the developing human neocortex during a crucial period for cortical neuron development. In addition the shapes of human

and chimpanzee HAR1 RNA molecules are significantly different. The team surmised that HAR1 and the other human accelerated regions provide new candidates in the search for uniquely human biology.

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