MDCAT BY FUTURE DOCTORS (TOUSEEF AHMAD)

UNIT

27

BIOLOGY AND HUMAN WELFARE

KEY CONCEPTS

27.1 Integrated Disease Management

27.2 Vaccination

27.3 Schedule of Vaccination against Common Diseases

27.4 Animal Husbandry

27.5 Latest Techniques Used For Plant Improvement

27.6 Home Gardening

27.7 Role Of Microbes In Human Welfare

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What we need to go for in the new world is not the application of physical science for the production of goods to get money-power, but the application of biological science to build better men and a better society. The first step in the new world must be the abolition of poverty, and we must concentrate on building men and women before we build new cities.

The age which is now passing away is largely the age of physical science, with its inventions and discoveries, which have given us power over the forces of Nature. It is to be hoped that when this War is over the age of physical science will be replaced by an age of biological science-the study of life in all its manifestations. Biology is contributing in many aspects of human life for instance human population is increasing continuously; approximately seven billion people are living on the planet earth.

All of our food and many daily useable home articles are derived from either plants or animals. The development of improved high yielding varieties of these organisms is only possible through the biological research. Due to the modern inventions, the consumption of energy has been increased many fold. Therefore many power generation plants have been installed and are being installed. These plants and the use of modern inventions in our daily life also drastically change our

27.1 INTEGRATED DISEASE MANAGEMENT

Effective control of a particular disastrous disease or all the common diseases of a population can be achieved by using all relevant, appropriate methods of disease control. Such an approach of disease control is known as integrated disease management Combating of disease by utilizing all methods as and when required and ensuring the participation of community in this program is very useful way of disease control. This requires an awareness of the community about the severity of the problem, its causes and its remedies. Public awareness can be ensured by using print and electronic media, by arranging seminars in school and colleges, or by person to person communication.

In integrated disease management, every available method of disease control is used like preventive measures, drug treatment, vaccination, and different kinds of therapies. Actually the real objective is to stop the further spread of disease and to prevent its new onset. This is proved very effective program for elimination and control of the dangerous disease from the human society.

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27.2 VACCINATION

Vaccination is the administration of vaccine to stimulate the immune system of an individual to develop artificially induced active immunity against an infectious disease. Vaccines can prevent the effects of infection by many pathogens.

27.2.1 Vaccine:

A vaccine may be intact but inactivated (non-infective) or an attenuated (with reduced infectivity) form of the causative pathogens (bacteria or viruses), or purified components of the pathogen that have been found to be highly immunogenic (e.g. the outer coat proteins of a virus particle). Toxoids are produced for the immunization against toxin-based diseases, such as tetanospasmin of tetanus, by destroying the toxic but preserving the immunogenic effect.

27.2.2 How does vaccine work?

When the body is exposed to the weak or dead organisms (vaccine), the body is triggered to produce antibodies. Since the injected agents are weak or dead, the body does not actually suffer the disease, but an immune response is initiated. Now the body is fully equipped to fight against the actual causative agent like virus or bacteria that attack the body later in life. The same principle works in the body in case of natural active immunity. That is the reason why some childhood diseases occur only once in the lifetime.

27.2.3 History of vaccine:

Edward Jenner was the first scientist who developed a vaccine against small pox in 1796. He conducted an experiment on 8 year old boy, James Philip. He scratched the skin of the boy and introduced into the area a liquid of cowpox obtained from the hand of milkmaid who contracted it from cows. Later when boy was exposed to small pox, he did not suffer the disease. James Philip thus immunized against small pox.

Later Louis Pasteur discovered that aging or attenuated culture of bacteria that cause fowl cholera when introduced into healthy chickens developed immunity against that disease instead of causing the disease. Pasteur next applied this principle of inoculation with attenuated cultures to the prevention of anthrax and rabies, and again it worked. The term vaccine was proposed by the Pasteur, who honored the Edward Jenner because the term is derived from the Latin **Vacca** which means cow because the first vaccine was made from cowpox liquid.

Fig:27.1 Edward Jenner (1749-1823)

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27.2.4 Types of Vaccines:

Scientists take many approaches to designing vaccines against a microbe. These choices are typically based on fundamental information about the microbe, such as how it infects cells and how the immune system responds to it, as well as practical considerations, such as regions of the world where the vaccine would be used. The following are some important types of vaccines:

- Live, attenuated vaccines
- Inactivated vaccines
- Subunit vaccines
- Toxoid vaccines

1-Live, Attenuated Vaccines:

Live, attenuated vaccines contain a version of the living microbe that has been weakened in the lab so it can't cause disease. Because a live, attenuated vaccine is the closest thing to a natural infection, these vaccines are good "teachers" of the immune system: They elicit strong cellular and antibody responses and often confer lifelong immunity with only one or two doses. Despite the advantages of live, attenuated vaccines, there are some down sides. It is the nature of living things to change, or mutate, and the organisms used in live, attenuated vaccines are no different.

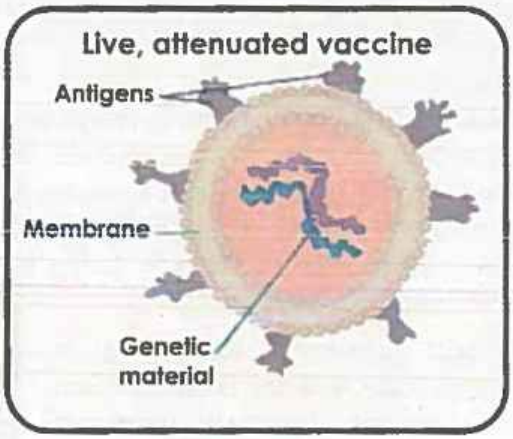

Fig: 27.2 An attenuated vaccine is a vaccine that comes from live microorganisms or viruses. These viruses are under adverse conditions that can lead to them losing virulence.

The remote possibility exists that an attenuated microbe in the vaccine could revert to a virulent form and cause disease. Examples include the viral diseases yellow fever, measles, rubella, and mumps and the bacterial disease typhoid.

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2- Inactivated or killed Vaccines:

Scientists produce inactivated vaccines by killing the disease-causing microbe with chemicals, heat, or radiation. Such vaccines are more stable and safer than live vaccines: The dead microbes can't mutate back to their disease-causing state.

Inactivated vaccines usually don't require refrigeration, and they can be easily stored and transported in a freeze-dried form, which makes them accessible to people in developing countries.

Most inactivated vaccines, however, stimulate a weaker immune system response than do live vaccines. So it would likely take several additional doses, or booster shots, to maintain a person's immunity.

Examples are the influenza vaccine, cholera vaccine, bubonic plague vaccine, polio vaccine, hepatitis A vaccine, and rabies vaccine.

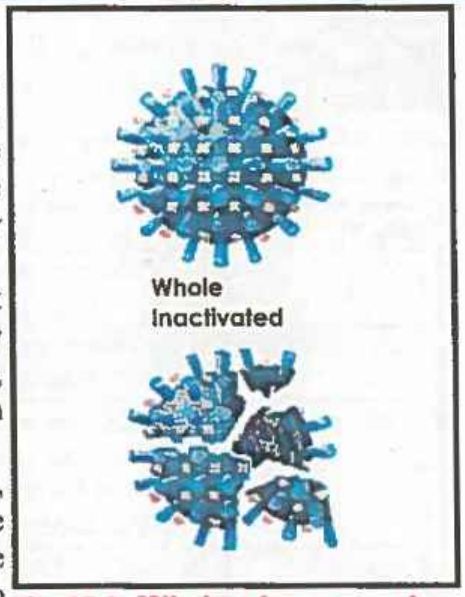

Fig:27.3 Whole virus may be inactivated by heat or chemicals, subunit vaccines may be generated by breaking open viruses or expressing specific proteins.

3- Subunit Vaccines:

Instead of the entire microbe, subunit vaccines include only the antigens that best stimulate the immune system. In some cases, these vaccines use epitopes—the very specific parts of the antigen that antibodies or T cells recognize and bind to. Because subunit vaccines contain only the essential antigens and not all the other molecules that make up the microbe, the chances of adverse reactions to the vaccine are lower. Examples include the subunit vaccine against Hepatitis B virus that is composed of only the surface proteins of the virus.

4- Toxoid Vaccines:

For bacteria that secrete toxins, or harmful chemicals, a toxoid vaccine might be the answer. These vaccines are used when a bacterial toxin is the main cause of illness.

Scientists have found that they can inactivate toxins by treating them with formalin, a solution of formaldehyde and sterilized water. Such "detoxified" toxins, called toxoids, and are safe for use in vaccines. Vaccines against diphtheria and tetanus are examples of toxoid vaccines.

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27.3 SCHEDULE OF VACCINATION AGAINST COMMON DISEASES

In the following table 27.1 a general schedule of vaccination against some common diseases is given.

Table 27.1 General schedule of vaccination

Disease	Vaccine	Type	Age group
Polio	OPV (Oral Polio Vaccine)	Live vaccine	From birth to 5 years of age
Tuberculosis	BCG (Bacillus Calmette Guerin)	Live vaccine	At birth
Typhoid	Typhoid vaccine TAB vaccine (Typhoid Paratyphoid A & Paratyphoid B)	Killed vaccine	At 2 years of age
Hepatitis	Hepatitis-B Vaccine	Subunit vaccine	At any age
Diphtheria + Tetanus	Diphtheria toxoid vaccine Tetanus toxoid vaccine	Toxoid vaccine	Generally in childhood

27.4 ANIMAL HUSBANDRY

Ever since the beginning of civilization, humans have depended on animals for many requirements, such as that of food (milk, meat and egg), clothing (hide or wool), labour (pulling, carrying load) and security etc. The development of desirable qualities in all such animal species, through creating better breeds, has been an important human achievement. For this, humans have consistently tried to improve the breeds of domesticated animals to make them more useful for them.

The branch of science, which deals with the study of various breeds of domesticated animals and their management for obtaining better products and services from them, is known as **Animal Husbandry.** The term husbandry derives from the word "husband" which means 'one who takes care'. When it incorporates the study of proper utilization of economically important domestic animals, it is called **Livestock Management.**

Being a country that has a largely agriculture-based industrial system, animal husbandry plays an important role in the rural economy of Pakistan and is a major source of livelihood for many farmers. It is estimated that there are between 30 to 35 million people in Pakistan's current labor force who are engaged in livestock.

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27.4.1 Different Categories of Animals (livestock):

- Wild –Those that breed better where they are free than they do when they are captivated. They have no common use for humans. Examples are Lion, Tiger, Rhinoceros, Deer etc.
- Tamed – Those, which are caught from the wild and trained to be useful to humans in some way. Elephant, Chimpanzee, Gorilla, Yak etc.
- Domesticated – Those that are of use at home and are easily bred and looked after by humans. Common domesticated animals are dog, horse, cow, sheep, buffalo, fowl etc.

For Your Information

Comparison of average milk yields across countries shows that one New Zealand dairy animal produces as much milk as three dairy animals in Pakistan; while one American cow produces as much as seven Pakistani cows.

27.4.2 Importance of domestic animals:

On the basis of utility, domestic animals are categorized into the following functional groups:

- Milk yielding animals (Cattle, buffalo, goat, sheep, and etc.).
- Draught animals (used for load Bullock, horse, donkey, mule, bearing camel, elephant, yak etc.)
- Fibre, hide and skin yielding Sheep, goat, cattle, buffalo, camel etc.
- Meat and egg yielding animals Fowl (hen) and duck, goat, buffalo, etc.

Fig: 27.4 Cattle play an important role in the rural economy.

27.4.3 Types of animal husbandry

There are several forms of animal husbandry out of them some important forms are given below.

Milk and meat yielding animals:

Depending upon the availability and regional considerations different animals are reared for the purposes of yielding milk and meat. Cattles are considered to have been one of the first animals domesticated by man for agricultural purposes.

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Cattle mainly include cow, bull, oxen, goat, sheep etc. The females of the species provide milk, which in turn contribute animal protein to the diet of people. While the female species of these cattle are used for milk, the male species play an important role in the agricultural economy by providing labour, meat and hide. Milk itself is taken in many forms like ghee, curd, butter and cheese etc. The excreta of these animals used as manure, in biogas and as fuel.

For Your Information

This breed is from Holland. This is by far the best diary breed among exotic cattle regarding milk yield. On an average it gives 25 litres of milk per day, whereas a cross breed H.F. cow gives 10 - 15 lts per day.

Holstein Friesian
(Milk yield - 7200-9000 kgs)

Dairy products:

Milk as drawn from the animals is known as full cream milk. When the cream is separated and the remaining milk is called toned milk. This milk contains no fat and is known as skimmed milk. On the basis of fat contents the various milk product are as follows:

- **Cream:** It is prepared by churning milk; the fat comes on the top which is separated by draining out the liquid. It is known as cream with 10-70% fat contents.
- **Curd:** Milk is converted to curd due to bacterial activities.
- **Butter Milk:** It is the left over liquid after removal of butter.
- **Ghee:** After heating butter, the water evaporates and fat contents are almost 100%.
- **Condensed milk:** Milk is concentrated by removing water contents with or without adding sugar. It has 31% milk solids with 9% fats.
- **Powdered milk:** It is the powdered form of milk.
- **Cheese:** It is coagulated milk protein-casein with fat and water.
- **Khoya:** A desiccated milk product prepared by evaporating water contents and reducing the bulk to about 70-75%.

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For Your Information

Most common breed of buffalo is Nili Ravi which constitutes 76.7% of the total buffalo population in Pakistan. Local Cattles include Sahiwal, Cholistani, Dajal, Dhani, and Rojhan. Sahiwal are a high yielding breed but the pure blood is diminishing due to cross breeding. An example of crossbred dairy animals with varying degrees of a highly productive dairy product is Australian Holstein Friesian with local Sahiwal and Cholistani.

- **Cattle Dung:** Cattle dung is mainly used to make dung cakes for burning as fuels. It is used mainly in villages. The farmers also use cattle dung to produce bio gas and the leftover residue as manure. Biogas plant (Gobar gas plant) Bio gas plant is a chamber where animal excreta (Cow dung, buffalo dung etc.) and some anaerobic bacteria are fed into airtight biogas chamber. Decomposition of excreta produces methane gas used as a smoke free gas for cooking. This gas can also be utilized for lighting. The left over solid residue serves as good manure.

Draught animals

Draught animals are animals need for carrying load. From ancient time a number of animal species have been used for special purposes by humans, utilizing their mechanical strength, endurance and speed. These include horse for riding and swift running; elephant for riding, strength and heavy load lifting, camel for riding in sandy desert and ability to survive without water for long duration, donkey and mule (a hybrid of male donkey and female horse) for carrying load.Most of the draught animals are herbivorous and survive on leaves of trees, shrubs and bushes. While raising them, they are also fed on grains, beans, cottonseeds, maize and bran besides dry/ green fodder.

Fig: 27.5 Cattle play an important role in the rural economy.

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Fiber, hide and skin yielding animals:

Besides providing meat, milk and transport, livestock provide many commercially useful products such as fibre, skin and hide. Generally sheep and goat provide fibres for making of products like woolen strings, ropes, carpets, clothing and brushes etc.

Egg yielding animals:

This category consists of egg producing animals whose eggs are used as food by mankind to provide proteins. Poultry farming is defined as a term for rearing and keeping of birds such as fowl, duck and hen for egg and meat. Poultry farming has become popular because it is comparatively easy to start and maintain. It gives quick return within one to six month of investments, is easily manageable and requires less space and labour. Poultry birds and their eggs are a rich source of nutrients.

Fig: 27.6 Poultry farming is considered to be one of the profitable business.

27.4.4 Genetic improvement in animals:

The application of laws of animal health and reproduction genetics has contributed towards increase in milk, egg and meat productivity. The increase in egg production brought about the silver revolution in the area of animal husbandry. The methods being widely used are artificial insemination and embryo transplant.

Artificial insemination:

Artificial insemination involves collection of semen from a healthy bull of the desired breed, its storage at low temperatures and introduction into the females of cattle of other breeds for bringing about fertilization using sterilized (germ free) equipment. Advantages of this method are:

(a) Up to 3000 females can be fertilized from semen collected from one bull.
(b) The semen can be stored for a long period and transported over long distances.
(c) It is economical and has high success rates of fertilization.

Embryo transplant:

This method of breed improvement has been quite successful in sheep and goat. In this method, embryos (depending on their period of development) from superior breeds are removed during the early stages of pregnancy and are transferred to the other female with inferior characters, in whose body the gestation period is completed.

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By this technique, quality and productivity in the livestock can be improved. Unlike artificial insemination, this method has low success rate due to greater chances of contamination.

27.5 LATEST TECHNIQUES USED FOR PLANTS

From ancient times plant breeders have been struggling for the improvement of crop plants. Traits that breeders have tried to incorporate into crop plants by using various techniques in the last 100 years include:

- Increased quality and yield of the crop
- ncreased tolerance of environmental pressures (salinity, extreme temperature, drought)
- Resistance to viruses, fungi and bacteria
- Increased tolerance to insect pests
- Increased tolerance of herbicides

Classical breeding relies largely on homologous recombination between chromosomes to generate genetic diversity.

Fig: 27.7Hercules, a "Liger", a Lion/Tiger hybrid.

The classical plant breeder may also makes use of a number of in vitro techniques such as protoplast fusion, embryo rescue or mutagenesis to generate diversity and produce hybrid plants that would not exist in nature. In addition many new techniques are also being employed by the breeders for the improvement of crop plants.These techniques may include acclimatization, selective breeding, hybridization and backcrossing. Plant improvement by genetic engineering is also becoming popular day by day.

27.5.1 Acclimatization:

Acclimatization or acclimation is the process of an individual organism adjusting to a gradual change in its environment, (such as a change in temperature, humidity, photoperiod, or pH) allowing it to maintain performance across a range of environmental conditions. Acclimatization occurs in a short period of time (days to weeks), and within the organism's lifetime (compare to adaptation). and acclimatization are different terms in the sense that acclimation is used under laboratory conditions, while acclimatization is "in the field" or in nature. In order to maintain performance across a range of environmental conditions, there are several strategies organisms use to acclimate.

In response to changes in temperature, organisms can change the biochemistry of cell membranes making them more fluid in cold temperatures and

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less fluid in warm temperatures by increasing the number of membrane proteins. Organisms may also express specific proteins called **heat shock proteins** that may act as molecular chaperons (protein that assists non-covalent folding) and help the cell maintain function under periods of extreme stress. It has been shown, that organisms which are acclimated to high or low temperatures display relatively high resting levels of heat shock proteins so that when they are exposed to even more extreme temperatures the proteins are readily available.

Expression of heat shock proteins and regulation of membrane fluidity are just two of many biochemical methods organisms use to acclimate to novel environments

Many plants, such as maple trees, irises, and tomatoes, can survive freezing temperatures if the temperature gradually drops lower and lower each night over a period of days or weeks. The same drop might kill them if it occurred suddenly. Studies have shown that tomato plants that were acclimated to higher temperature over several days were more efficient at photosynthesis at relatively high temperatures than were plants that were not allowed to acclimate.

Fig: 27. 8 Acclimation is in process. In this case, shoots are removed from the sterile environment and placed in soil in a high humidity environment.

27.5.2 Selective breeding:

Selective breeding is the art and science of changing the genetics of plants in order to produce desired characteristics. Plant breeding can be accomplished through many different techniques ranging from simply selecting plants with desirable characteristics for propagation, to more complex molecular techniques.Sometimes many different genes can influence a desirable trait in plant breeding. The use of tools such as molecular markers or DNA fingerprinting can map thousands of genes. This allows plant breeders to screen large populations of plants for those that possess the trait of interest. The screening is based on the presence or absence of a certain gene as determined by laboratory procedures, rather than on the visual identification of the expressed trait in the plant.

International development agencies believe that breeding new crops is important for ensuring food security by developing new varieties that are higher-

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yielding, resistant to pests and diseases, drought-resistant or regionally adapted to different environments and growing conditions.

27.5.3 Hybridization and backcrossing:

Classical plant breeding uses deliberate interbreeding (crossing) of closely or distantly related individuals to produce new crop varieties or lines with desirable properties. This process is known as hybridization. Plants are crossbred to introduce traits/genes from one variety or line into a new genetic background. For example, a mildew-resistant pea may be crossed with a high-yielding but susceptible pea, the goal of the cross being to introduce mildew resistance without losing the high-yield characteristics.

Progeny from the cross would then be crossed with the high-yielding parent to ensure that the progeny were most like the high-yielding parent. This type of hybridization is called backcrossing. The progeny from that cross would then be tested for yield and mildew resistance and high-yielding resistant plants would be further developed. Plants may also be crossed with themselves to produce inbred varieties for breeding.

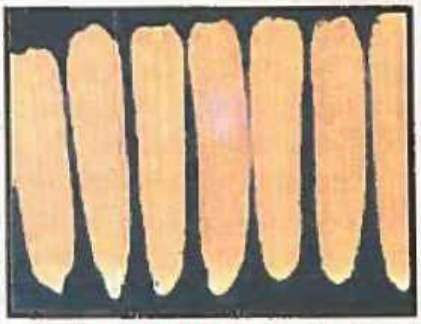

Fig: 27.9 Hybrid maize

27.5.4 Role of Genetic engineering in crop improvement:

Since last two decades, genetic engineering has been imparting a very significant role in crop improvement. Desired traits/genes can be inserted in the plant genome by genetic recombination using the bacteria Agrobacterium tumefaciens or A. rhizogenes, or by direct methods like the gene gun or microinjection.

The majority of commercially released transgenic plants are currently limited to plants that have introduced resistance to insect pests and herbicides. Insect resistance is achieved through incorporation of a gene from *Bacillus thuringiensis* (Bt) that encodes a protein that is toxic to some insects. For example, the cotton bollworm, a common cotton pest, feeds on Bt cotton it will ingest the toxin and die. Herbicides usually work by binding to certain plant enzymes and inhibiting their action.

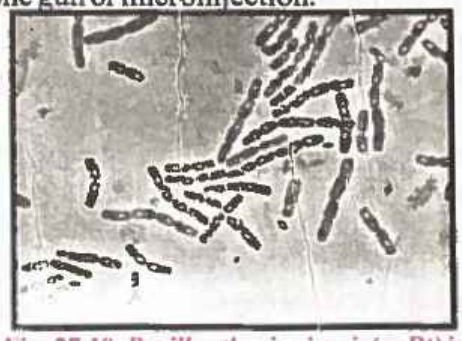

Fig: 27.10 *Bacillus thuringiensis* (or Bt) is a soil-dwelling bacterium, commonly used as a biological alternative to a pesticide; alternatively, the Cry toxin may be extracted and used as a pesticide.

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The enzymes that the herbicide inhibits are known as the herbicides target site. Herbicide resistance can be engineered into crops by expressing a version of target site protein that is not inhibited by the herbicide. This is the method used to produce glyphosate resistant crop plants.

27.6 HOME GARDENING

Home gardening is a popular hobby for a number of reasons. Some people garden for exercise and some for the enjoyment of harvesting flavorful produce that can be eaten fresh from the garden or preserved for use during winter. Others garden so they can grow a wider variety of vegetables and herbs than are available at their local grocery store.

In recent years many people are growing vegetables to save money on their grocery bill. Flower gardens are planted as a hobby and their aesthetic beauty. A garden can be a wonderful place for children. They provide opportunities for play, learning, and for having fun.

Regardless of motive, gardening can be as simple or as complex a project as you make it. As the interest in all aspects of gardening has increased, so has the need for more information and education. Careful planning can make gardening easier, more productive, and more enjoyable. In planning your garden, it is important to consider a few basics.

Fig: 27.11 Home gardening provide opportunities for play, learning, and fun.

Many ornamental plants spice the home gardens with their colorful flowers and foliage. Beds of color provide brilliant accents against backgrounds of permanent plantings, soften man-made lines, and provide graceful transitions from one outdoor area to another. Flowers can be used to catch the eye, accent a view, frame a door, or just draw attention to their own blooms.

There are many good reasons for growing a vegetable in home gardens. A garden offers the opportunity to enjoy vegetables at their freshest. Sometimes only minutes elapse between harvest, preparation, and eating.

On the other hand, most fresh vegetables available at the grocery store travel about 1,800 miles between producer and consumer, and this travel often occurs over a period of several days.

27.6.1 Some Seasonal fruits and vegetables:

In order to eat fresh fruits and vegetables, it's good to know when and what is available fresh.

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Here is a seasonality chart that will help you in choice for home gardening. This chart could be slightly different in different parts of the country.

Winter January, February	Spring March, April, May	Summer June, July, August	Fall Sep, Oct, Nov
Cabbage	Asparagus	Corn	Apples
Cauliflower	Basil	Cucumbers	Cabbage
Celery Root	Beans	Dates	Cauliflower
Grapefruit	Berries	Figs	Cranberries
Mandarin	Broccoli	Grapes	Cucumbers
Oranges	Cabbage	Mangoes	Dates
Sweet Oranges	Cucumbers	Okra	Fennel
Pears	Radish	Peaches	Grapes
Spinach	Mangoes	Chile Peppers	Pears
Sweet Potatoes	Okra	Sweet Peppers	Chile Peppers
	Sweet Oranges	Plums	Sweet Peppers
	Papayas	Tomatoes	Spinach
	Peas	Watermelon	Sweet Potatoes
	Chile Peppers		
	Sweet Peppers		
	Spinach		
	Turnips		

27.7 ROLE OF MICROBES IN HUMAN WELFARE

Microorganisms or microbes are generic terms for the group of living organisms which are microscopic in size, and include bacteria, viruses, algae, fungi, and protozoa. Microorganisms have a great impact on many areas of biology and general human welfares. Some are beneficial to man while others are harmful. The beneficial functions include production of bread, cheese, antibiotics, vaccines, vitamins, enzymes and many other products. Microorganisms occupy an important position in the ecosystem. They are required for the various cycles of nature, such as carbon, nitrogen, oxygen, and Sulphur that take place in the ecosystem.

27.7.1 Role of Microbe in food processing:

There are many useful applications of microorganisms in the food processing industry. They influence the quality, availability and quantity of food. Microorganisms are used to change one substance to another which is used as food such as milk to yoghurt and cheese, sugar to wine and bread.

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Yoghurt making:

Yoghurt is a dairy product which is produced by bacterial fermentation of milk. Most commonly cow's milk is used, though it can be made from any kind of milk. The milk sugar, i.e. lactose is fermented into lactic acid by the friendly bacteria, *Streptococcus salivarius*, *S. thermophiles* and *Lactobacillus bulgaricus*. These bacteria are collectively known as lactic acid bacteria or LAB. The bacteria feed on the lactose and release lactic acid as a bye product. The acid causes the curdling of the milk protein, casein into solid mass called curd. The gel like texture and taste of yoghurt is due to the fermentation of lactose to lactic acid. The increased acidity (pH=4-5) also prevents the proliferation of other potentially pathogenic bacteria.

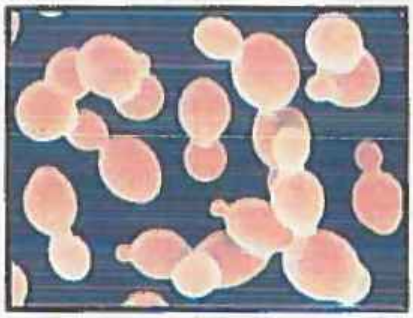

Fig: 27.12 *Saccharomyces cervisiae*

Cheese making:

Cheese is a generic term for a diverse group of milk-based food products. Cheese is solid food produced by milk of various animals throughout the world in wide-ranging flavors, textures, and forms.

As described above that fermentation of milk leads to lactic acid production which sour the milk. This leads to the coagulation of milk protein, casein. The solid part of the milk produced by coagulation is known as **curd** and the liquid is known as **whey**.

For Your Information

Coagulation can be controlled using rennet tablets, which contains the enzyme renin. Renin is an enzyme present in the stomach of calves and in human infant but now is also available through genetically engineered bacteria. In addition, coagulation can also be done by using acids such as vinegar or lemon juice.

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The curds can be separated and pressed into desired shape and whey is used as food source for yeast, which in turn can be processed as cattle feed and is rich in protein and vitamins. The cheese can be matured or ripened by the addition of bacteria or fungi or both. The bacteria added reduce the pH, alters the texture and develop a flavour.

27.7.2 Role of Microbes in Alcohol industry:

Alcohol is most common solvent used in laboratories, chemical industry, and as a fuel. It is produced during anaerobic respiration of yeast, i.e. *Saccharomyces cervisiae*, which converts sugar to ethanol and carbon dioxide. This is known as alcoholic fermentation.

Depending on the type of sugar, different type of alcohol can be made.

- Beer is prepared from the fermentation of maltose by yeast.
- Wine is made from the fermentation of grape sugar by yeast.

Beer is brewed from barley grain, which is partially germinated to convert the starch to maltose. This process of conversion is known as **malting**. Gibberellins and amylase are used to speed up the process of germination and to increase the amount of sugar to produce more alcohol. The sugar is extracted by crushing the grain and adding hot water. The liquid obtained after this procedure is known as **wort.** Next the wort is fermented by the yeast to produce alcohol.

27.7.3 Role of Microbes in Pharmaceutical industry:

Insulin is a pharmaceutically important compound produced commercially by transgenic *E. coli*. In earlier times, insulin was isolated from pancreas of dead animals (cadavers). Today, human insulin gene is introduced into *E. coli* by recombinant DNA technology.

Many compounds of pharmaceutical importance are being derived from various kinds of microorganisms. Some of these compounds include insulin, penicillin, monoclonal antibodies, cyclosporine and etc.These bacteria are grown in bioreactors (large tanks containing bacterial media). The insulin can be extracted, purified and is ready to use. The two main advantages of the insulin produced by the recombinant DNA technology are as follows:

- It is chemically identical to the human insulin.
- It can be made available in unlimited quantities.

Fig: 27.13 *E. coli*

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Penicillin is a group of antibiotics derived from Penicillium fungi. Penicillin is a secondary metabolite of fungus *Penicillium* that is produced when growth of the fungus is inhibited by stress. It is not produced during active growth.

Cyclosporin is an immunosuppressive agents used in organ transplant patients. It is produced by a fungus, Trichoderma polysporum.

The lovastatin produced by the yeast *Monascus purpureus*, is a blood cholesterol lowering agents, it acts as a competitive inhibitor for the enzyme which is responsible for the synthesis of cholesterol, thereby stopping its synthesis.

27.7.4 Role of Microbes in Waste Treatment:

Sewage treatment or domestic wastewater treatment is the process of removing contaminants from waste water and household sewage, both runoff (effluents) and domestic.

Fig: 27.14 A sewage treatment plant.

It includes physical, chemical, and biological processes to remove physical, chemical and biological contaminants. Its objective is to produce an environmentally-safe fluid waste stream (or treated effluent) and a solid waste (or treated sludge) suitable for disposal or reuse (usually as farm fertilizer). A sewage treatment plant is nothing more than a

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giant microbial culture breading facility where microbes are engaged to work for our benefit.

27.7.5 Role of Microbes in Energy generation:

The widespread use of fossil fuels has brought numerous benefits to industrialized societies. Large amounts of agricultural, domestic and industrial wastes (mainly consists of biomass) generated in these countries as a result of development, have potentially detrimental effects both on the environment and on human health. Biotechnology is one of the future-oriented technologies, and one that will play a major role in the exploitation of biomass energy. All biomass (plant, animal and microbial), originates through CO2 fixation by photosynthesis. Biomass utilization is consequently included in the global carbon cycle of the biosphere.

For Your Information

Approximately 114 kilocalories of free energy are stored in plant biomass for every mole of CO_2 fixed during photosynthesis. Solar radiation striking the earth on an annual basis is equivalent to 178,000 terawatts, i.e. 15,000 times that of current global energy consumption. Although photosynthetic energy capture is estimated to be ten times that of global annual energy consumption, only a small part of this solar radiation is used for photosynthesis.

Biomass energy in developing countries, originates from fuel wood, animal wastes, and agricultural residues. This biomass can be used to generate energy with the help of microbial activity. Some important examples are given below.

Biogas

Biogas is 50-75% methane and the remainder is carbon dioxide with traces of nitrogen and other gases. Different groups of microorganisms are used in the process of fermentation of various organic substrates to produce biogas. Methanogens are the bacteria used for the production of methane from carbon and hydrogen.

Fig: 27.15 Biogas plant in one of the village of Pakistan

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Methanobacterium is an example of methanogen. Methanogens symbiotically live in the in the gut of cattle from where they are passed to sewage through their wastes.

Biogas production from activated sludge:

The solid waste that is taken out from the settling tanks at various stages in sewage treatment plants is known as activated sludge. It is alive with microbiological activity. Methane gas is given off, and this can be detected by your nose in the vicinity of sewage treatment plants. Methane produced in this way is referred as biogas.

The sludge is removed to large concrete vats that can be sealed. Excess effluent water is drained from the bottom of the vat. Anaerobic microbes (Methanobacteria) within the sewage are now allowed to work, breaking down all the organic matter. A sealed vat, though, will build up pressure and burst, from the methane given off by the microbes, so the gas is vented from the vat and in countries where energy is at a premium, is often used to power machinery in the sewage plant.

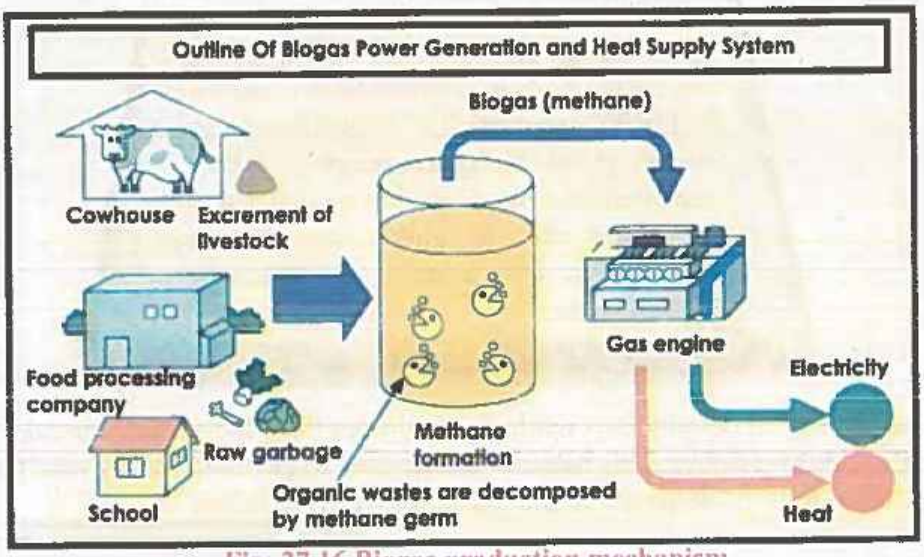

Fig: 27.16 Biogas production mechanism.

Up to 50% of the sludge can be digested in the vats, but once the process starts to wane the vats are emptied and the waste material can be spread out on the ground to dry in shallow concrete pits. Once this has happened the material can be collected, bagged, and sold as land fertilizer. It is safe to handle and extremely effective in the fields, provided it is free from industrial pollutants.

Biogas production from cattle's dung (gobar):

Methanobacteria found in the rumen of cattle help in the breakdown of cellulose which is present on the fodder of cattle.

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For Your Information

Janelle Curtis of Biodesign Institute at Arizona State University has discovered certain Bacteria that have evolved to utilize almost any chemical as a food source. In the microbial fuel cell, bacteria form a biofilm, a living community that is attached to the electrode by a sticky sugar and protein coated biofilm matrix. When grown without oxygen, the byproducts of bacterial metabolism of waste include carbon dioxide, electrons and hydrogen ions. Electrons produced by the bacteria are shuttled onto the electrode by the biofilm matrix, creating a thriving ecosystem called the biofilm anode and generating electricity

Cattle's dung known as gobar is rich in these bacteria therefore dung is used for the production of biogas. This gas is also known as gobar gas. The biogas plant is a tank which is 10-15 ft. deep. The biowastes and dung are added into the tank. The gas produced is collected and sent out through an outlet while the slurry left in the tank can be used as fertilizer.

Other than animal manure and sewage sludge, food and domestic wastes, crop remains, paper wastes are also used as substrate for fermentation. Crops like maize, sugarcane, sugar beet and water plants like water hyacinth may also be used.

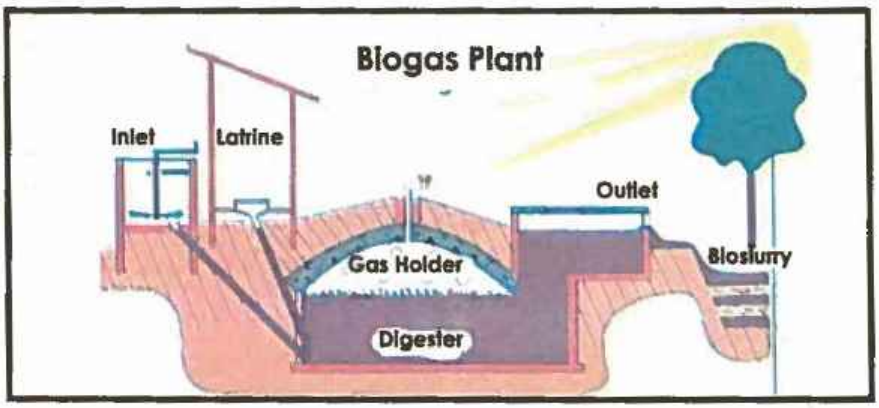

Fig: 27.17 Biogas Production plant.

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Uses of Biogas:

Methane can be used as a fuel both in internal combustion engines (i.e as in car) and in gas turbines (as in an airliner). These engines can power pumps and sluices, generate electricity and even deliver the excess power into the electricity grid system. Thus your local sewage plant can be eco-friendly, by adding no net increase in greenhouse gasses or other pollutants to the environment. It also allows a certainty of power supply to the treatment plant, for it is not at the mercy of electricity grid or public gas supply.

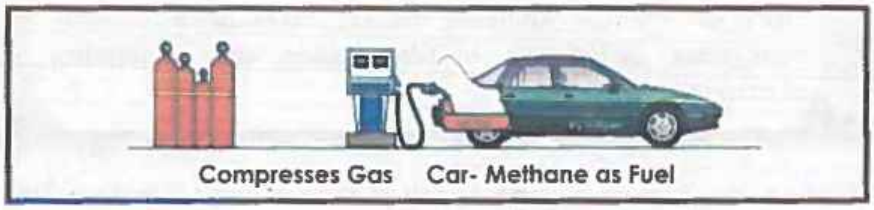

Fig: 27.18 Methane used as fuel.

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KEY POINTS

- In integrated disease management, every available method of disease control is used like preventive measures, drug treatment, vaccination, and different kinds of therapies.
- Vaccination is the administration of vaccine to stimulate the immune system of an individual to develop artificially induced active immunity against an infectious disease.
- Some important types of vaccines are live, attenuated vaccines, inactivated vaccines, subunit vaccines and toxoid vaccines.
- The branch of science, which deals with the study of various breeds of domesticated animals and their management for obtaining better products and services from them, is known as **Animal Husbandry.**
- Artificial insemination involves collection of semen from a healthy bull of the desired breed, its storage at low temperatures and introduction into the females of cattle of other breeds for bringing about fertilization using sterilized (germ free) equipment.
- Selective breeding is the art and science of changing the genetics of plants in order to produce desired characteristics.
- Classical plant breeding uses deliberate interbreeding (crossing) of closely or distantly related individuals to produce new crop varieties or lines with desirable properties. This process is known as hybridization.
- Microorganisms are used to change one substance to another which is used as food such as milk to yoghurt and cheese, sugar to wine and bread.
- Insulin is a pharmaceutically important compound produced commercially by transgenic *E. coli.* In earlier times, insulin was isolated from pancreas of dead animals (cadavers). Today, human insulin gene is introduced into *E. coli* by recombinant DNA technology.
- Sewage treatment or domestic wastewater treatment is the process of removing contaminants from waste water and household sewage, both runoff (effluents) and domestic. It includes physical, chemical, and biological processes to remove physical, chemical and biological contaminants.
- Biogas is 50-75% methane and the remainder is carbon dioxide with traces of nitrogen and other gases.

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EXERCISE ?

1. Multiple choice questions

i. Which of the following is not included in integrated disease management?
(a) awareness through media (b) vaccination and medication
(c) both a & b (d) none of them

ii. BCG vaccine is a type of:
(a) live attenuated vaccine (b) killed vaccine
(c) subunit vaccine (d) conjugated vaccine

iii. Study of proper utilization of economically important domestic animals, it is called:
(a) Animal Husbandry (b) Wild life Management
(c) Livestock Management (d) none of them

iv. **Holstein Friesian was imported from** Holland. This is by far the best diary breed among exotic cattle regarding milk yield. On an average it gives:
(a) 10 liter of milk per day (b) 15 liter of milk per day
(c) 20 liter of milk per day (d) 25 liter of milk per day.

2. Short Questions

i. Differentiate between animal husbandry and livestock management.
ii. What is the importance of artificial insemination?
iii. What is biogas?
iv. Write a note on the process of cheese making.
v. What is acclimatization? Explain briefly with the help of an example.
vi. List the traits that breeders have tried to incorporate into crop plants by using various techniques?
vii. Give the importance of domestic animals?
viii. What are conjugate vaccines, give an example.
ix. How did Edward Jenner prepare the first vaccine?

3. Long Questions

i. What is vaccine? Describe its mode of action and various types.
ii. What are dairy animals? Also describe various kinds of dairy products?
iii. Describe any two methods of crop improvement.
iv. Explain the methods for the production of biogas.

4. Analyzing and interpreting

- Correlate the role of biotechnology and genetic engineering in crop improvement.

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EXERCISE ?

5. **Science, Technology & Society Connections**
   - Justify the importance of vaccination campaigns observed worldwide to curb the diseases.
   - List the objectives of the institutions of the federal health department and UNO working for integrated disease management.
   - Assess the impact of livestock in boosting up of national economy.

6. **Online learning**
   - www.sciencedaily.com
   - www.fas.org
   - www.nespak.com
   - www.environment.gov.pk
   - www.czs.org

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GLOSSARY

A

Adrenocorticotropic Hormone (ACTH): A hormone produced by the anterior pituitarythat stimulates the adrenal cortex to release several hormones including cortisol.

Aldosterone: A hormone secreted by the adrenal glands that controls the reabsorption of sodium in the renal tubule of the nephron.

Alleles: Alternate forms of a gene.

Alveoli: Tiny, thin-walled, inflatable sacs in the lungs where oxygen and carbon dioxide are exchanged.

Aneuploidy: Variation in chromosome number involving one or a small number of chromosomes; commonly involves the gain or loss of a single chromosome.

Anticodon: A sequence of three nucleotides on the transfer RNA molecule that recognizes and pairs with a specific codon on a messenger RNA molecule; helps control the sequence of amino acids in a growing polypeptide chain.

Assortment: A way in which meiosis produces new combinations of genetic information. Paternal and maternal chromosomes line up randomly during synapsis, so each daughter cell is likely to receive an assortment of maternal and paternal chromosomes rather than a complete set from either.

Autosomes: The chromosomes other than the sex chromosomes. Each member of an autosome pair (in diploid organisms) is of similar length and in the genes it carries.

B

Barriers to gene flow: Factors, such as geographic, mechanical, and behavioral isolating mechanisms that restrict gene flow between populations, leading to populations with differing allele frequencies.

Biochemical cycle: The flow of an element through.the living tissue and physical environment of an ; e. g., the carbon, hydrogen, oxygen, nitrogen, sulfur, and phosphorus cycles.

Biomass: The total weight of living tissue in a community.

Biome: A large-scale grouping that includes many communities of a similar nature.

Blastocoels: The fluid-filled cavity at the center of a blastula.

Blastocyst: The developmental stage of the fertilized ovum by the time it is ready to implant; formed from the morula and consists of an inner cell mass, an internal cavity, and an outer layer of cells (the trophoblast).

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Blastula: A ball of cells surrounding a fluid-filled cavity (the blastocoel) that is produced by the repeated cleavage of a zygote.

Bronchitis: A respiratory disorder characterized by excess mucus production and swelling of the bronchioles; caused by long-term exposure to irritants such as cigarette smoke and air pollutants.

C

Calcitonin: A hormone produced by the thyroid that plays a role in regulating calcium levels.

Carnivores: Term applied to a heterotroph, usually an animal, that eats other animals. Carnivores function as secondary, tertiary, or top consumers in food chains and food webs.

Catastrophism: Once-popular belief that events in earth history had occurred in the past a sudden events and by processes unlike those operating today. Periods of catastrophic change were followed by long periods of little change. A subgroup, the Diluvialists, contended that Noah's Flood was the last of many floods which had occurred throughout earth history.

Chemotrophs: Organisms (usually bacteria) that derive energy from inorganic reactions; also known as chemosynthetic.

Chromosomes: Structures in the nucleus of a eukaryotic cell that consist of DNA molecules that contain the genes.

Chromosome theory of inheritance: Holds that chromosomes are the cellular components that physically contain genes; proposed in 1903 by Walter Sutton and Theodore Boveri.

Clavicle: The collar bone.

Cleavage furrow: A constriction of the cell membrane at the equator of the cell that marks the beginning of cytokinesis in animal cells. The cell divides as the furrow deepens.

Climax community: The stage in community succession where the community has become relatively stable through successful adjustment to its environment.

Clone: An exact copy of a DNA segment; produced by recombinant DNA technology.

Closed community: A community in which populations have similar range boundaries and density peaks; forms a discrete unit with sharp boundaries.

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Codominance: A type of inheritance in which heterozygotes fully express both alleles.

Codon: A sequence of three nucleotides in messenger RNA that codes for a single amino acid.

Community age: One of the factors that helps cause the latitudinal diversity gradient. Tropical communities have had more time to evolve because they have been less disrupted by advancing ice sheets and other relatively recent climatic changes.

Consumers: The higher levels in a food pyramid; consist of primary consumers, which feed on the producers, and secondary consumers, which feed on the primary consumers.

Continuous variation: Occurs when the phenotypes of traits controlled by a single gene cannot be sorted into two distinct phenotypic classes, but rather fall into a series of overlapping classes.

Convergent evolution: The development of similar structures in distantly related organisms as a result of adapting to similar environments and/or strategies of life. Example: wings of birds and insects, the body shape of dolphins, sharks, and the extinct marine reptiles known as ichthyosaurs.

D

Deletion: The loss of a chromosome segment without altering the number of chromosomes.

Dendrites: Short, highly branched fibers that carry signals toward the cell body of a neuron.

Deoxyribose: Five-carbon sugar found in nucleotides of DNA.

Dibetes mellitus, Types I and II: A disorder associated with defects in insulin action. Type I diabetes is characterized by inadequate insulin secretion; Type II diabetes is characterized by impaired insulin secretion in response to elevated blood glucose levels or by loss of sensitivity to insulin by target cells.

Diencephalon: Part of the forebrain; consists of the thalamus and hypothalamus.

Divergent evolution: The divergence of a single interbreeding population or species into two or more descendant species.

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DNA hybridization: The formation of hybrid DNA molecules that contain a strand of DNA from two different species. The number of complementary sequences in common in the two strands is an indication of the degree of relatedness of the species.

DNA ligase: In recombinant DNA technology, an enzyme that seals together two DNA fragments from different sources to form a recombinant DNA molecule.

DNA polymerase: In DNA replication, the enzyme that links the complementary nucleotides together to form the newly synthesized strand.

Dominance: The property of one of a pair of alleles that suppresses the expression of the other member of the pair in heterozygotes.

Dominance hierarchy: A social structure among a group of animals in which one is dominant and the others have subordinate nonbreeding positions.

E

Ecological niche: The role an organism occupies and the function it performs in an ecosystem; closely associated with feeding.

Ecological time: A timescale that focuses on community events that occur on the order of tens to hundreds of years.

Emphysema: Lung disease characterized by shortness of breath, often associated with smoking.

Endometrium: The inner lining of the uterus.

Endothermy: The internal control of body temperature; the ability to generate and maintain internal body heat.

Epinephrine: A hormone produced by the adrenal medulla and secreted under stress; contributes to the "fight or flight" response.

Epistasis: The masking of the effects of one gene by the action of another, example: widow's peak masked by the baldness gene.

Excretion: The process of removing the waste products of cellular metabolism from the body.

Exon: The DNA bases that code for an amino acid sequence. Exons are separated by introns that code for no amino acid sequences.

Extinction: The elimination of all individuals in a group, both by natural (dinosaurs, trilobites) and human-induced (dodo, passenger pigeon,

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F

Fibroblast: A term applied to a cell of connective tissue that is separated from similar cells by some degree of matrix material; fibroblasts secrete elastin and collagen protein fibers.

Follicles (ovary): Structures in the ovary consisting of a developing egg surrounded by a layer of follicle cells.

Founder effect: The difference in gene pools between an original population and a new population founded by one or a few individuals randomly separated from the original population, as when an island population is founded by one or a few individuals; often accentuates.

G

Gap junctions: Junctions between the plasma membranes of animal cells that allow communication between the cytoplasm of adjacent cells.

Gene pool: The sum of all the genetic information carried by members of a population. Note: there is ***no*** diving in the deep end of the gene pool!

Gene therapy: The insertion of normal or genetically altered genes into cells through the use of recombinant DNA technology; usually done to replace defective genes as part of the treatment of genetic disorders.

Genetic divergence: The separation of a population's gene pool from the gene pools of other populations due to mutation, genetic drift, and selection. Continued divergence can lead to speciation.

Genetic drift: Random changes in the frequency of alleles from generation to generation; especially in small populations, can lead to the elimination of a particular allele by chance alone.

Genetic maps: Diagrams showing the order of and distance between genes; constructed using crossover information.

Glial cells: Nonconducting cells that serve as support cells in the nervous system and help to protect neurons.

Gonorrhea: A sexually transmitted disease that is caused by a bacterium that inpames and damages epithelial cells of the reproductive

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H

Hemizygous: Having one or more genes that have no allele counterparts. Usually applied to genes on the male's X chromosome (in humans).

Homologues: A pair of chromosomes in which one member of the pair is obtained from the organism's maternal parent and the other from the paternal parent; found in diploid cells. Also commonly referred to as homologous chromosomes.

Hypothalamus: A region in the brain beneath the thalamus; consists of many aggregations of nerve cells and controls a variety ofautonomic functions aimed at maintaining homeostasis.

I

Immovable joint: A joint in which the bones interlock and are held together by Þbers or bony processes that prevent the joint from moving; e.g., the bones of the cranium.

Implantation: The process in which the blastocyst embeds in the endometrium.

Incomplete dominance : A type of inheritance in which the heterozygote has a phenotype intermediate to those of the homozygous parents.

Inheritance of acquired characteristics: Lamarck's view that features acquired during an organism's lifetime would be passed on to succeeding generations, leading to inheritable change in species over time.

Initiation: The Þrst step in translation; occurs when a messenger RNA molecule, a ribosomal subunit, and a transfer RNA molecule carrying the Þrst amino acid bind together to form a complex; begins at the start codon on mRNA.

Initiation codon (AUG): Three-base sequence on the messenger RNA that codes for the amino acid methionine; the start command for protein synthesis.

Insertion: A type of mutation in which a new DNA base is inserted into an existing sequence of DNA bases. This shifts the reference frame in protein synthesis, resulting (sometimes) in altered amino acid sequences.

Intron: In eukaryotes, bases of a gene transcribed but later excised from the mRNA prior to exporting from the nucleus and subsequent translation of the message into a polypeptide.

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K

Karyotype: The chromosomal characteristics of a cell; also, a representation of the chromosomes aligned in pairs.

Klinefelter syndrome: In humans, a genetically determined condition in which the individual has two X and one Y chromosome. Affected individuals are male and typically tall and infertile.

L

Langerhans' cells: Epidermal cells that participate in the inpammatory response by engulfing microorganisms and releasing chemicals that mobilize immune system cells.

Larynx: A hollow structure at the beginning of the trachea. The vocal cords extend across the opening of the larynx.

L-dopa: A chemical related to dopamine that is used in the treatment of Parkinson's disease.

Ligaments: Dense parallel bundles of connective tissue that strengthen joints and hold the bones in place.

Linkage: The condition in which the inheritance of a specific chromosome is coupled with that of a given gene. The genes stay together during meiosis and end up in the same gamete.

M

Meissner's corpuscles: Sensory receptors concentrated in the epidermis of the fingers and lips that make these areas very sensitive to touch.

Messenger RNA (mRNA): "Blueprint" for protein synthesis that is transcribed from one strand of the DNA (gene) and which is translatedat the ribosome into a polypeptide sequence.

Methionine: The amino acid coded for by the initiation codon; all polypeptides begin with methionine, although post-translational reactions may remove it.

Morula: The solid-ball stage of the pre-emplantation embryo.

Mutation: Any heritable change in the nucleotide sequence of DNA; can involve substitutions, insertions, or deletions of one or more nucleotides.

Mutation rate: The average occurrence of mutations in a species per a given unit of time.

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Myofibrils: Striated contractile microfilaments in skeletal muscle cells.

Myosin: Thick protein filaments in the center sections of sarcomeres

N

Negative feedback: The stopping of the synthesis of an enzyme by the accumulation of the products of the enzyme-mediated reaction.

Negative feedback control: Occurs when information produced by the feedback reverses the direction of the response; regulates the secretion of most hormones.

Net primary productivity (NPP): The rate at which producer (usually plants) biomass is created in a community.

Niche: The biological role played by a species.

Node of Ranvier: A gap between two of the Schwann cells that make up an axon's myelin sheath; serves as a point for generating a nerve impulse.

Nondisjunction: The failure of chromosomes to separate properly during cell division. The unequal segregation of chromosomes during meiosis. This forms cells with either too many (possibly one or more single or sets of chromosomes too many) or too few chromosomes. Thought to be a common cause for Down Syndrome, where sufferers often have an extra copy of chromosome 21.

Nucleotide sequences: The genetic code encrypted in the sequence of bases along a nucleic acid.

O

Oncogenes: Genes that can activate cell division in cells that normally do not divide or do so only slowly. A gene that when over-expressed leads to cancer, but which normally functions in cell division.

Oocyte: A cell that will/is undergo/ing development into a female gamete.

Osmoconformers: Marine organisms that have no system of osmoregulation and must change the composition of their body fluids as the composition of the water changes; include invertebrates such as jellyfish, scallops, and crabs.

Osmoregulation: The regulation of the movement of water by osmosis into and out of cells; the maintenance of water balance within the body.

Osmoregulators: Marine vertebrates whose body fluids have about one-third the solute concentration of seawater; must therefore undergo osmoregulation.

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Osteoblasts: Bone-forming cells.

Osteoclasts: Cells that remove material to form the central cavity in a long bone.

Osteocytes: Bone cells that lay down new bone; found in the concentric layers of compact bone. Bone cell, a type of connective tissue.

Osteoporosis: A disorder in which the mineral portion of bone is lost, making the bone weak and brittle; occurs most commonly in postmenopausal women.

Oviducts: Tubes that connect the ovaries and the uterus; transport sperm to the ova, transport the fertilized ova to the uterus, and serve as the site of fertilization; also called the fallopian tubes or uterine tubes.

Ovulation: The release of the oocyte onto the surface of the ovary; occurs at the midpoint of the ovarian cycle. The release of the ovum (egg) from the ovary after the peaking of luteinizing hormone concentration in the blood during the menstrual cycle.

Ovum: The female gamete, egg.

Oxytocin: A peptide hormone secreted by the posterior pituitary that stimulates the contraction of the uterus during childbirth.

Ozone: A triatomic (O_3) form of oxygen that is formed in the stratosphere when sunlight strikes oxygen atoms. This atmospheric ozone helps filter radiation from the sun.

P

Pacinian corpuscles: Sensory receptors located deep in the epidermis that detect pressure and vibration.

Paleontology: The study of ancient life by collection and analysis of fossils.

Pancreatic islets: Clusters of endocrine cells in the pancreas that secrete insulin and glucagon; also known as islets of Langerhans.

Parasympathetic system: The subdivision of the autonomic nervous system that reverses the effects of the sympathetic nervous system. Part of the autonomic nervous system that controls heartbeat, respiration and other vital functions.

Pectoral girdle: In humans, the bony arch by which the arms are attached to the rest of the skeleton; composed of the clavicle and scapula.

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Pedigree analysis: A type of genetic analysis in which a trait is traced through several generations of a family to determine how the trait is inherited. The information is displayed in a pedigree chart using standard symbols.

Pelvis: The hollow cavity formed by the two hipbones.

Peripheral nervous system: The division of the nervous system that connects the central nervous system to other parts of the body. Components of the nervous system that transmit messages to the central nervous system.

Pineal gland: A small gland located between the cerebral hemispheres of the brain that secretes melatonin.

Pioneer community: The initial community of colonizing species.

Placenta: An organ produced from interlocking maternal and embryonic tissue in placental mammals; supplies nutrients to the embryo and fetus and removes wastes.

Plasmids: Self-replicating, circular DNA molecules found in bacterial cells; often used as vectors in recombinant DNA technology. Small circles of double-stranded DNA found in some bacteria. Plasmids can carry from four to 20 genes. Plasmids are a commonly used vector in recombinant DNA studies.

Pleiotropic: A term describing a genotype with multiple phenotypic effects. For example: sickle-cell anemia produces a multitude of consequences in those it affects, such as heart disease, jidney problem, etc.

Polygenic inheritance: Occurs when a trait is controlled by several gene pairs; usually results in continuous variation.

Polymerase chain reaction (PCR): A method of amplifying or copying DNA fragments that is faster than cloning. The fragments are combined with DNA polymerase, nucleotides, and other components to form a mixture in which the DNA is cyclically amplified.

Polynucleotides: Long chains of nucleotides formed by chemical links between the sugar and phosphate groups.

Pons: The region that, with the medulla oblongata, makes up the hindbrain, which controls heart rate, constriction and dilation of blood vessels, respiration, and digestion.

Positive feedback control: Occurs when information produced by the feedback increases and accelerates the response.

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GLOSSARY

Principle of segregation: Mendel's Þrst law; holds that each pair of factors of heredity separate during gamete formation so that each gamete receives one member of a pair.

Prions: Infectious agents composed only of one or more protein molecules without any accompanying genetic information.

Purine: One of the groups of nitrogenous bases that are part of a nucleotide. Purines are adenine and guanine, and are double-ring structures.

Pyrimidine: One of the groups of nitrogenous bases that are part of a nucleotide. Pyrimidines are single ringed, and consist of the bases thymine (in DNA), uracil (replacing thymine in RNA),

Recombinant DNA molecules: New combinations of DNA fragments formed by cutting DNA segments from two sources with restriction enzyme and then joining the fragments together with DNA ligase. Interspecies transfer of genes usually through a vector such as a virus or plasmid.

Recombinant DNA technology: A series of techniques in which DNA fragments are linked to self-replicating forms of DNA to create recombinant DNA molecules. These molecules in turn are replicated in a host cell to create clones of the inserted segments.

Recombination: A way in which meiosis produces new combinations of genetic information. During synapsis, chromatids may exchange parts with other chromatids, leading to a physical exchange of chromosome parts; thus, genes from both parents may be combined on the same chromosome, creating a new combination.

Reflex: A response to a stimulus that occurs without conscious effort; one of the simplest forms of behavior.

Reflex arc: Pathway of neurons, effector(s) and sensory receptors that participate in a reflex.

Renin: An enzyme secreted by the kidneys that converts angiotensinogen into angiotensin II.

Replication: Process by which DNA is duplicated prior to cell division.

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Resting potential: The difference in electrical charge across the plasma membrane of a neuron.

Restriction fragment length polymorphism (RFLP): A heritable difference in DNA fragment length and fragment number; passed from generation to generation in a codominant way.

Rheumatoid arthritis: A crippling form of arthritis that begins with inþammation and thickening of the synovial membrane, followed by bone degeneration and disÞgurement.

RNA transcript: Term applied to RNA transcribed in the nucleus.

Sarcomeres: The functional units of skeletal muscle; consist of Þlaments of myosin and actin.

Saturated fat: A fat with single covalent bonds between the carbons of its fatty acids.

Schwann cells: Specialized glial cells that form the myelin sheath that coats many axons. Cells surrounding the axons of some neurons, thus forming the myelin sheath.

Secretin: A hormone produced in the duodenum that stimulates alkaline secretions by the pancreas and inhibits gastric emptying.

Selective breeding: The selection of individuals with desirable traits for use in breeding. Over many generations, the practice leads to the development of strains with the desired characteristics.

Sex linkage: The condition in which the inheritance of a sex chromosome is coupled with that of a given gene; e.g., red-green color blindness and hemophilia in humans. Traits located on the X-chromosome.

Skeletal muscle: Muscle that is generally attached to the skeleton and causes body parts to move; consists of muscle fibers. Voluntary muscle cells that have a striated appearance. These muscles control skeletal movements and are normally under conscious control.

Sliding filament model: Model of muscular contraction in which the actin filaments in the sarcomere slide past the myosin filaments, shortening the sarcomere and therefore the muscle.

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Smooth muscle: Muscle that lacks striations; found around circulatory system vessels and in the walls of such organs as the stomach, intestines, and bladder. Involuntary, not striated cells that control autonomic functions such as digestion and artery contraction.

Social behavior: Behavior that takes place in a social context and results from the interaction between and among individuals.

Sodium-potassium pump: The mechanism that uses ATP energy to reset the sodium and potassium ions after transmission of a nerve impulse.

Somatic nervous system: The portion of the peripheral nervous system consisting of the motor neuron pathways that innervate skeletal muscles.

Somatostatin: Pancreatic hormone that controls the rate of nutrient absorption into the bloodstream.

Start codon: The codon (AUG) on a messenger RNA molecule where protein synthesis begins.

Stem cells: Cells in bone marrow that produce lymphocytes by mitotic division.

Sternum: The breastbone.

Steroids: Compounds with a skeleton of four rings of carbon to which various side groups are attached; one of the three main classes of hormones. sticky ends Term applied to DNA sequences cut with restriction enzymes where the cuts will bond with each other or with another sequence cut with the same enzyme.

Stop codon: The codon on a messenger RNA molecule where protein synthesis stops.

Synapse: The junction between an axon and an adjacent neuron.

Synapsis: The alignment of chromosomes during meiosis I so that each chromosome is beside its homologue.

Synaptic cleft: The space between the end of a neuron and an adjacent cell. synaptic vesicles Vesicles at the synapse end of an axon that contain the

T

Target cell: A cell that a particular hormone effects by its direct action (either passing through the membrane or binding to a surface receptor).

Tarsals: The bones that make up the ankle joint.

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Taxis: The behavior when an animal turns and moves toward or away from an external stimulus (pl.: taxes).

Template strand: The strand of DNA that is transcribed to make RNA.

Temporal lobe: The lobe of the cerebral cortex that is responsible for processing auditory signals.

Tendons: Bundles of connective tissue that link muscle to bone. Fibrous connective tissue that connects muscle to bone.

Termination: The end of translation; occurs when the ribosome reaches the stop codon on the messenger RNA molecule and the polypeptide, the messenger RNA, and the transfer RNA molecule are released from the ribosome.

Termination codon: One of three three-base sequences that initiate termination of the protein synthesis process. See stop codon.

Testosterone: Male sex hormone that stimulates sperm formation, promotes the development of the male duct system in the fetus, and is responsible for secondary sex characteristics such as facial hair growth.

Tetrad: The four chromatids in each cluster during synapsis; formed by the two sister chromatids in each of the two homologous chromosomes.

Transcription: The synthesis of RNA from a DNA template. The making of RNA from one strand of the DNA molecule.

Transfer RNAs (tRNAs): Small, single-stranded RNA molecules that bind to amino acids and deliver them to the proper codon on messenger RNA. The trucks of protein synthesis that carry the specified amino acid to the ribosome. Abbreviated tRNA.

Translation: The synthesis of protein on a template of messenger RNA; consists of three steps: initiation, elongation, and termination. Making of a polypeptide sequence by translating the genetic code of an mRNA molecule associated with a ribosome.

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Translocation: 1) The movement of a segment from one chromosome to another without altering the number of chromosomes. 2) the movement of puids through the phloem from one part of a plant to another, with the direction of movement depending on the pressure gradients between source and sink regions.

Tropic hormone: Hormone made by one gland that causes another gland to secrete a hormone.

Tropism: The movement of plant parts toward or away from a stimulus in the plant's environment. Plant movement in response to an environmental stimulus.

True-breeding: Occurs when self-fertilization gives rise to the same traits in all offspring, generation after generation. Now interpreted as equivalent to homozygous.

U

Umbilical cord: The structure that connects the placenta and the embryo; contains the umbilical arteries and the umbilical vein.

Uracil: The pyrimidine that replaces thymine in RNA molecules and nucleotides.

Ureter: A muscular tube that transports urine by peristaltic contractions from the kidney to the bladder.

Urethra: A narrow tube that transports urine from the bladder to the outside of the body. In males, it also conducts sperm and semen to the outside.

Urine: Fluid containing various wastes that is produced in the kidney and excreted from the bladder.

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V

Vasectomy: A contraceptive procedure in men in which the vas deferens is cut and the cut ends are sealed to prevent the transportation of sperm. Surgical separation of the vas deferens so that sperm, while still produced, do not leave the body.

Vasopressin: See antidiuretic hormone.

Vectors: Self-replicating DNA molecules that can be joined with DNA fragments to form recombinant DNA molecules.

Vestigial structures: Nonfunctional remains of organs that were functional in ancestral species and may still be functional in related species; e.g., the dewclaws of dogs.

X

X-chromosome: One of the sex chromosomes.

Z

Z lines: Dense areas in myofibrils that mark the beginning of the sarcomeres. The actin filaments of the sarcomeres are anchored in the Z lines.

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Useful Websites for Biology Students

- www.biology
- web.ukonline.co.uk/webwise/spinneret
- www.biology.about.com
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