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IV. Methods and Equipment for Pest Control

THE DIRECT METHOD

The so-called direct method, outlined in this chapter, includes both mechanical and chemical control measures against animal pests. Choice and application depend on the cost and the equipment available.

1. MECHANICAL CONTROL

Mechanical methods, used chiefly in the past, are: shaking the insects off the plants and collecting them and their eggs; pruning out affected plant material and burning or otherwise destroying it; crushing underground insect larvae (caterpillars and grubs) by repeated rolling, deep ploughing or other cultural practices; tying sticky bands round the trunks of trees to stop insects from climbing up; placing bait plants among a crop to attract insects which can then be removed and destroyed.

Pots used as pitfalls or trenches dug in the soil are also effective ways of catching nocturnal, non-flying insects such as crickets and mole-crickets. All these measures can be useful auxiliaries to chemical methods.

2. CHEMICAL CONTROL

Chemical methods, although far from perfect and being constantly improved, form the most efficient weapon against pests and diseases at a time when plant protection is becoming more and more necessary. Whereas many insecticides are highly selective, acting only against certain groups of insects, others may be harmful also to higher animals and man. Chemical control uses preparations which are particularly poisonous for Arthropods.

Modern insecticides are chiefly synthetic and their manufacture is unlimited. They have advantages over the earlier insecticides, which were based on natural products, in that they have better resistance to sun and rain, a longer lasting effect on the plant, with no damaging side-effects, and new modes of action. They have mainly replaced the earlier insecticides.

Insecticides are classified according to their mode of action as follows:

a) Feeding or Stomach Poisons

Poison is ingested by the insects with the food. It is lethal only when, reaching the digestive canal, it is absorbed by the cells of the mid-intestine. External contact has no toxic effect on insects.

b) Systemics

Systemic insecticides are absorbed by the roots, stems and leaves and carried to other parts of the plant by the sap stream. Piercing-sucking or biting-chewing insects ingest some of the toxicant when feeding on cell sap or plant tissue (leaves) and die. It is known that some systemic insecticides and acaricides are transformed into toxic compounds only after penetrating the plant tissue. Systemics act either as stomach or as contact poisons. Translocation with the sap stream depends greatly on the transpiration rate of a plant. In plants with heavy transpiration such as those growing in dry areas the toxicant is distributed much faster than in plants growing in humid climates. Systemics may be stored in various parts of a plant. For this reason they should be applied a safe time before the crop is harvested or consumed, because they may also be poisonous for the consumer.

c) Direct or Contact Poisons

Conctact poisons, owing to their lipoid-solving properties, may enter the chitinous epidermis of various parts of an insect, such as tarsi, abdomen, intersegmental membrane and wings. They act chiefly on the central nervous system, blocking complex ferment systems (cholinesterase) and may upset the chemical composition of the cell. Insects must be in direct contact with this type of insecticide, even if only for a short time, in order that it can take effect. It is therefore used against biting and sucking pests. Toxic substance, ingested with the food, is translocated from the mouth straight into the body; its action is correspondingly rapid.

d) Contact Poisons with Local Penetration Properties

These are substances which, when applied externally to leaves and fruits, penetrate the tissue, subsequently killing the pests which feed on the underside of the leaves or inside the fruits. Unlike systemics this type of poison is not absorbed by the plant tissue and distributed to other parts.

e) Fumigants

Poisonous gas reaches the insects through the respiratory system (tracheae). Fumigants are most commonly used in closed spaces such as buildings and warehouses to protect stored goods, and in soil disinfection against grubs, nematodes and the like.

Toxic action can be increased by adding a **Synergist,** which in itself may or may not have insecticidal properties. Synergism is obtained when the total effect of the components is greater than the sum of their effects taken independently.

The so-called **Attractants** are also a valuable aid in attracting plant attacking insects. These are either natural or synthetic, usually strongly aromatic substances which, added to insecticides, produce a vapour which attracts the insects to the insecticides. Attractants have been used with success in the control of fruit fly.

Repellents, usually substances with a strong smell, act in the opposite way by keeping pests away. They are used in agriculture as a protective against damage caused by game and rodents, but no effective compounds against plant injuring insects have yet been found. Their use so far is confined to blood-sucking insects and mites harmful to man and animals.

Insecticides are not equally effective against all members or all development stages of one species. Larval and nymphal stages are much less susceptible shortly before moulting than immediately afterwards; younger larvae can be killed with smaller amounts of poison than older ones.

None of the plant protecting preparations is a panacea against all pests. It is possible, however, to combine different substances so as to obtain a compound with a wider range of lethal properties. In practical pest control combined sprays of insecticides, acaricides and fungicides, directed at the same time against insects, mites and fungus diseases, are very successful.

In recent years research has developed selective insecticides and acaricides. Owing to their mode of action and application it is possible to kill certain harmful insects and mites without doing any harm to useful animals. Preservation of the biocoenosis is a great step forward, and an important starting point in the control of pest attacks, since such substances are harmless to parasites and predators of pests, which, by their activity, enhance the insecticidal effect of the chemical. Selective compounds will have to be the main concern of future research in pest control.

3. PRODUCT FORMULATION

Concentrated, highly active chemicals, either in crystalline, amorphous, oily or liquid form must be adequately formulated for use in low concentrations.

Active substances are mixed with inert fillers and may be commercially available in various forms, according to the purpose they have to serve. The size of particles is very important as the effect, distribution and adhesive properties depend thereon. Hygroscopic properties of inert fillers in "solid formulations" are of prime importance in the tropics. High absorbing properties may cause "caking" or "balling", rendering the products unusuable. Air-tight packing and dry storage of products prevent such deteriorations.

The main formulations are:

a) Dusts

The active chemical is combined with a water-repellent inert filler such as talc or pyrophyllite. Owing to the absorbing properties of such inert fillers, pastes or even liquid substances may be made into dry, powdery products. Adhesive agents help to fix the insecticidal dust on the surface of the plants and increase its resistance to wind and rain. The proportion of active substance depends on its toxicity to insects and lies between 1 and 10%. "Dustability" depends on the size and weight of the particles. Weight is usually between 0.2 and 0.5 kilogram per litre. The particle size which influences dispersion and adherence may vary from one product to another and range between 50 and 100 microns (1 micron = 0.001 millimetre). Dusts are ready for use and can be applied at any time. They require no water, so their use is indicated particularly for areas where water is scarce or where water transport is difficult. Dusts are used chiefly on low crops such as cotton, beans, rice and others, and spraying equipment is relatively simple. They disperse well on the plants so that the underside of the leaves can also be reached easily. Dusts are less suited to humid areas, because they are too easily washed off by rain.

b) Granulate

Coarse-grained, relatively heavy substances, such as calcium carbonate, serve as inert fillers. In special cases the active chemical is mixed in with granulated artificial fertilizers or coarse-grained baits.

Depending on local conditions, the proportion of active substance should be between 1 and 10%, the particle size within 500 and 2000 microns and the weight between 0.6 and 0.9 kilogram per litre. Granulated insecticides can be applied either by hand or by aircraft.

When used against soil inhabiting insect larvae (grubs, wireworms) they are spread over a field and then harrowed in mechanically. For insects living above the ground such as caterpillars, crickets and locusts, the granulated insecticides, mixed with bait substances, are spread over the soil surface. These products are also effective against caterpillars damaging the stems of plants. In this case the grains are spread over the plants from where they roll down the leaves into the leaf sheaths (sugar cane). There they form toxic deposits against the young stem borers.

c) Wettable Powders

These dust formulations of liquid or solid pesticides are applied in aqueous suspensions. By adding wetting agents to the inert fillers, the surface tension is reduced, while the wetting properties are enhanced considerably so that the speed of suspension is accelerated. To prevent rapid settling of the particles, protective colloids are mixed to these products. Wettable powders available today contain between 20 and 90% active ingredient, according to their form (oily, amorphous, crystalline), 50% being the formulation commonly on the market. The weight lies between 0.2 and 0.5 kilogram per litre. Wettable powders with a high percentage of active substance, i.e. with a small amount of inert fillers, are usually resistant against rain and compatible to plants. Particle size may vary from 5 to 50 microns. Since wettable powders can be used in combination with other preparations such as fungicides, or as tank mixtures they are economical in transport.

d) Pastes

Pastes are highly concentrated suspensions of active substance in water, to which dispersers and emulsifiers have been added. Their advantages are: good adhesive properties and resistance to rain. Specific gravity is about 1 and the particle size varies between 5 and 50 microns.

e) Emulsifiable Solutions

These are liquid mixtures of active substance with solvents (xylene, alcohol, oils) and emulsifiers, the latter helping dispersion in water. When diluted in water, an emulsified mixture is obtained which is easy to handle and therefore widely used in plant protection. Toxicity of the active ingredient, stability of the emulsion and suspension rate of droplets depend on the particle size of the droplets. Owing to the liquid form of the particles, which measure from 1 to

30 microns, emulsifiable solutions are less likely to obstruct the spray nozzles, a disadvantage of wettable powders. They wet readily and form a continuous film on the leaves, but are somewhat unstable and must therefore be used up within a few hours. The combining of mixtures of emulsifiable solutions with certain fungicides and other products (wettable powders) is restricted, as the emulsions may separate and thus become less effective. Also suspension rate and wetting properties may be affected.

f) Aerosols

Aerosols are liquids which are atomised into ultra-fine droplets similar to a mist. Products on the market today consist of a toxic agent, a solvent and a propellent which are together forced by high pressure into an aerosol dispenser. When the valve of a dispenser is opened, the insecticidal solution is released; both solvent and propellent vaporise rapidly, while the active substance remains suspended in the air as a fine mist (particle size 5-10 microns).

Aerosols are used in dwellings against houseflies, mosquitoes, moths and other insects; recently plant sprays have been developed on the same principle for horticultural use.

g) Fog Solutions

Fog solutions are a further form of atomised liquids. They are highly concentrated insecticidal solutions mixed with organic solvents. Application, either as *cold fog* or as *thermal fog* requires special equipment. Whereas cold fog is obtained by a compressed air blast tearing the fog solution into very fine particles, in thermal fog the solvent is vaporised by heat and the active substance sprayed as condensation fog (see Fig. 85). Particle size lies between 5 and 50 microns, according to the method of application. Owing to the small amount of inert fillers they contain, the usually highly concentrated fog solutions are very effective and have good adhesive properties.

h) Fumigants

In fumigation, poisonous gas is generated by heat. In most commercial fumigants such as candles, shells, tablets, cardboard discs, the active substance is mixed in a highly inflammable compound (potassium nitrate and cellulose as source of oxygen and as combustion regulator). The resulting smoke, with a particle size of 1-5 microns, carries the insecticide particles. Fumigants are particularly recommended for use in greenhouses, seed-beds and storage rooms. In special cases and in calm weather they may also be applied against pest invasions in dense crops.

i) Glues

Before modern synthetic insecticides were developed, glues were frequently used. Sticky bands, a few centimetres wide, were tied round the trunks of trees to stop caterpillars, beetles, ants and the like. This method is seldom used nowadays. It is, however, very useful especially in combination with baits (see also page 46) when insects of a particular area are to be captured for identification, or as a protective measure against game. Glues are made in the following way: 30 parts colophonium or cumaron resin are melted with 2 parts wax; 20 parts linseed oil or linseed varnish are added and the ingredients thoroughly mixed.

4. METHOD OF APPLICATION

Successful pest control, besides depending on the effectiveness of the products and the timing of application, relies to a great extent on the methods of application and the capacity of equipment. Choice of formulations and equipment also depends on the type and extent of a crop, the nature of the pest, local conditions and cost. It is therefore not possible to give a general recommendation for the use and suitability of equipment. Information should be obtained from the various experimental stations or from the manufacturers themselves.

a) Application of Dusts with Dusting Machines

The simplest way of applying dusts to plants or soil is to use coarse-meshed bags. By gently shaking and knocking them the dust is gradually released (see Fig. 74).

In dusting machines an air stream is generated into which a controlled supply of powder is mixed and blown on to the objects to be treated.

There are many types of machines available, their design depending on the extent and speed of application required.

1) *Hand-operated dusters* (see Figs. 75 and 77).

The small hand-operated dusters, used in gardens and greenhouses, consist of a simple syringe. When compressed, an air stream is produced which, in passing over a container filled with insecticidal powder, sucks some of it up and disperses it as a fine cloud.

For treatment of large areas such as nurseries, the more powerful hand dusters, worked with bellows or fans, are best suited. These dusters have a container capacity of up to 2 kilograms of powder. Output is regulated by a slide in the powder container outlet. An agitator ensures even feeding to the outlet and prevents clogging. The air blast is obtained either by working the bellows with a lever or a rotary fan with a handle. The former type expels the dust intermittently, the latter continuously.

2) *Bellows-type knapsack hand dusters* (see Fig. 73).

These machines have considerable technical advantages over other systems. Their container capacity of 10-15 kilograms of powder considerably reduces delays for recharging. They are carried on the back with a minimum of fatigue and exclude the danger of inhalation of poisonous substance, as may occur with equipment carried in front. The air blast is obtained by lever-operated bellows. The dust is blown out through a hand lance attached to the machine by a flexible tube.

3) *Petrol-engine driven dusters* (see Figs. 76 and 78).

These dusters are fitted with a high pressure centrifugal blower, giving continuous and rapid distribution of powder over large areas.

Smaller models of this type are carried on the back, the lance being held in one hand. Larger and accordingly heavier models are mounted on wheels or on stretchers carried by two or four men. The lance through which the powder is emitted can be adjusted either vertically or horizontally.

b) Application of Liquid Insecticides with Spraying Equipment

Equipment for spraying liquid insecticides is adapted to the methods of application and to the type of crops to be treated; it is constructed accordingly.

High volume method

The high volume method uses sprayers in which the liquid is forced by high pressure through a nozzle and dispersed into fine droplets. The droplets may have a diameter of 150 microns and more. This method requires large quantities of liquid (for cotton for instance 600-800 litres per 10,000 sq.metres). The tanks for these sprayers must be suitably large.

1) *Hand-operated knapsack sprayers* (see Fig. 79)

The liquid is sucked up by a piston or a diaphragm pump worked by a handle, then passed through a compression cylinder which ensures even output, and finally forced by an air blast through the nozzle of a lance. Construction of nozzle and pumping pressure regulate the droplet size, the density and range of spray and the quantity of insecticide emitted. Fan spray nozzles produce a broad, fan-shaped spray, while cone spray nozzles emit a cone-shaped spray. The aperture size of the nozzle is determined by the formulation of the chemical used; suspensions, due to their tendency to clog, require larger apertures than emulsions.

Strainers fitted in the inlet tube and in the lance prevent obstruction of the nozzles, while agitators keep the liquid well stirred. To prevent corrosion of the pumps by the chemicals in use, they are made of brass and more recently of polyethylene. Equipment should be thoroughly cleaned after use, in order to be always in working condition.

2) *Pneumatic knapsack sprayers*

The insecticide is put under pressure by compressed air in a strongly built cylinder. The air pressure with which the liquid is expelled, is indicated by a manometer and varies between 6 and 10 atü (85 and 140 p.s.i.). Pressure falls with working and has to be restored by further pumping. Lance and distribution nozzles are similar to those of hand-operated knapsack sprayers (see above).

In some pneumatic knapsack sprayers the empty tank is first filled with compressed air and then the liquid added by another pump. The resulting pressure amounts to 10-15 atü (140-210 p.s.i). With these *high pressure knapsack sprayers* (see Fig. 81) several fillings can be sprayed without repumping, owing to a ball valve which prevents the compressed air from escaping as liquid diminishes.

Motor sprayers

Large estates require more powerful equipment for the size of their fields. The motor sprayers recommended in this case are fitted either with piston or diaphragm pumps which can develop a pressure of up to 100 atü (1420 p.s.i.) and thus give a powerful and far-reaching jet. These machines have a large tank from which the liquid is passed through a delivery hose or tube. As said before (see knapsack sprayers) nozzles and pump pressure regulate the distribution and application of the insecticide.

3) *Pumping stations*

These are suited either for perennial crops or for fields where machinery on wheels cannot be used. Liquid is passed by a stationary pump through a system of pipes to the planted area and then applied through flexible tubes fitted with nozzles. With special lances or guns the liquid can be distributed in a straight, far-reaching jet or with a short cone spray nozzle in a broad jet.

4) *Motor sprayers mounted on wheels*

Engine-driven pumps and tanks are mounted on trolleys. The mixture contained in the tank is sprayed under high pressure. Other equipment, developed and constructed for special conditions of application, may also be transported in the same way. Motor sprayers can be either self-propelled or trailers; they are fitted with either piston or diaphragm or centrifugal pumps, direct coupled to the engine.

Special spraying accessories are also available. Spray booms are suitable for application in low crops such as Cotton or Tobacco. These booms can be adjusted horizontally at right angles to the direction of movement (see Fig. 84). They have outlets at short intervals through which the liquid is spread in broad bands. The wheel track is adjustable so that this apparatus may be used in row crops of various spacings.

Vertically mounted booms are suitable for the treatment of rows of trees (Coffee, Cocoa, Citrus) (see Fig. 86).

Soil injectors attached to the pump by a flexible hose can also be used for the application of liquid insecticides, nematocides and fertilizers deeply into the soil. In this case, the point of the injector is pushed into the soil, and the liquid is applied by pressing a handle (see Fig. 82).

Centrifugal high pressure pumps force the liquid through a system of nozzles arranged in a circle (see Fig. 83). By closing single or groups of nozzles the spray direction can be regulated and adjusted according to requirements.

Low volume method

The low volume method requires the same amount of active substance as the high volume method, but the quantity of liquid used per given area is very much smaller. Diminution of liquid and thus increase of concentration of emulsions or suspensions reduces cost of transport for filler material (water) as well as for engine fuels, an advantage which makes operation more rapid and increases equipment capacity. With modern spraying machinery it is possible to reduce insecticidal mixture, with a correspondingly higher percentage of active ingredient, to 50 litres per 10,000 sq.metres. By this method the liquid is dispersed as a very fine mist of a droplet size of less than 150 microns. Smaller droplets than those obtained in the high volume method are produced by specially arranged nozzles and by pumps generating a high speed and high pressure air stream which tears the liquid into extremely fine particles. The small droplets of highly concentrated mixture give a better coverage and are less liable to harm a plant, since some substances, when applied in large quantities, cause burning of the leaves.

5) *Knapsack-type portable mistblowers* (see Fig. 80)

These machines consist of a high power fan mounted on a carrier and coupled with an engine, a tank holding several litres of liquid, a smaller fuel tank and a spray lance. The force of the air blast produced by the fan disperses liquid insecticides in uniform, ultra-fine droplets. The mixture is fed into the nozzle where it is atomised and drawn off by the air blast to the plants. The tank is held under pressure and the quantity of liquid used is regulated by interchangeable graduated taps. Knapsack mist sprayers can be operated in low crops as well as among trees (Cotton, Coffee, Cocoa, Citrus); the quantity of liquid required per 10,000 sq.metres is only about 100 litres. By changing some parts of the spraying lance, mist sprayers can be converted into dusters.

With the low volume method the plants are not, as with the high volume method, greatly wetted and covered with a visible film. The low volume method cannot be used for control measures which demand a relatively high minimal amount of liquid on the leaves, such as those against red spider and aphids. Operations should be undertaken in calm weather, so that the mist is not carried off by the wind.

6) *Transportable atomisers or mistblowers* (see Fig. 87)

These machines are either self-propelled or trailers and work on the same principle as knapsack atomisers. Highly concentrated insecticide is torn into very fine particles (diameter below 150 microns) by a powerful air blast and dispersed through a specially designed outlet. The mixture is spread from a distance of about 50 metres from the plants, the direction being controlled by a hand-operated outlet. The large machines, particularly suitable for trees (Coffee, Citrus) have to be used in calm weather. For spraying field crops, booms, several metres long, are fixed at right angles to the direction of movement. The outlets can be adjusted so that the spray is sent in any desired direction. With specially designed nozzles this type of apparatus can also be converted for dusting.

7) *Fog spraying: Cold fog*

The amount of liquid required per 10,000 sq.metres can be reduced even more by fog spraying. Highly concentrated active substance, diluted in organic solvents or oil, is sprayed in very fine droplets of less than 50 microns; the necessary quantity for 10,000 sq.metres lies between 20 and 25 litres. Insecticidal fogs are produced by a type of apparatus which operates by a high pressure air blast, similar to atomisers. The insecticidal solution is forced through very fine orifices into the air stream which tears it into extremely fine particles. After rapid evaporation of the solvent a rain resistant dispersion fog of toxic substance is obtained.

8) *Thermal fog*

In thermal fog apparatus the insecticide, diluted in organic solvents, is dispersed by hot air such as engine exhaust. The solvent readily evaporates in the hot air and the toxicant appears as condensation fog of ultra-fine particles (1-10 microns). For field application only heat resistant, non-volatile substances which form a condensation deposit can be used. Fogs are subject to air-drifting and are therefore recommended only for use in dense crops and during calm periods.

Swing fog apparatus (see Fig. 85) works on the same principle. In a combustion chamber a mixture of petrol and air is ignited. A series of explosions create gas and pressure vibrations of high speed in a swing tube. Through these vibrations fog solution, the surface tension of which is reduced in hot air, is torn into ultra-fine droplets of less than 20 microns. This aerosol apparatus is particularly suitable for treatment of enclosed spaces such as storage rooms (protective masks essential). Crops should be treated only when a slight breeze (3 metres per second) carries the dense fog horizontally and in the desired direction. Fog spraying in the field, either as aerosol or as dry fog, is chiefly done as a curative measure against sucking insects or those feeding externally on the plants. Swing fog apparatus can also be used against termites, the fog being blown into the galleries of their nests (see Fig. 65).

c) Application of Insecticides by Aircraft (see Fig. 61)

Large fields of monocultures, or plants that are difficult to reach, or mass invasions over large areas by insects such as locusts can be treated from aircraft. While airplanes are suitable for large, flat areas, helicopters have proved better suited to the treatment of small objects, difficult to reach, and they need only little space for take off and landing. Owing to the cost, the low volume method is used, with which highly concentrated insecticidal suspensions, emulsions or fog solutions are spread, as this is more economical. Suspensions and emulsions are forced by pumps or fans through the nozzles of a boom, several metres long, fixed at right angles to the flight direction (see Fig. 61). Fog solutions are blown out by the thermal fog method using exhaust gas from the aircraft engines. Insect control by aircraft requires an efficient signalling system between ground and aircraft and can be done only in favourable, i.e. calm weather.

5. ACTION OF PESTICIDES ON THE PLANT

Agriculturists demand the following properties from an insecticide: it must be absolutely harmless to the plant and, except in certain cases, it must be effective for at least several days. The residual effect of an insecticide depends to a great extent on the chemical stability and also on the vapour pressure of the product. The higher the pressure, the more rapidly a chemical will volatilize and lose its effectiveness. Degradation of stable compounds is slow even when they are exposed to direct sunlight, rain or other atmospheric influences; their residual effect is thus relatively long-lasting. By choosing formulations with suitable inert materials (protective substances) the residual effect of a pesticide can be improved.

Uniform and even dispersion of an insecticide intensifies its effect on the plants. The nature of the parts of the plant to be treated is important. Although most of the current insecticides nowadays have satisfactory wetting properties, a special wetting agent must be added when the substance is to be spread on hairy or waxy leaves and fruits. However, too great a proportion of a wetting agent will cause the droplets to coalesce rapidly so that the insecticide, when applied abundantly, may run off the surface it is intended to protect.

Residual effect and resistance to rain of a substance also depend on the physico-chemical properties of the inert material and on the affinity of the active substance for the plant cuticle. Many insecticidal compounds remain on the plant surface mixed with the inert material, whereas others, owing to their affinity for the lipoid layer of the plant, may rapidly penetrate the cuticle, accumulate in the tissue and remain there for some time. This property, which is found especially in penetrating and systemic insecticides, allows active substances even of solid formulations (dusts and powders) to enter through the cuticle into the tissue. The penetration rate depends on the chemical composition (wax and lipoids) rather than on the thickness of the cuticular layer; the activity and residual effect of a chemical, on the other hand, depend on the accumulation and degradation of active substances in the plant tissue.

The effect of systemics is often unsatisfactory or retarded. This may be due to insufficient dosage or faulty application. However, climatic factors can also be the cause. It is known that systemic insecticides, when applied to roots or some aerial parts of a plant with weak transpiration (leaves), are translocated more slowly than in plants with abundant transpiration. In areas of high air humidity and in damp glasshouses and frames insufficient or slow action must therefore be expected.

Insecticides must be applied during calm weather. The diversion of a spray or fog by wind means loss of spraying material and thus reduced effectiveness. When chemicals are applied during rain they are immediately washed off. Many pests occurring during the rainy season must therefore be controlled during the intervals when the plants are dry and the chemical film can dry and adhere before the next rain falls.

Newly formed parts of a plant (leaves, shoots, fruits) must be treated several times so as to protect the fresh tissue as it is being formed. Aqueous insecticidal mixtures may burn the foliage and fruits when they are applied in full sunshine, because the droplets act as lenses on the plant. This danger can be overcome by spraying either in the morning or late afternoon.

6. ORGANIZATION OF PHYTOSANITARY CAMPAIGNS

Carefully organized phytosanitary campaigns with chemical pesticides can improve the quantity as well as the quality of a crop. Although their value is acknowledged all over the world today, economic considerations must govern their use. Chemical pest control is still far from perfect and requires further improvements just as fertilization, irrigation and drainage, cultural methods, plant breeding and selection, crop succession, mechanization and rationalization of tropical and subtropical agriculture do. Initial cost of equipment, its maintenance and use by experienced staff have to be taken into consideration when campaigns are being planned.

Chemical campaigns can have either a *preventive* or a *curative* purpose. The choice of one or the other depends largely on the biology of the pest to be destroyed.

Preventive measures can be undertaken either against free-living or against endoparasitic pests, such as caterpillars, beetles and their larvae, gall lice, gall mites, nematodes and others which mine the plant tissue. Treating attacked plant parts (leaves, fruits, shoots, trunks) with toxic substance shortly before or during heaviest attack makes it possible to protect them from free-living or hatching insects before they mine the plants. Efficient preventive measures require some knowledge of the biology of a pest. Time of occurrence, peak (flight of the majority of the insect) and period of oviposition are decisive data for success.

Fig. 73-78. Dust Application.

Fig. 79-87. Machinery for applying liquid insecticides.

Application of the method as described in chapter II (page 42) for the identification of a pest (capturing and baiting), or direct inspection of a plant for possible infestation is in any case recommended and should make early and thus economic control possible.

Successful control of the majority of mining insect species is only achieved with concentrated and informed preventive methods. It is obvious that only insecticides with a relatively good residual effectiveness should be chosen for preventive application; the more persistent the effect, the longer the plant is protected. This is particularly important in the control of pests where the flight and oviposition periods last for several weeks. With these pests, as with species with several successive generations, periodically repeated campaigns are necessary. Preventive measures are also well suited for seedbeds where the young plants must be grown without risk of injury.

Curative or direct campaigns are undertaken where injurious insect stages are imminent and have to be eliminated or where present infestations must be checked. Such measures are directed mainly against free-living insects such as locusts, crickets, mole crickets, caterpillars, beetles and their larvae, thrips, aphids, mealybugs, coccids, plant bugs, psyllids, mites. Although the injurious activity of the insects is checked, the damage already done to a plant can of course not be repaired. With the aid of modern, penetrating insecticides curative measures can sometimes also be undertaken against endoparasitic insects mining in the plant tissue. Success of control in this case depends largely on the size, thickness and nature of the attacked parts of a plant, as well as on the development stage of the pest. Penetrating insecticides are translocated relatively well in the tissue of leaves and young small fruits or shoots, where they reach the young, delicate larval stages during their mining activity. Ligneous plant parts, on the other hand, do not absorb sufficient toxic substance, and in ripe fruits its effect is lost owing to insufficient penetration or reduced concentration of the insecticide.

On fruits with unevenly dispersed and therefore inefficient insecticidal films, heavy secondary fungus infection is often observed. This is due to lesions on the fruit skin, caused by gnawing larvae on which the insecticide acts only after they have entered the plant.

The decision when and where to undertake curative measures depends mainly on the density of an insect population. They are usually taken when damage is manifest or imminent. Numerically unimportant pest populations do not always reach such proportions that the yield of a crop is seriously reduced; very often they are weakened or destroyed in their early stages by climatic or biological factors, prior to the vegetation period of their host plants.

7. BIOLOGICAL CONTROL

Biological control can play an important part in the destruction of pest insects. A great number of *predators* and *parasites* feed on insects and sometimes develop within them, thus contributing to their destruction. It was feared that the regulating intervention of beneficial parasites such as ichneumon flies, ladybirds, hovering flies, mites and others might be checked by large-scale application of chemical insecticides, so that these would do more harm than good. Field experience, however, has shown the following facts: Progress in agriculture, especially the considerable extension of monocultures, often combined with weed control and the elimination of hedges upsets the balance of nature to the disadvantage of predators and parasites and to the advantage of pests. With unlimited amounts of food plants, the pests multiply massively, whereas predators and parasites first diminish in number or otherwise become dependent on a specific pest. Consequently the pest population will be parasitized and noticeably checked only after having caused serious damage. Neither can other insectivora such as birds, bats, hedgehogs, ants and the like considerably lower the population density of pests during the height of their reproductive periods. Nevertheless chemical control measures should be undertaken wherever possible in such a way that the natural enemies (predators, parasites and other insectivora) are spared. This can be done in the following manner:

a) by undertaking control actions before the majority of predators and parasites are present;
b) by using substances with a relatively narrow range of effectiveness;
c) by using substances which act only against one order of insects (for example stomach poisons against caterpillars; acaricides against red spider mites);
d) by using systemic insecticides which act on insects feeding on the treated plants without injuring either predators or parasites.

The problem of biological regulation of pest populations by predators and parasites can only be superficially mentioned here; other important questions, such as the breeding and selection of resistant crop varieties, the introduction of microorganisms (bacteria, fungi, virus) and the like cannot be dealt with in this book.

8. TIMING OF PHYTOSANITARY CAMPAIGNS

The time of chemical treatment is determined by the occurrence of a pest and its population density. These factors are closely related to the developmental stage of the host plant and its susceptibility to animal pests, and to climatic and environmental conditions. In tropical and subtropical regions where seasonal weather conditions (dry and rainy periods) are very pronounced, the development rhythm of a pest is adapted to climate and host plant.

Observations and control of occurrence, behaviour and development period of a pest, and knowledge of the factors which influence favourably the dynamics of a population, such as weather, temperature, humidity, development of a crop, are very important for the timing of campaigns. especially preventive ones. It is of course impossible to give here generally valid data as to the timing of treatment. The appendix contains detailed information for each pest. Here only general directives can be given.

1. Preventive Control

The success of control measures against all endoparasitic pests living and mining in the plant tissue depends largely on the adequate timing of preventive treatment with insecticides of long-lasting effect. With modern, systemically toxic pesticides it is possible, under certain circumstances, to defer the application considerably so that the youngest larval stages which have penetrated into the plant (especially into leaves and fruits) can be reached also. This procedure, considered as a curative, is at the same time a preventive measure which can be intensified considerably by adding a non-systemic but long-lasting product.

Examples of optimal timing under practical conditions:

To protect coffee berries against the berry borer, *Stephanoderes hampei,* the berries are treated with an appropriate insecticide at the moment when more than 5% of them show the characteristic boreholes.

The first preventive treatment is undertaken against caterpillars of the coffee berry moth, *Thliptoceras octoguttale,* immediately after flowering, when an intense flight of adult moths, threatening to damage a field, occurs.

To destroy the American cotton boll worm, *Heliothis obsoleta,* or other boll worms a suitable insecticide is applied when more than 5 buds per 100 shoots are attacked.

Odour baits will show the time when the flight of the Mediterranean fruit fly, *Ceratitis capitata,* is heaviest and the pest can be checked most successfully.

Effective control of the rice borer, *Chilo* sp., is possible only when the time of greatest density of moths on the wing is previously determined. The main part of the eggs are laid soon after the flight of the majority of moths. The hatching caterpillars boring into the rice shoots are killed by an insecticidal film which is spread at the moment when, or shortly before, the pest is about to penetrate into the plant.

2. Curative Control

Insecticides and acaricides must be applied as soon as possible after the first individuals of a pest have been observed in a field. In most cases the best time of control is probably the beginning of the vegetation period, i.e. the moment when the young plants emerge. For the destruction of pests with a rapid succession of generations or of individuals which continuously invade a crop from outside, as well as of those whose larvae and pupae hatch over a relatively long period, treatment has to be repeated at intervals of a few days.

Timing of treatment varies considerably with the type of a crop, its development and environmental conditions. No generally valid rule can be established. For the exact timing of a campaign the planter can nowadays obtain advice from well organized governmental or commercial plant protection organizations (research and experimental stations) in most countries. Such biological research stations collect observations and periodically publish them; they offer advice as to preventive and direct control measures and recommend the most effective chemicals. They can also provide information as to economic problems of phytosanitary campaigns.

9. EXAMINATION OF THE INSECTICIDES AND FIELD TRIALS

The effectiveness of insecticides under field conditions can be measured and compared in various ways. The simplest way is to examine the treated plants for dead or injured insects and to collect these. This is a rough and ready method from which no reliable results can be expected. For comparative studies of effectiveness a scheme, reproduceable ad libitum, is recommended, by which the dead and injured insects or the damaged plant parts are counted on treated and untreated plots. Conclusive results are obtained by field trials only when the ecology and behaviour of the insects are taken into consideration from the beginning of the test, as for instance the heavier infestation of a field's periphery, due to invasion from outside; the attraction and repellency between crops and pests and other factors. Before starting field trials a careful survey of the prevailing conditions (degree of infestation) must be made. The standard method of HOLTSMARK and LARSEN is recommended for assessing the possible variation of conditions and the errors arising therefrom. The method is to apply one compound to several plots simultaneously so that treated and untreated plots will occur as follows:

u	a	b	u	a	b	u	a	b	u	a	b

u = untreated plots, or plots treated with standard product;
a + b = products to be tested.

In this way each treated plot adjoins a control plot.

The size of the trial field is very important. The smaller the plots, the greater the element of hazard. It may be that one square metre of a trial plot treated in a particular way is infested by a pest which deposits its eggs, while the neighbouring trial plots, of equal size but differently treated, happen to be avoided. This may lead to the false conclusion that the non-infested plot is considered as "good". Such errors can be avoided only by measuring out sufficiently large trial fields of at least 25 sq.metres. An outline of the situation, showing also the relationship with neighbouring fields is a great help in field trials.

Another method is the *latin square design*. Here the number of trial plots is equal to the number of plot series. When laying them out, care must be taken that a similar plot does not lie on a diagonal line. The following diagram shows this arrangement:

Plot series:

a	b	c	d	e
1	2	3	4	5
3	4	5	1	2
5	1	2	3	4
2	3	4	5	1
4	5	1	2	3

To assess the effectiveness of product the plots or the same number of plants in each plot are examined at certain intervals (10 or more days) after treatment, and the dead, injured and living individuals are collected, the median values determined and the percentage of effectiveness established according to the formula of ABBOTT:

$$\frac{u - b}{u} \times 100 = \text{percent control}$$

u = number of living individuals (or number of attacked plants in untreated control plots;
b = number of living individuals in the treated plot;
u—b = number of individuals killed by the product (or number of uninjured plants).

To assess the toxicity within a determined period the following definitions are necessary:

1. Toxicity	injurious property of a chemical for an organism;
2. Toxicity coefficient	quantity of toxic substance injurious to an organism;
3. Period of toxicity	period between uptake of toxic substance and paralyzing or lethal effect on an insect;
4. Mortality	percentage of insects killed among a population by toxic substance.

Here is an example of a field trial, with which the effectiveness of three products (a, b and c) against the American cotton boll worm is measured. This example shows at the same time how the most important data can be presented in a test report.

Example:

Assessment of the effectiveness of products a, b and c against the American cotton boll worm.

Locality	Msulva (Ulanga District), Tanganyika
Plant species	*Gossypium* sp. Prov. East Africa
Development of crop at time of treatment	6 weeks old; first buds formed
Treatments	6. 4. 1961 14. 4. 1961 22. 4. 1961
Formulation	WP
Application method	high volume 1000 litres/hectare
Equipment	knapsack sprayer
Quantity per hectare (10,000 sq.metres)	750 grammes active ingredient
Standard product	X
Method	latin square with 5 series
Size of plots	10×10 m = 100 sq.metres
Temperature range	
maximum	32°C
minimum	19°C
Rain in millimetres	36

General remarks:

Occurrence of the pest: first sporadic signs of damage: 2. 4. 1961. Degree of attack immediately before treatment: 1-2 buds per 10 plants. Three preventive campaigns, starting 6. 4. 1961, repeated at weekly intervals.

Control:

The effectiveness of three products was determined by counting the buds attacked by the American cotton boll worm on a total of 50 plants per plot. Date: 25. 4. 1961.

Results:

Products	plot series	number of buds attacked by caterpillars	∅ median value	effectiveness in %
a	a	11		
	b	9		
	c	18	12	83.14
	d	6		
	e	16		
b	a	19		
	b	17		
	c	17	18.6	73.87
	d	19		
	e	21		
c	a	6		
	b	9		
	c	11	8	88.76
	d	5		
	e	9		
standard product	a	6		
	b	11		
	c	9	10	85.95
	d	9		
	e	15		
control (untreated)	a	61		
	b	83		
	c	56	71.2	
	d	69		
	e	87		

10. ASSESSMENT OF INSECTICIDAL RESIDUES ON PLANTS AND STORED PRODUCTS

The toxicity of modern insecticides ranges from low to very high. Assessment of insecticidal residues in human and animal food and on other goods in daily life is therefore of great hygienic importance. To avoid injury to human and animal health by insecticidal residues on fruits, vegetables and other food stuffs, special regulations are in force, especially in the USA regarding the so-called *tolerance values,* i.e. the highest degree of permitted toxic residues at harvesting time. The tolerance value established officially for each registered product indicates at the same time the interval to be observed between the last insecticidal treatment and harvest. Within this interval the toxic amount of a compound must fall below the permitted tolerance value (safety margin). Present-day plant protecting practice schedules trials of effectiveness by independent government organizations. The tolerance values are measured by toxicological experiments on one side and analysis of residues on treated plant material on the other. The tolerance is measured in ppm (parts per million: 1 ppm = 1 mgr. active substance per 1 kilogram). This represents the highest amount of insecticide allowable on treated plant material at harvest time. Manufacturers of insecticides prescribe the mode of application, dosage, and safety limit of their products. Tolerance values are not fixed higher than necessary for the desired success of control, even if chronic toxicity of a substance would allow far higher tolerance figures. There is no relation between the toxicity of a chemical and its tolerance value; a compound with a low tolerance must not necessarily be considered highly toxic. The safety margin depends on both the stability and toxicity of an insecticide and on the nature of the treated material. There are insecticides which have a pronounced affinity for waxy fruits and vegetables and accordingly possess a long-lasting effect, owing to their solubility in fats and lipoids, whereas on non-waxy materials their decomposition is relatively rapid. Weather, light, temperature and humidity are also factors which have to be taken into account when safety values are established. Tolerance and safety figures can never be valid for all the crop plants but must be specified for each kind of fruit, vegetable and other food stuff, and the proportion of these food stuffs to the total uptake of food must be taken into consideration. In practice this means that the tolerance and safety values as well as the concentration figures must be observed in the interest of public health.

Method of Assessing Insecticide Residues

Effectiveness of insecticidal residues on plant parts, soil or other materials can be determined by simple biological methods. Biological assay of the residual effect of many insecticides can be made with relatively simple means. Tests of *contact insecticides* require insects which react quickly to the compound under study, such as *Drosophila,* the fruit fly, which is frequently found on rotting fruits, or dung flies or meat flies (on manure, faeces, etc.). The test insects are placed on the material, the preparation and condition of which are important for sucessful results. For investigations of non-penetrating insecticides which remain on the surface of leaves or fruits, such as the majority of substances of the group of organochlorine compounds (dieldrin, DDT, etc.), whole leaves or fruits are exposed to the test insects in glass jars. In order to stop insects from escaping and to bring them into close contact with the test material, the containers should be as small as possible. For instance leaves covered with the insecticide to be tested are spread, the treated side upwards, on a clean sheet of paper and covered with a Petri dish; then the insects are introduced into the "test chamber". This is easy when they have previously been inactivated in low temperatures (refrigerator or cold water 0-5°C). In normal room temperature the insects recover within a few moments, run about on the test material so that their tarsi take up any possibly present residue. Insecticidal residue on whole fruits are tested according to their number and size either in jam jars or in glasses. A few drops of sugar water added to the fruits ensure the attraction of the flies and their close contact with the fruits.

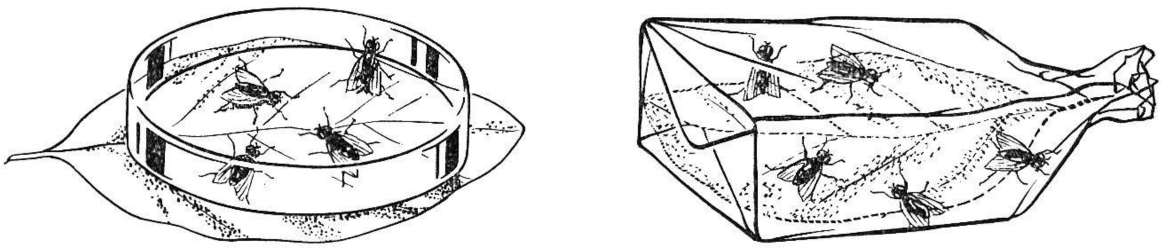

Fig. 88. Test chambers for assessment of insecticide residues.

For assessment of *systemic insecticides* (substances which penetrate into the plants) by this method, the cell sap has to be tested also. Leaves, fruits, or other plant parts are finely chopped, slightly squeezed and in this state presented to the test insects, preferably in Petri dishes (⌀ 10 cm). Where glass or plastic dishes are not available, glass tubes or cellophane bags can be used.

In such tests care has to be taken that the test insects find optimal biological conditions and that they are protected from the sun. To fulfil the requirements of comparative tests concurrent control tests have to be carried out with fresh leaves, fruits, earth samples, etc., both untreated and treated immediately before the test with a definite concentration of the insecticide under study. The normal death rate of the test insects under the given conditions can be determined with untreated material. The lethal effect, i.e. the insecticidal effectiveness of a product, can be established by comparison with the results obtained from treated control material. In order to rule out any remaining uncertainty factors or biological variations, a relatively large number of insects (20-50) should be used for each test.

The effectiveness of an insecticide is calculated by the time until *50% of the insects are moribund* (unable to walk and to fly). If, for instance, a control series of leaves treated with graded concentrations of a known insecticide is made concurrently, it is possible to establish by this method approximate quantities of the compound; the insecticidal film can then be determined approximately from the results obtained from the concentration range of the control tests.

Example of assessing the effectiveness of DDT on coffee berries:

Test material	Coffee berries *(Coffea arabica).* Insecticide treatment of berries against attack of the coffee berry moth *(Thliptoceras octoguttale).* Date: 2. 5. 1960. Size of berries: ∅ 6-8 mm.
Insecticide	DDT-WP 50%. Applied concentration: 0.2%. Application method: high volume.
Assessment of residual effectiveness by biological assay, 14. 5. 1960	
Test insects	*Drosophila* sp. (fruit fly).
Method	20 berries collected from coffee plants were wrapped in a cellophane bag together with 50 fruit flies. Temperature: 26°C. Two test series carried out concurrently.
Comparative control tests	DDT-WP 50% of known concentrations applied to so far untreated berries. When dry, the fruit flies were brought into contact in the same way as above.

Results:

Control series: Insecticide concentrations					Control: untreated berries	Test berries (concentration unknown)
0.2 %	0.15 %	0.1 %	0.05 %	0.025 %		
120′	150′	165′	195′	255′	8 h: all insects alive	180′

Figures = number of minutes which elapsed before 50% of the insects were moribund (unable to walk and to fly).

Conclusion:

The insecticide applied on 2. 5. 1960 on the coffee berries still had a marked residual effect on 14. 5. 1960, which corresponds with that of a fresh concentration of 0.1-0.05%. Reduction of the insecticide lies between 50 and 75%.

For assessment of *stomach poisons,* plants which had been treated with known concentrations of an insecticide, untreated plants, and plants treated with the insecticide under test are offered to an insect species which normally reacts to this insecticide. Test results can be obtained in the same way as in the method described above for contact poisons. When phytophagous larval stages (caterpillars or larvae of beetles) are used as test insects, the youngest stages are preferable, since they are considerably more susceptible than older stages.

The test methods for insecticides on plants and other materials, described in this chapter, are intended as a simple aid for the practical agriculturist, and may prove useful under field conditions. The finer biological methods with which even the smallest amounts of insecticides (0.1 ppm and less) can be measured, require special preliminaries and elaborate equipment; they are therefore reserved for the specialist.

11. DEVELOPMENT AND CAUSES OF RESISTANCE TO INSECTICIDES

Ineffectiveness of an insecticide need not necessarily be the result of unskilled application, faulty dosage or inferior quality of a product; it can also be due to the resistance of a pest against the poison applied. It is known that DDT-AS = DDT active substance (active ingredient) has only little or no effect at all on aphids, mealybugs and coccids. This resistance is a natural phenomenon; these insects tolerate even high amounts of toxic substance. It is possible, however, that formerly susceptible individuals gradually develop a certain resistance for a particular poison. In early times of plant protection cases of resistance were observed; resistance is thus not caused only by modern insecticides. In the USA, for instance, as early as the 1930s a relatively high resistance of the caterpillar of the codling moth against arsenic compounds after many years of application was noticed, and coccids acquired a strong resistance against the highly toxic hydrogen cyanide. Experience in the application of modern synthetic insecticides and acaricides shows that even after only a few years a pest can develop a marked resistance. Results with insecticides in human hygiene (e.g. DDT, Dieldrin, Lindane = organochlorine compounds and Malathion, Diazinon = organophosphorous compounds) merit special attention. For several years houseflies were successfully controlled by such contact insecticides, when in various parts of the world resistant strains occurred which could be controlled neither with the usual nor with higher dosages. In plant protection also cases of established insecticide or acaricide resistance are known, for instance the resistance of the Colorado beetle, codling moth, thrips to organochlorine compounds; numerous species of red spider mites to various organophosphorous compounds, even at dosages 20-30 times higher than normal. The number of pests which are resistant to insecticides is likely to increase in the coming years, especially owing to the extension of control measures.

Resistance to insecticides, which manifests itself in reduced susceptibility of an insect for a chemical, is the result of selection, the presence of sub-lethal amounts on a plant killing the delicate individuals, while those which tolerate a higher proportion of poison may survive. Thus the percentage of poison-tolerant individuals increases from one generation to another. Arthropods with a high reproductive potential and rapid succession of generations acquire their resistance more rapidly. Development of resistance is also speeded up by relatively closed populations which are little joined by fresh individuals from outside. Such selection processes may necessitate higher dosages of chemicals until their application becomes uneconomic.

Many research workers have found reasons for the causes which are responsible for the development of resistance. The relatively great temporal fluctuations of an insect population's reaction to a specific chemical point to a strong influence of constitutional and physiological factors. Susceptibility often depends on the fat and lipoid content in the blood and tissues of an insect. Species with a high proportion of fat can store greater quantities more rapidly and retain them better than those with a lower proportion. Finally the affinity of an insecticide to fats and lipoids of the insect body is also important. A further cause of the development of resistance is probably the presence of neutralizing enzymes. Such enzymes, present in the insect body, can transform penetrated substances into partly or completely inactive compounds, so that their harmful influence on specific centres is nullified. Where resistance is found to exist, the change to another insecticide usually re-establishes the effectiveness required in practice. Experience shows that various arthropods (houseflies, red spider mites) may develop resistance to a new chemical after only a few generations, owing to selective and hereditary enzymes and other defense mechanisms. These insects which are resistant to various compounds of an insecticide group, form strains of so-called *polyvalent resistance,* capable of developing resistance also for chemicals of other groups after a few generations. In poison-resistant insects the degree of resistance diminishes markedly when animals have not come into contact with any insecticidal substance for several generations. Fresh influence of an insecticide, however, can restore their resistance fairly quickly.

Further investigations will be necessary for the discovery of so far unknown factors causing the development of resistance. The greater our knowledge of the complicated relations existing in this field, the better shall we be able to draw the conclusions deriving therefrom. Although we possess today many insecticides of various chemical groups with which the resistant forms of a pest can be controlled, each chemical can provoke signs of resistance. An insecticidal panacea can therefore never be found.

12. GLOSSARY

Acaricide.—Substance or preparation which kills mites.

Active ingredient.—Component part of a formulation which is responsible for the pesticidal effect for which the formulation is designed.

Active substance.—see: Active ingredient.

Affinity.—Tendency of certain substances to unite with others.

Anal plate.—Chitinized shield on the dorsal side of the posterior abdominal segment.

Anal shield.—see: Anal plate.

Anal segment.—Posterior abdominal segment.

Anholocyclic race.—Plant lice which develop only on one host plant.

Apex.—The tip of a wing.

Arthropods.—Bilaterally-symmetrical animals, the body of which is divided into segments; comprising the classes:

1. Crustacea
2. Myriapoda
3. Arachnida
4. Insecta.

Bioassay.—Assessment of toxic substances by means of living organisms (insects and other arthropods).

Biocoenosis.—Assemblage or association of diverse organisms forming a natural oecological unit and more or less dependent one on another (forest, meadow).

Biological control.—Control of pests by means of other living organisms such as predatory or parasitic insects, birds, bacteria, fungi, viruses.

Biological regulation.—Equilibrium of the biocoenosis.

Bionomics.—see: Oecology.

Biotope.—Region uniform in environmental conditions and in its populations of animals or plants.

Callus.—Thickened and hardened part of plant or animal tissue.

carnivorous.—Preying or feeding on animals.

Cell protoplasm.—Substance of the cell body, comprising nucleus, cytoplasm and chromatophores (pigment-bearing cells).

Chemical stability.—Resistance to decomposition.

Chitin.—Substance forming the soft or hard, horny cover of arthropods.

Chlorosis.—A diseased condition of plants manifested as yellowing or blanching of the normally green parts, due to absence of chlorophyll.

chlorotic.—see: Chlorosis.

Cholinesterase.—Enzyme which influences the transmission of nervous reflexes in warm blooded animals.

Cocoon.—Globular or egg-shaped case, formed of hardened secretion from certain animal glands; either as homogeneous covering or silky material (salivary secretion).

Colloid.—Organic substances (starch, protein, silicic acid and others), insoluble in water, suspended or dispersed in liquid medium which diffuse not at all or only very slowly.

Condensation fog.—A suspension of fine droplets of active substances obtained by previously converting these substances into gas.

Cornicles.—see: Siphuncles.

Cuticula.—External, hardened, non-cellular membrane, secreted by the cells of the epidermis and covering them.

Diapause.—A temporary stopping of activity or growth in the development of insect larvae.

Dorsum.—The back, or upper side of an animal.

Droplet size.—The diameter of liquid particles dispersed by a pressurized dispenser, expressed in microns (thousandth of a millimetre).

Ectoparasite.—Insects and other arthropods and worms which dwell and feed on the outside of plants or other animals.

Elytron (elytra).—Outer hard wing-case, especially of coleopterous insects.

Endoparasite.—Insects and other arthropods and worms which live inside plants or other animals, feeding on their tissue.

Enzyme.—Naturally occurring, organic substances, the presence of which regulates biochemical processes in the organism.

Ethyl acetate.—Colourless liquid, obtained by the interaction of ethyl alcohol, sodium acetate, and sulphuric acid.

Exuvia.—Skins or coverings of animals, shed or cast off when moulting.

Ferment.—see: Enzyme.

Flagellum.—A whip-like appendage.

Genus.—An assemblage of closely related species (plural = genera).

Gummosis.—A plant disease, characterized by the formation of a colourless or brownish-red, resinous exudate.

Habitat.—Environment of an organism.

Halter (halteres).—One of a pair of club-shaped organs, which assist Diptera in balancing.

hemicephalous.—Having a poorly developed, but distinct head.

herbivorous.—Feeding on plant tissue.

heterogamous.—see: Heterogony.

Heterogony.—Alternation of generations, diverse in character, a sexual generation alternating with several secondary asexual generations.

Honeydew.—Saccharine, honey-like secretion, produced by aphids and which is eagerly sought for as food by other insects. Forms also culture medium for sooty mould.

Hormones.—Kinds of internal secretion that pass into the blood and produce or regulate specific physiological and evolutive processes.

hyaline.—Glass-like.

Hypertrophy.—Excessive growth or development of cells, leading to distortion, curling, or splitting of plant parts.

Imago.—Final adult, sexually mature stage of an insect after either complete or incomplete metamorphosis.

Inhibitor.—Any substance which retards a physiological process.

Inorganic compounds.—Substances which are composed of metallic, mineral, alkaline or acid elements, such as arsenate of lead, arsenate of lime, common salt.

Insectivora.—Animals feeding on insects.

Invertebrates.—Animals that have no backbone or spinal column.

Lamina.—The blade of a leaf.

Lasting effect.—Quality of an insecticide to kill even those insects which come into contact with the dried chemical deposit.

Lipoid.—A fatlike substance in animals or plants.

lipoid-solving.—1. Soluble in fats. 2. Capable of dissolving fats.

Micron.—0.001 millimetre or the millionth of a metre.

Morphology.—The outer form and structure of animals and plants.

Moulting.— The periodical shedding of the outer chitinous cuticle and its appendages of arthropods during their larval development.

necrotic.—Marked with patches of dead cells or tissue as a result of malnutrition.

Oecology.—Branch of biology dealing with living organisms' habits, modes of life, and relations to their surroundings.

omnivorous.—Eating both animal and vegetable food.

Organic solvents.—Organic liquids such as: ethanol, benzen, chloroform, ether, aceton, carbontetrachloride.

Parasite.—A plant or animal living in or upon another and drawing nutriment directly from it.

Parenchymatous tissue (Parenchym).—Tissue of cells of about equal length and breadth placed side by side.

Parthenogenetic reproduction.—Reproduction without sexual union; development of an organism from an unfertilized egg.

Pedicel.—A small, stalk-like structure in plants or animals.

Peduncle.—see: Pedicel.

Petiole.—Stalk of a leaf, part of a leaf and not of the stem axis.

Phloem.—Plant tissue which conducts the elaborated food material from the leaves down the stem.

Phytotoxicity.—Poisonous action or effect on a plant.

polyphagous.—Feeding on various kinds of plants.

Predators.—Insects and other arthropods which live by preying upon eggs, larvae, pupae or adults of other animal species.

Pronotum.—The dorsal plate of an insect's prothorax.

Pupation.—The passage from the larval to the pupal stage.

Residual effect.—The effect of the pesticidal substance which adheres or remains on a plant.

Respiration.—The entire series of physical and chemical processes accomplishing oxidation and the removal of carbon dioxide.

Rhizome.—An elongated underground stem, usually horizontal, often thickened into a food reserve.

Rostrum.—The beak or snout of an insect.

saprobous.—Feeding on decaying plant or animal matter.

Scutellum.—Small, often wedge-shaped shield, plate or scale between the elytra of certain insects, especially Coleoptera and Heteroptera.

Siphons.—see: Siphuncles.

Siphuncles.—A pair of tubular processes on the dorsal side of the 5th or 6th abdominal segment of certain insects (Aphids).

Sooty mould.—A black velvety coating on leaves, shoots and other plant parts, produced by various fungus species of the genus *Apiosporium*. These fungi develop in the honeydew and disturb assimilation of plants, without, however, penetrating into the tissue.

Species.—A group of animals or plants which possess in common one or more characters distinguishing them from other similar groups and do or may interbreed and reproduce their characters in their offspring, exhibiting between each other only minor differences.

Spiracle.—A breathing-hole in certain animals.

Sternite.—The chitinous plate that forms the ventral surface of the thoracic and abdominal segments.

Sublethal dose.—Dose insufficient to cause death.

Synergism.—Combined action of two compounds such that the total effect is greater than the sum of the two effects taken independently.—Increase of the efficiency of a compound when it is combined with another, not necessarily toxic compound.

synthetic.—Artificially produced.

Tergite.—The dorsal plate or portion of the thoracic and abdominal segments.

Toxicity.—Degree of being poisonous.

Toxicity, acute.—Toxicity of one dose.

Toxicity, chronic.—Toxicity of a series of doses.

Transpiration.—The emission or exhalation of watery vapour from the surface of green tissues in plants.

Urticaria (skin irritation).—An inflammatory disease of the skin, characterized by wales and blisters, and accompanied by intense itching.

Vector (carrier).—An organism which carries and transmits disease-causing microorganisms, e.g. aphids as vectors of virus.

Virulence.—Infectiousness and pathogenicity of disease-causing microorganisms for the host (plant or animal).

Virus.—Poisonous substances, i.e. ultramicroscopical organisms which may cause infectious disease (see also under Tobacco, page 355).

Xylem.—Plant tissue which conveys water from the roots up the stem.

13. CONVERSION TABLES FOR WEIGHTS, MEASURES AND TEMPERATURES

(Reproduced from "Scientific Tables Geigy"
by kind permission of J. R. Geigy S.A. Basle)

Conversion of Length Units (Feet and Inches/Centimeters)

Examples: (*a*) 45 in = 3 ft 9 in
(*b*) 60⅜ in = 153.4 cm; 2.23 in = 2 in + 0.23 in = 5.08 cm + 0.5842 cm = 5.6642 cm; 3 ft 8¾ in = 113.7 cm
(*c*) 101 cm = 39.764 in ≈ 3 ft 3¾ in; 10.1 cm = 3.9764 in

Inches or Feet and Inches – Centimeters

in	ft + in	0	⅛ (0.125)	¼ (0.25)	⅜ (0.375)	½ (0.5)	⅝ (0.625)	¾ (0.75)	⅞ (0.875)	in	ft + in	0	⅛ (0.125)	¼ (0.25)	⅜ (0.375)	½ (0.5)	⅝ (0.625)	¾ (0.75)	⅞ (0.875)
0	**0** 0	0.000	0.318	0.635	0.953	1.270	1.588	1.905	2.223	54	**4** 6	137.2	137.5	137.8	138.1	138.4	138.7	139.1	139.4
1	**0** 1	2.540	2.858	3.175	3.493	3.810	4.128	4.445	4.763	55	**4** 7	139.7	140.0	140.3	140.7	141.0	141.3	141.6	141.9
2	**0** 2	5.080	5.398	5.715	6.033	6.350	6.668	6.985	7.303	56	**4** 8	142.2	142.6	142.9	143.2	143.5	143.8	144.1	144.5
3	**0** 3	7.620	7.938	8.255	8.573	8.890	9.208	9.525	9.843	57	**4** 9	144.8	145.1	145.4	145.7	146.1	146.4	146.7	147.0
4	**0** 4	10.16	10.48	10.80	11.11	11.43	11.75	12.07	12.38	58	**4** 10	147.3	147.6	148.0	148.3	148.6	148.9	149.2	149.5
5	**0** 5	12.70	13.02	13.34	13.65	13.97	14.29	14.61	14.92	59	**4** 11	149.9	150.2	150.5	150.8	151.1	151.4	151.8	152.1
6	**0** 6	15.24	15.56	15.88	16.19	16.51	16.83	17.15	17.46	**60**	**5** 0	152.4	152.7	153.0	153.4	153.7	154.0	154.3	154.6
7	**0** 7	17.78	18.10	18.42	18.73	19.05	19.37	19.69	20.00	61	**5** 1	154.9	155.3	155.6	155.9	156.2	156.5	156.8	157.2
8	**0** 8	20.32	20.64	20.96	21.27	21.59	21.91	22.23	22.54	62	**5** 2	157.5	157.8	158.1	158.4	158.8	159.1	159.4	159.7
9	**0** 9	22.86	23.18	23.50	23.81	24.13	24.45	24.77	25.08	63	**5** 3	160.0	160.3	160.7	161.0	161.3	161.6	161.9	162.2
10	**0** 10	25.40	25.72	26.04	26.35	26.67	26.99	27.31	27.62	64	**5** 4	162.6	162.9	163.2	163.5	163.8	164.1	164.5	164.8
11	**0** 11	27.94	28.26	28.58	28.89	29.21	29.53	29.85	30.16	65	**5** 5	165.1	165.4	165.7	166.1	166.4	166.7	167.0	167.3
12	**1** 0	30.48	30.80	31.12	31.43	31.75	32.07	32.39	32.70	**66**	**5** 6	167.6	168.0	168.3	168.6	168.9	169.2	169.5	169.9
13	**1** 1	33.02	33.34	33.66	33.97	34.29	34.61	34.93	35.24	67	**5** 7	170.2	170.5	170.8	171.1	171.5	171.8	172.1	172.4
14	**1** 2	35.56	35.88	36.20	36.51	36.83	37.15	37.47	37.78	68	**5** 8	172.7	173.0	173.4	173.7	174.0	174.3	174.6	174.9
15	**1** 3	38.10	38.42	38.74	39.05	39.37	39.69	40.01	40.32	69	**5** 9	175.3	175.6	175.9	176.2	176.5	176.8	177.2	177.5
16	**1** 4	40.64	40.96	41.28	41.59	41.91	42.23	42.55	42.86	70	**5** 10	177.8	178.1	178.4	178.8	179.1	179.4	179.7	180.0
17	**1** 5	43.18	43.50	43.82	44.13	44.45	44.77	45.09	45.40	71	**5** 11	180.3	180.7	181.0	181.3	181.6	181.9	182.2	182.6
18	**1** 6	45.72	46.04	46.36	46.67	46.99	47.31	47.63	47.94	**72**	**6** 0	182.9	183.2	183.5	183.8	184.2	184.5	184.8	185.1
19	**1** 7	48.26	48.58	48.90	49.21	49.53	49.85	50.17	50.48	73	**6** 1	185.4	185.7	186.1	186.4	186.7	187.0	187.3	187.6
20	**1** 8	50.80	51.12	51.44	51.75	52.07	52.39	52.71	53.02	74	**6** 2	188.0	188.3	188.6	188.9	189.2	189.5	189.9	190.2
21	**1** 9	53.34	53.66	53.98	54.29	54.61	54.93	55.25	55.56	75	**6** 3	190.5	190.8	191.1	191.5	191.8	192.1	192.4	192.7
22	**1** 10	55.88	56.20	56.52	56.83	57.15	57.47	57.79	58.10	76	**6** 4	193.0	193.4	193.7	194.0	194.3	194.6	194.9	195.3
23	**1** 11	58.42	58.74	59.06	59.37	59.69	60.01	60.33	60.64	77	**6** 5	195.6	195.9	196.2	196.5	196.9	197.2	197.5	197.8
24	**2** 0	60.96	61.28	61.60	61.91	62.23	62.55	62.87	63.18	**78**	**6** 6	198.1	198.4	198.8	199.1	199.4	199.7	200.0	200.3
25	**2** 1	63.50	63.82	64.14	64.45	64.77	65.09	65.41	65.72	79	**6** 7	200.7	201.0	201.3	201.6	201.9	202.2	202.6	202.9
26	**2** 2	66.04	66.36	66.68	66.99	67.31	67.63	67.95	68.26	80	**6** 8	203.2	203.5	203.8	204.2	204.5	204.8	205.1	205.4
27	**2** 3	68.58	68.90	69.22	69.53	69.85	70.17	70.49	70.80	81	**6** 9	205.7	206.1	206.4	206.7	207.0	207.3	207.6	208.0
28	**2** 4	71.12	71.44	71.76	72.07	72.39	72.71	73.03	73.34	82	**6** 10	208.3	208.6	208.9	209.2	209.6	209.9	210.2	210.5
29	**2** 5	73.66	73.98	74.30	74.61	74.93	75.25	75.57	75.88	83	**6** 11	210.8	211.1	211.5	211.8	212.1	212.4	212.7	213.0
30	**2** 6	76.20	76.52	76.84	77.15	77.47	77.79	78.11	78.42	**84**	**7** 0	213.4	213.7	214.0	214.3	214.6	214.9	215.3	215.6
31	**2** 7	78.74	79.06	79.38	79.69	80.01	80.33	80.65	80.96	85	**7** 1	215.9	216.2	216.5	216.9	217.2	217.5	217.8	218.1
32	**2** 8	81.28	81.60	81.92	82.23	82.55	82.87	83.19	83.50	86	**7** 2	218.4	218.8	219.1	219.4	219.7	220.0	220.3	220.7
33	**2** 9	83.82	84.14	84.46	84.77	85.09	85.41	85.73	86.04	87	**7** 3	221.0	221.3	221.6	221.9	222.3	222.6	222.9	223.2
34	**2** 10	86.36	86.68	87.00	87.31	87.63	87.95	88.27	88.58	88	**7** 4	223.5	223.8	224.2	224.5	224.8	225.1	225.4	225.7
35	**2** 11	88.90	89.22	89.54	89.85	90.17	90.49	90.81	91.12	89	**7** 5	226.1	226.4	226.7	227.0	227.3	227.6	228.0	228.3
36	**3** 0	91.44	91.76	92.08	92.39	92.71	93.03	93.35	93.66	**90**	**7** 6	228.6	228.9	229.2	229.6	229.9	230.2	230.5	230.8
37	**3** 1	93.98	94.30	94.62	94.93	95.25	95.57	95.89	96.20	91	**7** 7	231.1	231.5	231.8	232.1	232.4	232.7	233.0	233.4
38	**3** 2	96.52	96.84	97.16	97.47	97.79	98.11	98.43	98.74	92	**7** 8	233.7	234.0	234.3	234.6	235.0	235.3	235.6	235.9
39	**3** 3	99.06	99.38	99.70	100.0	100.3	100.6	101.0	101.3	93	**7** 9	236.2	236.5	236.9	237.2	237.5	237.8	238.1	238.4
40	**3** 4	101.6	101.9	102.2	102.6	102.9	103.2	103.5	103.8	94	**7** 10	238.8	239.1	239.4	239.7	240.0	240.3	240.7	241.0
41	**3** 5	104.1	104.5	104.8	105.1	105.4	105.7	106.0	106.4	95	**7** 11	241.3	241.6	241.9	242.3	242.6	242.9	243.2	243.5
42	**3** 6	106.7	107.0	107.3	107.6	108.0	108.3	108.6	108.9	**96**	**8** 0	243.8	244.2	244.5	244.8	245.1	245.4	245.7	246.1
43	**3** 7	109.2	109.5	109.9	110.2	110.5	110.8	111.1	111.4	97	**8** 1	246.4	246.7	247.0	247.3	247.7	248.0	248.3	248.6
44	**3** 8	111.8	112.1	112.4	112.7	113.0	113.3	113.7	114.0	98	**8** 2	248.9	249.2	249.6	249.9	250.2	250.5	250.8	251.1
45	**3** 9	114.3	114.6	114.9	115.3	115.6	115.9	116.2	116.5	99	**8** 3	251.5	251.8	252.1	252.4	252.7	253.0	253.4	253.7
46	**3** 10	116.8	117.2	117.4	117.8	118.1	118.4	118.7	119.1	100	**8** 4	254.0	254.3	254.6	255.0	255.3	255.6	255.9	256.2
47	**3** 11	119.4	119.7	120.0	120.3	120.7	121.0	121.3	121.6	101	**8** 5	256.5	256.9	257.2	257.5	257.8	258.1	258.4	258.8
48	**4** 0	121.9	122.2	122.6	122.9	123.2	123.5	123.8	124.1	**102**	**8** 6	259.1	259.4	259.7	260.0	260.4	260.7	261.0	261.3
49	**4** 1	124.5	124.8	125.1	125.4	125.7	126.0	126.4	126.7	103	**8** 7	261.6	261.9	262.3	262.6	262.9	263.2	263.5	263.8
50	**4** 2	127.0	127.3	127.6	128.0	128.3	128.6	128.9	129.2	104	**8** 8	264.2	264.5	264.8	265.1	265.4	265.7	266.1	266.4
51	**4** 3	129.5	129.9	130.2	130.5	130.8	131.1	131.4	131.8	105	**8** 9	266.7	267.0	267.3	267.7	268.0	268.3	268.6	268.9
52	**4** 4	132.1	132.4	132.7	133.0	133.4	133.7	134.0	134.3	106	**8** 10	269.2	269.6	269.9	270.2	270.5	270.8	271.1	271.5
53	**4** 5	134.6	134.9	135.3	135.6	135.9	136.2	136.5	136.8	107	**8** 11	271.8	272.1	272.4	272.7	273.1	273.4	273.7	274.0

Centimeters – Inches or Feet and Inches

cm	0		1		2		3		4		5		6		7		8		9	
	in	ft+in†	in	ft+in†	in	ft+in†	in	ft+in†	in	ft+in†	in	ft+in†	in	ft+in†	in	ft+in†	in	ft+in†	in	ft+in†
0	0.0000	**0** 0	0.3937	**0** 0⅜	0.7874	**0** 0¾	1.1811	**0** 1⅛	1.5748	**0** 1⅝	1.9685	**0** 2	2.3622	**0** 2⅜	2.7559	**0** 2¾	3.1496	**0** 3⅛	3.5433	**0** 3½
10	3.9370	**0** 3⅞	4.3307	**0** 4⅜	4.7244	**0** 4¾	5.1181	**0** 5⅛	5.5118	**0** 5½	5.9055	**0** 5⅞	6.2992	**0** 6¼	6.6929	**0** 6¾	7.0866	**0** 7⅛	7.4803	**0** 7½
20	7.8740	**0** 7⅞	8.2677	**0** 8¼	8.6614	**0** 8⅝	9.0551	**0** 9	9.4488	**0** 9½	9.8425	**0** 9⅞	10.236	**0** 10¼	10.630	**0** 10⅝	11.024	**0** 11	11.417	**0** 11⅜
30	11.811	**0** 11¾	12.205	**1** 0¼	12.598	**1** 0⅝	12.992	**1** 1	13.386	**1** 1⅜	13.780	**1** 1¾	14.173	**1** 2⅛	14.567	**1** 2⅝	14.961	**1** 3	15.354	**1** 3⅜
40	15.748	**1** 3¾	16.142	**1** 4⅛	16.535	**1** 4½	16.929	**1** 4⅞	17.323	**1** 5⅜	17.717	**1** 5¾	18.110	**1** 6⅛	18.504	**1** 6½	18.898	**1** 6⅞	19.291	**1** 7¼
50	19.685	**1** 7⅝	20.079	**1** 8⅛	20.472	**1** 8½	20.866	**1** 8⅞	21.260	**1** 9¼	21.654	**1** 9⅝	22.047	**1** 10	22.441	**1** 10½	22.835	**1** 10⅞	23.228	**1** 11¼
60	23.622	**1** 11⅝	24.016	**2** 0	24.409	**2** 0⅜	24.803	**2** 0¾	25.197	**2** 1¼	25.591	**2** 1⅝	25.984	**2** 2	26.378	**2** 2⅜	26.772	**2** 2¾	27.165	**2** 3⅛
70	27.559	**2** 3½	27.953	**2** 4	28.346	**2** 4⅜	28.740	**2** 4¾	29.134	**2** 5⅛	29.528	**2** 5½	29.921	**2** 5⅞	30.315	**2** 6⅜	30.709	**2** 6¾	31.102	**2** 7⅛
80	31.496	**2** 7½	31.890	**2** 7⅞	32.283	**2** 8¼	32.677	**2** 8⅝	33.071	**2** 9⅛	33.465	**2** 9½	33.858	**2** 9⅞	34.252	**2** 10¼	34.646	**2** 10⅝	35.039	**2** 11
90	35.433	**2** 11⅜	35.827	**2** 11⅞	36.220	**3** 0¼	36.614	**3** 0⅝	37.008	**3** 1	37.402	**3** 1⅜	37.795	**3** 1¾	38.189	**3** 2¼	38.583	**3** 2⅝	38.976	**3** 3
100	39.370	**3** 3⅜	39.764	**3** 3¾	40.157	**3** 4⅛	40.551	**3** 4½	40.945	**3** 5	41.339	**3** 5⅜	41.732	**3** 5¾	42.126	**3** 6⅛	42.520	**3** 6½	42.913	**3** 6⅞
110	43.307	**3** 7¼	43.701	**3** 7¾	44.094	**3** 8⅛	44.488	**3** 8½	44.882	**3** 8⅞	45.276	**3** 9¼	45.669	**3** 9⅝	46.063	**3** 10⅛	46.457	**3** 10½	46.850	**3** 10⅞
120	47.244	**3** 11¼	47.638	**3** 11⅝	48.031	**4** 0	48.425	**4** 0⅜	48.819	**4** 0⅞	49.213	**4** 1¼	49.606	**4** 1⅝	50.000	**4** 2	50.394	**4** 2⅜	50.787	**4** 2¾
130	51.181	**4** 3⅛	51.575	**4** 3⅝	51.968	**4** 4	52.362	**4** 4⅜	52.756	**4** 4¾	53.150	**4** 5⅛	53.543	**4** 5½	53.937	**4** 5⅞	54.331	**4** 6⅜	54.724	**4** 6¾
140	55.118	**4** 7⅛	55.512	**4** 7½	55.905	**4** 7⅞	56.299	**4** 8¼	56.693	**4** 8¾	57.087	**4** 9⅛	57.480	**4** 9½	57.874	**4** 9⅞	58.268	**4** 10¼	58.661	**4** 10⅝
150	59.055	**4** 11	59.449	**4** 11½	59.842	**4** 11⅞	60.236	**5** 0¼	60.630	**5** 0⅝	61.024	**5** 1	61.417	**5** 1⅜	61.811	**5** 1¾	62.205	**5** 2¼	62.598	**5** 2⅝
160	62.992	**5** 3	63.386	**5** 3⅜	63.779	**5** 3¾	64.173	**5** 4⅛	64.567	**5** 4⅝	64.961	**5** 5	65.354	**5** 5⅜	65.748	**5** 5¾	66.142	**5** 6⅛	66.535	**5** 6½
170	66.929	**5** 6⅞	67.323	**5** 7⅜	67.716	**5** 7¾	68.110	**5** 8⅛	68.504	**5** 8½	68.898	**5** 8⅞	69.291	**5** 9¼	69.685	**5** 9⅝	70.079	**5** 10⅛	70.472	**5** 10½
180	70.866	**5** 10⅞	71.260	**5** 11¼	71.653	**5** 11⅝	72.047	**6** 0	72.441	**6** 0½	72.835	**6** 0⅞	73.228	**6** 1¼	73.622	**6** 1⅝	74.016	**6** 2	74.409	**6** 2⅜
190	74.803	**6** 2¾	75.197	**6** 3¼	75.590	**6** 3⅝	75.984	**6** 4	76.378	**6** 4⅜	76.772	**6** 4¾	77.165	**6** 5⅛	77.559	**6** 5½	77.953	**6** 6	78.346	**6** 6⅜
200	78.740	**6** 6¾	79.134	**6** 7⅛	79.527	**6** 7½	79.921	**6** 7⅞	80.315	**6** 8⅜	80.709	**6** 8¾	81.102	**6** 9⅛	81.496	**6** 9½	81.890	**6** 9⅞	82.283	**6** 10¼
210	82.677	**6** 10⅝	83.071	**6** 11⅛	83.464	**6** 11½	83.858	**6** 11⅞	84.252	**7** 0¼	84.646	**7** 0⅝	85.039	**7** 1	85.433	**7** 1⅜	85.827	**7** 1⅞	86.220	**7** 2¼
220	86.614	**7** 2⅝	87.008	**7** 3	87.401	**7** 3⅜	87.795	**7** 3¾	88.189	**7** 4¼	88.583	**7** 4⅝	88.976	**7** 5	89.370	**7** 5⅜	89.764	**7** 5¾	90.157	**7** 6⅛
230	90.551	**7** 6½	90.945	**7** 7	91.338	**7** 7⅜	91.732	**7** 7¾	92.126	**7** 8⅛	92.520	**7** 8½	92.913	**7** 8⅞	93.307	**7** 9¼	93.701	**7** 9¾	94.094	**7** 10⅛
240	94.488	**7** 10½	94.882	**7** 10⅞	95.275	**7** 11¼	95.669	**7** 11⅝	96.063	**8** 0⅛	96.457	**8** 0½	96.850	**8** 0⅞	97.244	**8** 1¼	97.638	**8** 1⅝	98.031	**8** 2
250	98.425	**8** 2⅜	98.819	**8** 2⅞	99.212	**8** 3¼	99.606	**8** 3⅝	100.00	**8** 4	100.39	**8** 4⅜	100.79	**8** 4¾	101.18	**8** 5⅛	101.57	**8** 5⅝	101.97	**8** 6
260	102.36	**8** 6⅜	102.76	**8** 6¾	103.15	**8** 7⅛	103.54	**8** 7½	103.94	**8** 8	104.33	**8** 8⅜	104.72	**8** 8¾	105.12	**8** 9⅛	105.51	**8** 9½	105.91	**8** 9⅞
270	106.30	**8** 10¼	106.69	**8** 10¾	107.09	**8** 11⅛	107.48	**8** 11½	107.87	**8** 11⅞	108.27	**9** 0¼	108.66	**9** 0⅝	109.05	**9** 1	109.45	**9** 1½	109.84	**9** 1⅞
280	110.24	**9** 2¼	110.63	**9** 2⅝	111.02	**9** 3	111.42	**9** 3⅜	111.81	**9** 3¾	112.20	**9** 4¼	112.60	**9** 4⅝	112.99	**9** 5	113.39	**9** 5⅜	113.78	**9** 5¾
290	114.17	**9** 6⅛	114.57	**9** 6⅝	114.96	**9** 7	115.35	**9** 7⅜	115.75	**9** 7¾	116.14	**9** 8⅛	116.54	**9** 8½	116.93	**9** 8⅞	117.32	**9** 9⅜	117.72	**9** 9¾

Conversion of Mass and Capacity Units

Ounces (avoirdupois) – Grams

	0	1	2	3	4	5	6	7	8	9
0	00.000	28.350	56.699	85.049	113.40	141.75	170.10	198.45	226.80	255.15
10	283.50	311.84	340.19	368.54	396.89	425.24	453.59	481.94	510.29	538.64
20	566.99	595.34	623.69	652.04	680.39	708.74	737.09	765.44	793.79	822.14
30	850.49	878.84	907.18	935.53	963.88	992.23	1020.6	1048.9	1077.3	1105.6
40	1134.0	1162.3	1190.7	1219.0	1247.4	1275.7	1304.1	1332.4	1360.8	1389.1
50	1417.5	1445.8	1474.2	1502.5	1530.9	1559.2	1587.6	1615.9	1644.3	1672.6
60	1701.0	1729.3	1757.7	1786.0	1814.4	1842.7	1871.1	1899.4	1927.8	1956.1
70	1984.5	2012.8	2041.2	2069.5	2097.9	2126.2	2154.6	2182.9	2211.3	2239.6
80	2268.0	2296.3	2324.7	2353.0	2381.4	2409.7	2438.1	2466.4	2494.8	2523.1
90	2551.5	2579.8	2608.2	2636.5	2664.9	2693.2	2721.6	2749.9	2778.3	2806.6

Grams – Ounces (avoirdupois)

	0	1	2	3	4	5	6	7	8	9
0	0.0000	0.0353	0.0705	0.1058	0.1411	0.1764	0.2116	0.2469	0.2822	0.3175
10	0.3527	0.3880	0.4233	0.4586	0.4938	0.5291	0.5644	0.5997	0.6349	0.6702
20	0.7055	0.7408	0.7760	0.8113	0.8466	0.8818	0.9171	0.9524	0.9877	1.0229
30	1.0582	1.0935	1.1288	1.1640	1.1993	1.2346	1.2699	1.3051	1.3404	1.3757
40	1.4110	1.4462	1.4815	1.5168	1.5521	1.5873	1.6226	1.6579	1.6932	1.7284
50	1.7637	1.7990	1.8342	1.8695	1.9048	1.9401	1.9753	2.0106	2.0459	2.0812
60	2.1164	2.1517	2.1870	2.2223	2.2575	2.2928	2.3281	2.3634	2.3986	2.4339
70	2.4692	2.5045	2.5397	2.5750	2.6103	2.6455	2.6808	2.7161	2.7514	2.7866
80	2.8219	2.8572	2.8925	2.9277	2.9630	2.9983	3.0336	3.0688	3.1041	3.1394
90	3.1747	3.2099	3.2452	3.2805	3.3158	3.3510	3.3863	3.4216	3.4568	3.4921

Ounces (apothecary) – Grams

	0	1	2	3	4	5	6	7	8	9
0	00.000	31.103	62.207	93.310	124.41	155.52	186.62	217.72	248.83	279.93
10	311.03	342.14	373.24	404.35	435.45	466.55	497.66	528.76	559.86	590.97
20	622.07	653.17	684.28	715.38	746.48	777.59	808.69	839.79	870.90	902.00
30	933.10	964.21	995.31	1026.4	1057.5	1088.6	1119.7	1150.8	1181.9	1213.0
40	1244.1	1275.2	1306.3	1337.4	1368.6	1399.7	1430.8	1461.9	1493.0	1524.1
50	1555.2	1586.3	1617.4	1648.5	1679.6	1710.7	1741.8	1772.9	1804.0	1835.1
60	1866.2	1897.3	1928.4	1959.5	1990.6	2021.7	2052.8	2083.9	2115.0	2146.1
70	2177.2	2208.3	2239.5	2270.6	2301.7	2332.8	2363.9	2395.0	2426.1	2457.2
80	2488.3	2519.4	2550.5	2581.6	2612.7	2643.8	2674.9	2706.0	2737.1	2768.2
90	2799.3	2830.4	2861.5	2892.6	2923.7	2954.8	2985.9	3017.0	3048.1	3079.2

Grams – Ounces (apothecary)

	0	1	2	3	4	5	6	7	8	9
0	0.0000	0.0322	0.0643	0.0965	0.1286	0.1608	0.1929	0.2251	0.2572	0.2894
10	0.3215	0.3537	0.3858	0.4180	0.4501	0.4823	0.5144	0.5466	0.5787	0.6109
20	0.6430	0.6752	0.7073	0.7395	0.7716	0.8038	0.8359	0.8681	0.9002	0.9324
30	0.9645	0.9967	1.0288	1.0610	1.0931	1.1253	1.1574	1.1896	1.2217	1.2539
40	1.2860	1.3182	1.3503	1.3825	1.4146	1.4468	1.4789	1.5111	1.5432	1.5754
50	1.6075	1.6397	1.6718	1.7040	1.7361	1.7683	1.8004	1.8326	1.8647	1.8969
60	1.9290	1.9612	1.9933	2.0255	2.0576	2.0898	2.1219	2.1541	2.1863	2.2184
70	2.2506	2.2827	2.3149	2.3470	2.3792	2.4113	2.4435	2.4756	2.5078	2.5399
80	2.5721	2.6042	2.6364	2.6685	2.7007	2.7328	2.7650	2.7971	2.8293	2.8614
90	2.8936	2.9257	2.9579	2.9900	3.0222	3.0543	3.0865	3.1186	3.1508	3.1829

Fluid ounces (Brit.) – Milliliters

	0	1	2	3	4	5	6	7	8	9
0	00.000	28.412	56.825	85.237	113.65	142.06	170.47	198.89	227.30	255.71
10	284.12	312.53	340.95	369.36	397.77	426.18	454.60	483.01	511.42	539.83
20	568.25	596.66	625.07	653.48	681.89	710.31	738.72	767.13	795.54	823.96
30	852.37	880.78	909.19	937.60	966.02	994.43	1022.8	1051.3	1079.7	1108.1
40	1136.5	1164.9	1193.3	1221.7	1250.1	1278.6	1307.0	1335.4	1363.8	1392.2
50	1420.6	1449.0	1477.4	1505.9	1534.3	1562.7	1591.1	1619.5	1647.9	1676.3
60	1704.7	1733.1	1761.6	1790.0	1818.4	1846.8	1875.2	1903.6	1932.0	1960.4
70	1988.9	2017.3	2045.7	2074.1	2102.5	2130.9	2159.3	2187.7	2216.2	2244.6
80	2273.0	2301.4	2329.8	2358.2	2386.6	2415.0	2443.5	2471.9	2500.3	2528.7
90	2557.1	2585.5	2613.9	2642.3	2670.8	2699.2	2727.6	2756.0	2784.4	2812.8

Milliliters – Fluid ounces (Brit.)

	0	1	2	3	4	5	6	7	8	9
0	0.0000	0.0352	0.0704	0.1056	0.1408	0.1760	0.2112	0.2464	0.2816	0.3168
10	0.3520	0.3872	0.4224	0.4575	0.4927	0.5279	0.5631	0.5983	0.6335	0.6687
20	0.7039	0.7391	0.7743	0.8095	0.8447	0.8799	0.9151	0.9503	0.9855	1.0207
30	1.0559	1.0911	1.1263	1.1615	1.1967	1.2319	1.2671	1.3023	1.3375	1.3726
40	1.4078	1.4430	1.4782	1.5134	1.5486	1.5838	1.6190	1.6542	1.6894	1.7246
50	1.7598	1.7950	1.8302	1.8654	1.9006	1.9358	1.9710	2.0062	2.0414	2.0766
60	2.1118	2.1470	2.1822	2.2174	2.2525	2.2877	2.3229	2.3581	2.3933	2.4285
70	2.4637	2.4989	2.5341	2.5693	2.6045	2.6397	2.6749	2.7101	2.7453	2.7805
80	2.8157	2.8509	2.8861	2.9213	2.9565	2.9917	3.0269	3.0621	3.0973	3.1324
90	3.1676	3.2028	3.2380	3.2732	3.3084	3.3436	3.3788	3.4140	3.4492	3.4844

Fluid ounces (US) – Milliliters

	0	1	2	3	4	5	6	7	8	9
0	00.000	29.573	59.146	88.719	118.29	147.86	177.44	207.01	236.58	266.16
10	295.73	325.30	354.87	384.45	414.02	443.59	473.17	502.74	532.31	561.88
20	591.46	621.03	650.60	680.18	709.75	739.32	768.89	798.47	828.04	857.61
30	887.19	916.76	946.33	975.91	1005.5	1035.1	1064.6	1094.2	1123.8	1153.3
40	1182.9	1212.5	1242.1	1271.6	1301.2	1330.8	1360.4	1389.9	1419.5	1449.1
50	1478.6	1508.2	1537.8	1567.4	1596.9	1626.5	1656.1	1685.7	1715.2	1744.8
60	1774.4	1803.9	1833.5	1863.1	1892.7	1922.2	1951.8	1981.4	2011.0	2040.5
70	2070.1	2099.7	2129.2	2158.8	2188.4	2218.0	2247.5	2277.1	2306.7	2336.3
80	2365.8	2395.4	2425.0	2454.5	2484.1	2513.7	2543.3	2572.8	2602.4	2632.0
90	2661.6	2691.1	2720.7	2750.3	2779.9	2809.4	2839.0	2868.6	2898.1	2927.7

Milliliters – Fluid ounces (US)

	0	1	2	3	4	5	6	7	8	9
0	0.0000	0.0338	0.0676	0.1014	0.1353	0.1691	0.2029	0.2367	0.2705	0.3043
10	0.3381	0.3720	0.4058	0.4396	0.4734	0.5072	0.5410	0.5749	0.6087	0.6425
20	0.6763	0.7101	0.7439	0.7777	0.8116	0.8454	0.8792	0.9130	0.9468	0.9806
30	1.0144	1.0483	1.0821	1.1159	1.1497	1.1835	1.2173	1.2511	1.2850	1.3188
40	1.3526	1.3864	1.4202	1.4540	1.4878	1.5217	1.5555	1.5893	1.6231	1.6569
50	1.6907	1.7246	1.7584	1.7922	1.8260	1.8598	1.8936	1.9274	1.9613	1.9951
60	2.0289	2.0627	2.0965	2.1303	2.1641	2.1980	2.2318	2.2656	2.2994	2.3332
70	2.3670	2.4008	2.4347	2.4685	2.5023	2.5361	2.5699	2.6037	2.6376	2.6714
80	2.7052	2.7390	2.7728	2.8066	2.8404	2.8743	2.9081	2.9419	2.9757	3.0095
90	3.0433	3.0771	3.1110	3.1448	3.1786	3.2124	3.2462	3.2800	3.3138	3.3477

Pints (Brit.) – Liters

	0	1	2	3	4	5	6	7	8	9
0	0.0000	0.5682	1.1365	1.7047	2.2730	2.8412	3.4095	3.9777	4.5460	5.1142
10	5.6825	6.2507	6.8189	7.3872	7.9554	8.5237	9.0919	9.6602	10.228	10.797
20	11.365	11.933	12.501	13.070	13.638	14.206	14.774	15.343	15.911	16.479
30	17.047	17.616	18.184	18.752	19.320	19.889	20.457	21.025	21.593	22.162
40	22.730	23.298	23.866	24.435	25.003	25.571	26.139	26.708	27.276	27.844
50	28.412	28.981	29.549	30.117	30.685	31.253	31.822	32.390	32.958	33.526
60	34.095	34.663	35.231	35.799	36.368	36.936	37.504	38.072	38.641	39.209
70	39.777	40.345	40.914	41.482	42.050	42.618	43.187	43.755	44.323	44.891
80	45.460	46.028	46.596	47.164	47.733	48.301	48.869	49.437	50.006	50.574
90	51.142	51.710	52.279	52.847	53.415	53.983	54.552	55.120	55.688	56.256

Liters – Pints (Brit.)

	0	1	2	3	4	5	6	7	8	9
0	0.0000	1.7598	3.5196	5.2794	7.0392	8.7990	10.559	12.319	14.078	15.838
10	17.598	19.358	21.118	22.877	24.637	26.397	28.157	29.917	31.676	33.436
20	35.196	36.956	38.716	40.475	42.235	43.995	45.755	47.515	49.274	51.034
30	52.794	54.554	56.314	58.073	59.833	61.593	63.353	65.113	66.873	68.632
40	70.392	72.152	73.912	75.672	77.431	79.191	80.951	82.711	84.471	86.230
50	87.990	89.750	91.510	93.270	95.029	96.789	98.549	100.31	102.07	103.83
60	105.59	107.35	109.11	110.87	112.63	114.39	116.15	117.91	119.67	121.43
70	123.19	124.95	126.71	128.47	130.23	131.99	133.75	135.50	137.26	139.02
80	140.78	142.54	144.30	146.06	147.82	149.58	151.34	153.10	154.86	156.62
90	158.38	160.14	161.90	163.66	165.42	167.18	168.94	170.70	172.46	174.22

Pints (US) – Liters

	0	1	2	3	4	5	6	7	8	9
0	0.0000	0.4732	0.9463	1.4195	1.8927	2.3658	2.8390	3.3122	3.7853	4.2585
10	4.7317	5.2048	5.6780	6.1512	6.6243	7.0975	7.5707	8.0438	8.5170	8.9902
20	9.4633	9.9365	10.410	10.883	11.356	11.829	12.302	12.775	13.249	13.722
30	14.195	14.668	15.141	15.614	16.088	16.561	17.034	17.507	17.980	18.453
40	18.927	19.400	19.873	20.346	20.819	21.292	21.766	22.239	22.712	23.185
50	23.658	24.131	24.605	25.078	25.551	26.024	26.497	26.970	27.444	27.917
60	28.390	28.863	29.336	29.809	30.283	30.756	31.229	31.702	32.175	32.648
70	33.122	33.595	34.068	34.541	35.014	35.487	35.961	36.434	36.907	37.380
80	37.853	38.326	38.800	39.273	39.746	40.219	40.692	41.165	41.639	42.112
90	42.585	43.058	43.531	44.004	44.478	44.951	45.424	45.897	46.370	46.843

Liters – Pints (US)

	0	1	2	3	4	5	6	7	8	9
0	0.0000	2.1134	4.2268	6.3403	8.4537	10.567	12.681	14.794	16.907	19.021
10	21.134	23.248	25.361	27.474	29.588	31.701	33.815	35.928	38.042	40.155
20	42.268	44.382	46.495	48.609	50.722	52.836	54.949	57.062	59.176	61.289
30	63.403	65.516	67.630	69.743	71.856	73.970	76.083	78.197	80.310	82.423
40	84.537	86.650	88.764	90.877	92.991	95.104	97.217	99.331	101.44	103.56
50	105.67	107.78	109.90	112.01	114.12	116.24	118.35	120.47	122.58	124.69
60	126.81	128.92	131.03	133.15	135.26	137.37	139.49	141.60	143.71	145.83
70	147.94	150.05	152.17	154.28	156.39	158.51	160.62	162.73	164.85	166.96
80	169.07	171.19	173.30	175.41	177.53	179.64	181.75	183.87	185.98	188.09
90	190.21	192.32	194.43	196.55	198.66	200.78	202.89	205.00	207.12	209.23

Gallons (Brit.) – Liters

	0	1	2	3	4	5	6	7	8	9
0	0.0000	4.5460	9.0919	13.638	18.184	22.730	27.276	31.822	36.368	40.914
10	45.460	50.006	54.552	59.098	63.643	68.189	72.735	77.281	81.827	86.373
20	90.919	95.465	100.01	104.56	109.10	113.65	118.20	122.74	127.29	131.83
30	136.38	140.92	145.47	150.02	154.56	159.11	163.65	168.20	172.75	177.29
40	181.84	186.38	190.93	195.48	200.02	204.57	209.11	213.66	218.21	222.75
50	227.30	231.84	236.39	240.94	245.48	250.03	254.57	259.12	263.67	268.21
60	272.76	277.30	281.85	286.40	290.94	295.49	300.03	304.58	309.13	313.67
70	318.22	322.76	327.31	331.86	336.40	340.95	345.49	350.04	354.59	359.13
80	363.68	368.22	372.77	377.31	381.86	386.41	390.95	395.50	400.04	404.59
90	409.14	413.68	418.23	422.77	427.32	431.87	436.41	440.96	445.50	450.05

Liters – Gallons (Brit.)

	0	1	2	3	4	5	6	7	8	9
0	0.0000	0.2200	0.4400	0.6599	0.8799	1.0999	1.3199	1.5398	1.7598	1.9798
10	2.1998	2.4197	2.6397	2.8597	3.0797	3.2996	3.5196	3.7396	3.9596	4.1795
20	4.3995	4.6195	4.8395	5.0594	5.2794	5.4994	5.7194	5.9393	6.1593	6.3793
30	6.5993	6.8192	7.0392	7.2592	7.4792	7.6991	7.9191	8.1391	8.3591	8.5790
40	8.7990	9.0190	9.2390	9.4589	9.6789	9.8989	10.119	10.339	10.559	10.779
50	10.999	11.219	11.439	11.659	11.879	12.099	12.319	12.539	12.759	12.979
60	13.199	13.418	13.638	13.858	14.078	14.298	14.518	14.738	14.958	15.178
70	15.398	15.618	15.838	16.058	16.278	16.498	16.718	16.938	17.158	17.378
80	17.598	17.818	18.038	18.258	18.478	18.698	18.918	19.138	19.358	19.578
90	19.798	20.018	20.238	20.458	20.678	20.898	21.118	21.338	21.558	21.778

Gallons (US) – Liters

	0	1	2	3	4	5	6	7	8	9
0	0.0000	3.7853	7.5707	11.356	15.141	18.927	22.712	26.497	30.283	34.068
10	37.853	41.639	45.424	49.209	52.995	56.780	60.565	64.351	68.136	71.921
20	75.707	79.492	83.277	87.063	90.848	94.633	98.419	102.20	105.99	109.77
30	113.56	117.35	121.13	124.92	128.70	132.49	136.27	140.06	143.84	147.63
40	151.41	155.20	158.98	162.77	166.55	170.34	174.13	177.91	181.70	185.48
50	189.27	193.05	196.84	200.62	204.41	208.19	211.98	215.76	219.55	223.33
60	227.12	230.91	234.69	238.48	242.26	246.05	249.83	253.62	257.40	261.19
70	264.97	268.76	272.54	276.33	280.11	283.90	287.69	291.47	295.26	299.04
80	302.83	306.61	310.40	314.18	317.97	321.75	325.54	329.32	333.11	336.89
90	340.68	344.46	348.25	352.04	355.82	359.61	363.39	367.18	370.96	374.75

Liters – Gallons (US)

	0	1	2	3	4	5	6	7	8	9
0	0.0000	0.2642	0.5284	0.7925	1.0567	1.3209	1.5851	1.8492	2.1134	2.3776
10	2.6418	2.9060	3.1701	3.4343	3.6985	3.9627	4.2268	4.4910	4.7552	5.0194
20	5.2836	5.5477	5.8119	6.0761	6.3403	6.6044	6.8686	7.1328	7.3970	7.6612
30	7.9253	8.1895	8.4537	8.7179	8.9820	9.2462	9.5104	9.7746	10.039	10.303
40	10.567	10.831	11.095	11.360	11.624	11.888	12.152	12.416	12.681	12.945
50	13.209	13.473	13.737	14.001	14.266	14.530	14.794	15.058	15.322	15.586
60	15.851	16.115	16.379	16.643	16.907	17.172	17.436	17.700	17.964	18.228
70	18.492	18.757	19.021	19.285	19.549	19.813	20.078	20.342	20.606	20.870
80	21.134	21.398	21.663	21.927	22.191	22.455	22.719	22.983	23.248	23.512
90	23.776	24.040	24.304	24.569	24.833	25.097	25.361	25.625	25.889	26.154

Examples: 445 gr = 28 836 mg; 44.5 gr = 2883.6 mg; 4.45 gr = 288.36 mg; 0.445 gr = 28.84 mg

Examples: 445 mg = 6.8674 gr; 44.5 mg = 0.6867 gr; 4.45 mg = 0.0687 gr; 0.445 mg = 0.006 87 gr

Grains – Milligrams

gr	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
10	647.99	654.47	660.95	667.43	673.91	680.39	686.87	693.35	699.83	706.31
11	712.79	719.27	725.75	732.23	738.71	745.19	751.67	758.15	764.63	771.11
12	777.59	784.07	790.55	797.03	803.51	809.99	816.47	822.95	829.43	835.91
13	842.39	848.87	855.35	861.83	868.31	874.79	881.27	887.75	894.23	900.70
14	907.18	913.66	920.14	926.62	933.10	939.58	946.06	952.54	959.02	965.50
15	971.98	978.46	984.94	991.42	997.90	1004.4	1010.9	1017.3	1023.8	1030.3
16	1036.8	1043.3	1049.7	1056.2	1062.7	1069.2	1075.7	1082.1	1088.6	1095.1
17	1101.6	1108.1	1114.5	1121.0	1127.5	1134.0	1140.5	1146.9	1153.4	1159.9
18	1166.4	1172.9	1179.3	1185.8	1192.3	1198.8	1205.3	1211.7	1218.2	1224.7
19	1231.2	1237.7	1244.1	1250.6	1257.1	1263.6	1270.1	1276.5	1283.0	1289.5
20	1296.0	1302.5	1308.9	1315.4	1321.9	1328.4	1334.9	1341.3	1347.8	1354.3
21	1360.8	1367.3	1373.7	1380.2	1386.7	1393.2	1399.7	1406.1	1412.6	1419.1
22	1425.6	1432.1	1438.5	1445.0	1451.5	1458.0	1464.5	1470.9	1477.4	1483.9
23	1490.4	1496.9	1503.3	1509.8	1516.3	1522.8	1529.3	1535.7	1542.2	1548.7
24	1555.2	1561.7	1568.1	1574.6	1581.1	1587.6	1594.1	1600.5	1607.0	1613.5
25	1620.0	1626.5	1632.9	1639.4	1645.9	1652.4	1658.9	1665.3	1671.8	1678.3
26	1684.8	1691.3	1697.7	1704.2	1710.7	1717.2	1723.7	1730.1	1736.6	1743.1
27	1749.6	1756.1	1762.5	1769.0	1775.5	1782.0	1788.5	1794.9	1801.4	1807.9
28	1814.4	1820.8	1827.3	1833.8	1840.3	1846.8	1853.2	1859.7	1866.2	1872.7
29	1879.2	1885.6	1892.1	1898.6	1905.1	1911.6	1918.0	1924.5	1931.0	1937.5
30	1944.0	1950.4	1956.9	1963.4	1969.9	1976.4	1982.8	1989.3	1995.8	2002.3
31	2008.8	2015.2	2021.7	2028.2	2034.7	2041.2	2047.6	2054.1	2060.6	2067.1
32	2073.6	2080.0	2086.5	2093.0	2099.5	2106.0	2112.4	2118.9	2125.4	2131.9
33	2138.4	2144.8	2151.3	2157.8	2164.3	2170.8	2177.2	2183.7	2190.2	2196.7
34	2203.2	2209.6	2216.1	2222.6	2229.1	2235.6	2242.0	2248.5	2255.0	2261.5
35	2268.0	2274.4	2280.9	2287.4	2293.9	2300.4	2306.8	2313.3	2319.8	2326.3
36	2332.8	2339.2	2345.7	2352.2	2358.7	2365.2	2371.6	2378.1	2384.6	2391.1
37	2397.6	2404.0	2410.5	2417.0	2423.5	2430.0	2436.4	2442.9	2449.4	2455.9
38	2462.4	2468.8	2475.3	2481.8	2488.3	2494.8	2501.2	2507.7	2514.2	2520.7
39	2527.2	2533.6	2540.1	2546.6	2553.1	2559.6	2566.0	2572.5	2579.0	2585.5
40	2592.0	2598.4	2604.9	2611.4	2617.9	2624.4	2630.8	2637.3	2643.8	2650.3
41	2656.8	2663.2	2669.7	2676.2	2682.7	2689.2	2695.6	2702.1	2708.6	2715.1
42	2721.6	2728.0	2734.5	2741.0	2747.5	2754.0	2760.4	2766.9	2773.4	2779.9
43	2786.4	2792.8	2799.3	2805.8	2812.3	2818.8	2825.2	2831.7	2838.2	2844.7
44	2851.2	2857.6	2864.1	2870.6	2877.1	2883.6	2890.0	2896.5	2903.0	2909.5
45	2916.0	2922.4	2928.9	2935.4	2941.9	2948.4	2954.8	2961.3	2967.8	2974.3
46	2980.8	2987.2	2993.7	3000.2	3006.7	3013.1	3019.6	3026.1	3032.6	3039.1
47	3045.5	3052.0	3058.5	3065.0	3071.5	3077.9	3084.4	3090.9	3097.4	3103.9
48	3110.3	3116.8	3123.3	3129.8	3136.3	3142.7	3149.2	3155.7	3162.2	3168.7
49	3175.1	3181.6	3188.1	3194.6	3201.1	3207.5	3214.0	3220.5	3227.0	3233.5
50	3239.9	3246.4	3252.9	3259.4	3265.9	3272.3	3278.8	3285.3	3291.8	3298.3
51	3304.7	3311.2	3317.7	3324.2	3330.7	3337.1	3343.6	3350.1	3356.6	3363.1
52	3369.5	3376.0	3382.5	3389.0	3395.5	3401.9	3408.4	3414.9	3421.4	3427.9
53	3434.3	3440.8	3447.3	3453.8	3460.3	3466.7	3473.2	3479.7	3486.2	3492.7
54	3499.1	3505.6	3512.1	3518.6	3525.1	3531.5	3538.0	3544.5	3551.0	3557.5
55	3563.9	3570.4	3576.9	3583.4	3589.9	3596.3	3602.8	3609.3	3615.8	3622.3
56	3628.7	3635.2	3641.7	3648.2	3654.7	3661.1	3667.6	3674.1	3680.6	3687.1
57	3693.5	3700.0	3706.5	3713.0	3719.5	3725.9	3732.4	3738.9	3745.4	3751.9
58	3758.3	3764.8	3771.3	3777.8	3784.3	3790.7	3797.2	3803.7	3810.2	3816.7
59	3823.1	3829.6	3836.1	3842.6	3849.1	3855.5	3862.0	3868.5	3875.0	3881.5
60	3887.9	3894.4	3900.9	3907.4	3913.9	3920.3	3926.8	3933.3	3939.8	3946.3
61	3952.7	3959.2	3965.7	3972.2	3978.7	3985.1	3991.6	3998.1	4004.6	4011.1
62	4017.5	4024.0	4030.5	4037.0	4043.5	4049.9	4056.4	4062.9	4069.4	4075.9
63	4082.3	4088.8	4095.3	4101.8	4108.3	4114.7	4121.2	4127.7	4134.2	4140.7
64	4147.1	4153.6	4160.1	4166.6	4173.1	4179.5	4186.0	4192.5	4199.0	4205.4
65	4211.9	4218.4	4224.9	4231.4	4237.8	4244.3	4250.8	4257.3	4263.8	4270.2
66	4276.7	4283.2	4289.7	4296.2	4302.6	4309.1	4315.6	4322.1	4328.6	4335.0
67	4341.5	4348.0	4354.5	4361.0	4367.4	4373.9	4380.4	4386.9	4393.4	4399.8
68	4406.3	4412.8	4419.3	4425.8	4432.2	4438.7	4445.2	4451.7	4458.2	4464.6
69	4471.1	4477.6	4484.1	4490.6	4497.0	4503.5	4510.0	4516.5	4523.0	4529.4
70	4535.9	4542.4	4548.9	4555.4	4561.8	4568.3	4574.8	4581.3	4587.8	4594.2
71	4600.7	4607.2	4613.7	4620.2	4626.6	4633.1	4639.6	4646.1	4652.6	4659.0
72	4665.5	4672.0	4678.5	4685.0	4691.4	4697.9	4704.4	4710.9	4717.4	4723.8
73	4730.3	4736.8	4743.3	4749.8	4756.2	4762.7	4769.2	4775.7	4782.2	4788.6
74	4795.1	4801.6	4808.1	4814.6	4821.0	4827.5	4834.0	4840.5	4847.0	4853.4
75	4859.9	4866.4	4872.9	4879.4	4885.8	4892.3	4898.8	4905.3	4911.8	4918.2
76	4924.7	4931.2	4937.7	4944.2	4950.6	4957.1	4963.6	4970.1	4976.6	4983.0
77	4989.5	4996.0	5002.5	5009.0	5015.4	5021.9	5028.4	5034.9	5041.4	5047.8
78	5054.3	5060.8	5067.3	5073.8	5080.2	5086.7	5093.2	5099.7	5106.2	5112.6
79	5119.1	5125.6	5132.1	5138.6	5145.0	5151.5	5158.0	5164.5	5171.0	5177.4
80	5183.9	5190.4	5196.9	5203.4	5209.8	5216.3	5222.8	5229.3	5235.8	5242.2
81	5248.7	5255.2	5261.7	5268.2	5274.6	5281.1	5287.6	5294.1	5300.6	5307.0
82	5313.5	5320.0	5326.5	5333.0	5339.4	5345.9	5352.4	5358.9	5365.4	5371.8
83	5378.3	5384.8	5391.3	5397.8	5404.2	5410.7	5417.2	5423.7	5430.1	5436.6
84	5443.1	5449.6	5456.1	5462.5	5469.0	5475.5	5482.0	5488.5	5494.9	5501.4
85	5507.9	5514.4	5520.9	5527.3	5533.8	5540.3	5546.8	5553.3	5559.7	5566.2
86	5572.7	5579.2	5585.7	5592.1	5598.6	5605.1	5611.6	5618.1	5624.5	5631.0
87	5637.5	5644.0	5650.5	5656.9	5663.4	5669.9	5676.4	5682.9	5689.3	5695.8
88	5702.3	5708.8	5715.3	5721.7	5728.2	5734.7	5741.2	5747.7	5754.1	5760.6
89	5767.1	5773.6	5780.1	5786.5	5793.0	5799.5	5806.0	5812.5	5818.9	5825.4
90	5831.9	5838.4	5844.9	5851.3	5857.8	5864.3	5870.8	5877.3	5883.7	5890.2
91	5896.7	5903.2	5909.7	5916.1	5922.6	5929.1	5935.6	5942.1	5948.5	5955.0
92	5961.5	5968.0	5974.5	5980.9	5987.4	5993.9	6000.4	6006.9	6013.3	6019.8
93	6026.3	6032.8	6039.3	6045.7	6052.2	6058.7	6065.2	6071.7	6078.1	6084.6
94	6091.1	6097.6	6104.1	6110.5	6117.0	6123.5	6130.0	6136.5	6142.9	6149.4
95	6155.9	6162.4	6168.9	6175.3	6181.8	6188.3	6194.8	6201.3	6207.7	6214.2
96	6220.7	6227.2	6233.7	6240.1	6246.6	6253.1	6259.6	6266.1	6272.5	6279.0
97	6285.5	6292.0	6298.5	6304.9	6311.4	6317.9	6324.4	6330.9	6337.3	6343.8
98	6350.3	6356.8	6363.3	6369.7	6376.2	6382.7	6389.2	6395.7	6402.1	6408.6
99	6415.1	6421.6	6428.1	6434.5	6441.0	6447.5	6454.0	6460.5	6466.9	6473.4

Milligrams – Grains

mg	0	1	2	3	4	5	6	7	8	9
100	1.5432	1.5587	1.5741	1.5895	1.6050	1.6204	1.6358	1.6513	1.6667	1.6821
110	1.6976	1.7130	1.7284	1.7439	1.7593	1.7747	1.7902	1.8056	1.8210	1.8365
120	1.8519	1.8673	1.8827	1.8982	1.9136	1.9290	1.9445	1.9599	1.9753	1.9908
130	2.0062	2.0216	2.0371	2.0525	2.0679	2.0834	2.0988	2.1142	2.1297	2.1451
140	2.1605	2.1760	2.1914	2.2068	2.2223	2.2377	2.2531	2.2686	2.2840	2.2994
150	2.3149	2.3303	2.3457	2.3612	2.3766	2.3920	2.4074	2.4229	2.4383	2.4537
160	2.4692	2.4846	2.5000	2.5155	2.5309	2.5463	2.5618	2.5772	2.5926	2.6081
170	2.6235	2.6389	2.6544	2.6698	2.6852	2.7007	2.7161	2.7315	2.7470	2.7624
180	2.7778	2.7933	2.8087	2.8241	2.8396	2.8550	2.8704	2.8859	2.9013	2.9167
190	2.9321	2.9476	2.9630	2.9784	2.9939	3.0093	3.0247	3.0402	3.0556	3.0710
200	3.0865	3.1019	3.1173	3.1328	3.1482	3.1636	3.1791	3.1945	3.2099	3.2254
210	3.2408	3.2562	3.2717	3.2871	3.3025	3.3180	3.3334	3.3488	3.3643	3.3797
220	3.3951	3.4106	3.4260	3.4414	3.4568	3.4723	3.4877	3.5031	3.5186	3.5340
230	3.5494	3.5649	3.5803	3.5957	3.6112	3.6266	3.6420	3.6575	3.6729	3.6883
240	3.7038	3.7192	3.7346	3.7501	3.7655	3.7809	3.7964	3.8118	3.8272	3.8427
250	3.8581	3.8735	3.8890	3.9044	3.9198	3.9353	3.9507	3.9661	3.9815	3.9970
260	4.0124	4.0278	4.0433	4.0587	4.0741	4.0896	4.1050	4.1204	4.1359	4.1513
270	4.1667	4.1822	4.1976	4.2130	4.2285	4.2439	4.2593	4.2748	4.2902	4.3056
280	4.3211	4.3365	4.3519	4.3674	4.3828	4.3982	4.4137	4.4291	4.4445	4.4600
290	4.4754	4.4908	4.5062	4.5217	4.5371	4.5525	4.5680	4.5834	4.5988	4.6143
300	4.6297	4.6451	4.6606	4.6760	4.6914	4.7069	4.7223	4.7377	4.7532	4.7686
310	4.7840	4.7995	4.8149	4.8303	4.8458	4.8612	4.8766	4.8921	4.9075	4.9229
320	4.9384	4.9538	4.9692	4.9847	5.0001	5.0155	5.0309	5.0464	5.0618	5.0772
330	5.0927	5.1081	5.1235	5.1390	5.1544	5.1698	5.1853	5.2007	5.2161	5.2316
340	5.2470	5.2624	5.2779	5.2933	5.3087	5.3242	5.3396	5.3550	5.3705	5.3859
350	5.4013	5.4168	5.4322	5.4476	5.4631	5.4785	5.4939	5.5094	5.5248	5.5402
360	5.5556	5.5711	5.5865	5.6019	5.6174	5.6328	5.6482	5.6637	5.6791	5.6945
370	5.7100	5.7254	5.7408	5.7563	5.7717	5.7871	5.8026	5.8180	5.8334	5.8489
380	5.8643	5.8797	5.8952	5.9106	5.9260	5.9415	5.9569	5.9723	5.9878	6.0032
390	6.0186	6.0341	6.0495	6.0649	6.0803	6.0958	6.1112	6.1266	6.1421	6.1575
400	6.1729	6.1884	6.2038	6.2192	6.2347	6.2501	6.2655	6.2810	6.2964	6.3118
410	6.3273	6.3427	6.3581	6.3736	6.3890	6.4044	6.4199	6.4353	6.4507	6.4662
420	6.4816	6.4970	6.5125	6.5279	6.5433	6.5588	6.5742	6.5896	6.6051	6.6205
430	6.6359	6.6513	6.6668	6.6822	6.6976	6.7131	6.7285	6.7439	6.7594	6.7748
440	6.7902	6.8057	6.8211	6.8365	6.8520	6.8674	6.8828	6.8983	6.9137	6.9291
450	6.9446	6.9600	6.9754	6.9909	7.0063	7.0217	7.0372	7.0526	7.0680	7.0835
460	7.0989	7.1143	7.1298	7.1452	7.1606	7.1760	7.1915	7.2069	7.2223	7.2378
470	7.2532	7.2686	7.2841	7.2995	7.3149	7.3304	7.3458	7.3612	7.3767	7.3921
480	7.4075	7.4230	7.4384	7.4538	7.4693	7.4847	7.5001	7.5156	7.5310	7.5464
490	7.5619	7.5773	7.5927	7.6082	7.6236	7.6390	7.6545	7.6699	7.6853	7.7007
500	7.7162	7.7316	7.7470	7.7625	7.7779	7.7933	7.8088	7.8242	7.8396	7.8551
510	7.8705	7.8859	7.9014	7.9168	7.9322	7.9477	7.9631	7.9785	7.9940	8.0094
520	8.0248	8.0403	8.0557	8.0711	8.0866	8.1020	8.1174	8.1329	8.1483	8.1637
530	8.1792	8.1946	8.2100	8.2254	8.2409	8.2563	8.2717	8.2872	8.3026	8.3180
540	8.3335	8.3489	8.3643	8.3798	8.3952	8.4106	8.4261	8.4415	8.4569	8.4724
550	8.4878	8.5032	8.5187	8.5341	8.5495	8.5650	8.5804	8.5958	8.6113	8.6267
560	8.6421	8.6576	8.6730	8.6884	8.7039	8.7193	8.7347	8.7501	8.7656	8.7810
570	8.7964	8.8119	8.8273	8.8427	8.8582	8.8736	8.8890	8.9045	8.9199	8.9353
580	8.9508	8.9662	8.9816	8.9971	9.0125	9.0279	9.0434	9.0588	9.0742	9.0897
590	9.1051	9.1205	9.1360	9.1514	9.1668	9.1823	9.1977	9.2131	9.2286	9.2440
600	9.2594	9.2748	9.2903	9.3057	9.3211	9.3366	9.3520	9.3674	9.3829	9.3983
610	9.4137	9.4292	9.4446	9.4600	9.4755	9.4909	9.5063	9.5218	9.5372	9.5526
620	9.5681	9.5835	9.5989	9.6144	9.6298	9.6452	9.6607	9.6761	9.6915	9.7070
630	9.7224	9.7378	9.7533	9.7687	9.7841	9.7995	9.8150	9.8304	9.8458	9.8613
640	9.8767	9.8921	9.9076	9.9230	9.9384	9.9539	9.9693	9.9847	10.000	10.016
650	10.031	10.046	10.062	10.077	10.093	10.108	10.124	10.139	10.154	10.170
660	10.185	10.201	10.216	10.232	10.247	10.263	10.278	10.293	10.309	10.324
670	10.340	10.355	10.371	10.386	10.401	10.417	10.432	10.448	10.463	10.479
680	10.494	10.509	10.525	10.540	10.556	10.571	10.587	10.602	10.617	10.633
690	10.648	10.664	10.679	10.695	10.710	10.725	10.741	10.756	10.772	10.787
700	10.803	10.818	10.834	10.849	10.864	10.880	10.895	10.911	10.926	10.942
710	10.957	10.972	10.988	11.003	11.019	11.034	11.050	11.065	11.080	11.096
720	11.111	11.127	11.142	11.158	11.173	11.188	11.204	11.219	11.235	11.250
730	11.266	11.281	11.296	11.312	11.327	11.343	11.358	11.374	11.389	11.405
740	11.420	11.435	11.451	11.466	11.482	11.497	11.513	11.528	11.543	11.559
750	11.574	11.590	11.605	11.621	11.636	11.651	11.667	11.682	11.698	11.713
760	11.729	11.744	11.759	11.775	11.790	11.806	11.821	11.837	11.852	11.867
770	11.883	11.898	11.914	11.929	11.945	11.960	11.976	11.991	12.006	12.022
780	12.037	12.053	12.068	12.084	12.099	12.114	12.130	12.145	12.161	12.176
790	12.192	12.207	12.222	12.238	12.253	12.269	12.284	12.300	12.315	12.330
800	12.346	12.361	12.377	12.392	12.408	12.423	12.438	12.454	12.469	12.485
810	12.500	12.516	12.531	12.547	12.562	12.577	12.593	12.608	12.624	12.639
820	12.655	12.670	12.685	12.701	12.716	12.732	12.747	12.763	12.778	12.793
830	12.809	12.824	12.840	12.855	12.871	12.886	12.901	12.917	12.932	12.948
840	12.963	12.979	12.994	13.009	13.025	13.040	13.056	13.071	13.087	13.102
850	13.118	13.133	13.148	13.164	13.179	13.195	13.210	13.226	13.241	13.256
860	13.272	13.287	13.303	13.318	13.334	13.349	13.364	13.380	13.395	13.411
870	13.426	13.442	13.457	13.472	13.488	13.503	13.519	13.534	13.550	13.565
880	13.580	13.596	13.611	13.627	13.642	13.658	13.673	13.689	13.704	13.719
890	13.735	13.750	13.766	13.781	13.797	13.812	13.827	13.843	13.858	13.874
900	13.889	13.905	13.920	13.935	13.951	13.966	13.982	13.997	14.013	14.028
910	14.043	14.059	14.074	14.090	14.105	14.121	14.136	14.151	14.167	14.182
920	14.198	14.213	14.229	14.244	14.260	14.275	14.290	14.306	14.321	14.337
930	14.352	14.368	14.383	14.398	14.414	14.429	14.445	14.460	14.476	14.491
940	14.506	14.522	14.537	14.553	14.568	14.584	14.599	14.614	14.630	14.645
950	14.661	14.676	14.692	14.707	14.722	14.738	14.753	14.769	14.784	14.800
960	14.815	14.830	14.846	14.861	14.877	14.892	14.908	14.923	14.939	14.954
970	14.969	14.985	15.000	15.016	15.031	15.047	15.062	15.077	15.093	15.108
980	15.124	15.139	15.155	15.170	15.185	15.201	15.216	15.232	15.247	15.263
990	15.278	15.293	15.309	15.324	15.340	15.355	15.371	15.386	15.401	15.417

Conversion of Mass Units (Pounds / Kilograms)

Examples: 300 lb = 136.08 kg; 30 lb = 13.608 kg; 3 lb = 1.361 kg; 0.3 lb = 0.136 kg

Examples: 152 kg = 335.10 lb; 15.2 kg = 33.510 lb; 1.52 kg = 3.351 lb; 0.152 kg = 0.335 lb

Pounds (avoirdupois) – Kilograms

lb	0	1	2	3	4	5	6	7	8	9
100	45.359	45.813	46.266	46.720	47.174	47.627	48.081	48.534	48.988	49.442
110	49.895	50.349	50.802	51.256	51.710	52.163	52.617	53.070	53.524	53.977
120	54.431	54.885	55.338	55.792	56.245	56.699	57.153	57.606	58.060	58.513
130	58.967	59.421	59.874	60.328	60.781	61.235	61.689	62.142	62.596	63.049
140	63.503	63.957	64.410	64.864	65.317	65.771	66.224	66.678	67.132	67.585
150	68.039	68.492	68.946	69.400	69.853	70.307	70.760	71.214	71.668	72.121
160	72.575	73.028	73.482	73.936	74.389	74.843	75.296	75.750	76.204	76.657
170	77.111	77.564	78.018	78.471	78.925	79.379	79.832	80.286	80.739	81.193
180	81.647	82.100	82.554	83.007	83.461	83.915	84.368	84.822	85.275	85.729
190	86.183	86.636	87.090	87.543	87.997	88.451	88.904	89.358	89.811	90.265
200	90.718	91.172	91.626	92.079	92.533	92.986	93.440	93.894	94.347	94.801
210	95.254	95.708	96.162	96.615	97.069	97.522	97.976	98.430	98.883	99.337
220	99.790	100.24	100.70	101.15	101.60	102.06	102.51	102.97	103.42	103.87
230	104.33	104.78	105.23	105.69	106.14	106.59	107.05	107.50	107.95	108.41
240	108.86	109.32	109.77	110.22	110.68	111.13	111.58	112.04	112.49	112.94
250	113.40	113.85	114.31	114.76	115.21	115.67	116.12	116.57	117.03	117.48
260	117.93	118.39	118.84	119.29	119.75	120.20	120.66	121.11	121.56	122.02
270	122.47	122.92	123.38	123.83	124.28	124.74	125.19	125.65	126.10	126.55
280	127.01	127.46	127.91	128.37	128.82	129.27	129.73	130.18	130.63	131.09
290	131.54	132.00	132.45	132.90	133.36	133.81	134.26	134.72	135.17	135.62
300	136.08	136.53	136.98	137.44	137.89	138.35	138.80	139.25	139.71	140.16
310	140.61	141.07	141.52	141.97	142.43	142.88	143.34	143.79	144.24	144.70
320	145.15	145.60	146.06	146.51	146.96	147.42	147.87	148.32	148.78	149.23
330	149.69	150.14	150.59	151.05	151.50	151.95	152.41	152.86	153.31	153.77
340	154.22	154.68	155.13	155.58	156.04	156.49	156.94	157.40	157.85	158.30
350	158.76	159.21	159.66	160.12	160.57	161.03	161.48	161.93	162.39	162.84
360	163.29	163.75	164.20	164.65	165.11	165.56	166.01	166.47	166.92	167.38
370	167.83	168.28	168.74	169.19	169.64	170.10	170.55	171.00	171.46	171.91
380	172.37	172.82	173.27	173.73	174.18	174.63	175.09	175.54	175.99	176.45
390	176.90	177.35	177.81	178.26	178.72	179.17	179.62	180.08	180.53	180.98
400	181.44	181.89	182.34	182.80	183.25	183.70	184.16	184.61	185.07	185.52
410	185.97	186.43	186.88	187.33	187.79	188.24	188.69	189.15	189.60	190.06
420	190.51	190.96	191.42	191.87	192.32	192.78	193.23	193.68	194.14	194.59
430	195.04	195.50	195.95	196.41	196.86	197.31	197.77	198.22	198.67	199.13
440	199.58	200.03	200.49	200.94	201.40	201.85	202.30	202.76	203.21	203.66
450	204.12	204.57	205.02	205.48	205.93	206.38	206.84	207.29	207.75	208.20
460	208.65	209.11	209.56	210.01	210.47	210.92	211.37	211.83	212.28	212.73
470	213.19	213.64	214.10	214.55	215.00	215.46	215.91	216.36	216.82	217.27
480	217.72	218.18	218.63	219.09	219.54	219.99	220.45	220.90	221.35	221.81
490	222.26	222.71	223.17	223.62	224.07	224.53	224.98	225.44	225.89	226.34
500	226.80	227.25	227.70	228.16	228.61	229.06	229.52	229.97	230.42	230.88
510	231.33	231.79	232.24	232.69	233.15	233.60	234.05	234.51	234.96	235.41
520	235.87	236.32	236.78	237.23	237.68	238.14	238.59	239.04	239.50	239.95
530	240.40	240.86	241.31	241.76	242.22	242.67	243.13	243.58	244.03	244.49
540	244.94	245.39	245.85	246.30	246.75	247.21	247.66	248.12	248.57	249.02
550	249.48	249.93	250.38	250.84	251.29	251.74	252.20	252.65	253.10	253.56
560	254.01	254.47	254.92	255.37	255.83	256.28	256.73	257.19	257.64	258.09
570	258.55	259.00	259.45	259.91	260.36	260.82	261.27	261.72	262.18	262.63
580	263.08	263.54	263.99	264.44	264.90	265.35	265.81	266.26	266.71	267.17
590	267.62	268.07	268.53	268.98	269.43	269.89	270.34	270.79	271.25	271.70
600	272.16	272.61	273.06	273.52	273.97	274.42	274.88	275.33	275.78	276.24
610	276.69	277.14	277.60	278.05	278.51	278.96	279.41	279.87	280.32	280.77
620	281.23	281.68	282.13	282.59	283.04	283.50	283.95	284.40	284.86	285.31
630	285.76	286.22	286.67	287.12	287.58	288.03	288.48	288.94	289.39	289.85
640	290.30	290.75	291.21	291.66	292.11	292.57	293.02	293.47	293.93	294.38
650	294.84	295.29	295.74	296.20	296.65	297.10	297.56	298.01	298.46	298.92
660	299.37	299.82	300.28	300.73	301.19	301.64	302.09	302.55	303.00	303.45
670	303.91	304.36	304.81	305.27	305.72	306.17	306.63	307.08	307.54	307.99
680	308.44	308.90	309.35	309.80	310.26	310.71	311.16	311.62	312.07	312.53
690	312.98	313.43	313.89	314.34	314.79	315.25	315.70	316.15	316.61	317.06
700	317.51	317.97	318.42	318.88	319.33	319.78	320.24	320.69	321.14	321.60
710	322.05	322.50	322.96	323.41	323.86	324.32	324.77	325.23	325.68	326.13
720	326.59	327.04	327.49	327.95	328.40	328.85	329.31	329.76	330.22	330.67
730	331.12	331.58	332.03	332.48	332.94	333.39	333.84	334.30	334.75	335.20
740	335.66	336.11	336.57	337.02	337.47	337.93	338.38	338.83	339.29	339.74
750	340.19	340.65	341.10	341.56	342.01	342.46	342.92	343.37	343.82	344.28
760	344.73	345.18	345.64	346.09	346.54	347.00	347.45	347.91	348.36	348.81
770	349.27	349.72	350.17	350.63	351.08	351.53	351.99	352.44	352.89	353.35
780	353.80	354.26	354.71	355.16	355.62	356.07	356.52	356.98	357.43	357.88
790	358.34	358.79	359.25	359.70	360.15	360.61	361.06	361.51	361.97	362.42
800	362.87	363.33	363.78	364.23	364.69	365.14	365.60	366.05	366.50	366.96
810	367.41	367.86	368.32	368.77	369.22	369.68	370.13	370.58	371.04	371.49
820	371.95	372.40	372.85	373.31	373.76	374.21	374.67	375.12	375.57	376.03
830	376.48	376.94	377.39	377.84	378.30	378.75	379.20	379.66	380.11	380.56
840	381.02	381.47	381.92	382.38	382.83	383.29	383.74	384.19	384.65	385.10
850	385.55	386.01	386.46	386.91	387.37	387.82	388.28	388.73	389.18	389.64
860	390.09	390.54	391.00	391.45	391.90	392.36	392.81	393.26	393.72	394.17
870	394.63	395.08	395.53	395.99	396.44	396.89	397.35	397.80	398.25	398.71
880	399.16	399.61	400.07	400.52	400.98	401.43	401.88	402.34	402.79	403.24
890	403.70	404.15	404.60	405.06	405.51	405.97	406.42	406.87	407.33	407.78
900	408.23	408.69	409.14	409.59	410.05	410.50	410.95	411.41	411.86	412.32
910	412.77	413.22	413.68	414.13	414.58	415.04	415.49	415.94	416.40	416.85
920	417.31	417.76	418.21	418.67	419.12	419.57	420.03	420.48	420.93	421.39
930	421.84	422.29	422.75	423.20	423.66	424.11	424.56	425.02	425.47	425.92
940	426.38	426.83	427.28	427.74	428.19	428.64	429.10	429.55	430.01	430.46
950	430.91	431.37	431.82	432.27	432.73	433.18	433.63	434.09	434.54	435.00
960	435.45	435.90	436.36	436.81	437.26	437.72	438.17	438.62	439.08	439.53
970	439.98	440.44	440.89	441.35	441.80	442.25	442.71	443.16	443.61	444.07
980	444.52	444.97	445.43	445.88	446.33	446.79	447.24	447.70	448.15	448.60
990	449.06	449.51	449.96	450.42	450.87	451.32	451.78	452.23	452.69	453.14

Kilograms – Pounds (avoirdupois)

kg	0	1	2	3	4	5	6	7	8	9
100	220.46	222.67	224.87	227.08	229.28	231.49	233.69	235.89	238.10	240.30
110	242.51	244.71	246.92	249.12	251.33	253.53	255.74	257.94	260.15	262.35
120	264.55	266.76	268.96	271.17	273.37	275.58	277.78	279.99	282.19	284.40
130	286.60	288.81	291.01	293.21	295.42	297.62	299.83	302.03	304.24	306.44
140	308.65	310.85	313.06	315.26	317.47	319.67	321.87	324.08	326.28	328.49
150	330.69	332.90	335.10	337.31	339.51	341.72	343.92	346.13	348.33	350.53
160	352.74	354.94	357.15	359.35	361.56	363.76	365.97	368.17	370.38	372.58
170	374.79	376.99	379.19	381.40	383.60	385.81	388.01	390.22	392.42	394.63
180	396.83	399.04	401.24	403.45	405.65	407.86	410.06	412.26	414.47	416.67
190	418.88	421.08	423.29	425.49	427.70	429.90	432.11	434.31	436.52	438.72
200	440.92	443.13	445.33	447.54	449.74	451.95	454.15	456.36	458.56	460.77
210	462.97	465.18	467.38	469.58	471.79	473.99	476.20	478.40	480.61	482.81
220	485.02	487.22	489.43	491.63	493.84	496.04	498.24	500.45	502.65	504.86
230	507.06	509.27	511.47	513.68	515.88	518.09	520.29	522.50	524.70	526.90
240	529.11	531.31	533.52	535.72	537.93	540.13	542.34	544.54	546.75	548.95
250	551.16	553.36	555.56	557.77	559.97	562.18	564.38	566.59	568.79	571.00
260	573.20	575.41	577.61	579.82	582.02	584.22	586.43	588.63	590.84	593.04
270	595.25	597.45	599.66	601.86	604.07	606.27	608.48	610.68	612.88	615.09
280	617.29	619.50	621.70	623.91	626.11	628.32	630.52	632.73	634.93	637.14
290	639.34	641.55	643.75	645.95	648.16	650.36	652.57	654.77	656.98	659.18
300	661.39	663.59	665.80	668.00	670.21	672.41	674.61	676.82	679.02	681.23
310	683.43	685.64	687.84	690.05	692.25	694.46	696.66	698.87	701.07	703.27
320	705.48	707.68	709.89	712.09	714.30	716.50	718.71	720.91	723.12	725.32
330	727.53	729.73	731.93	734.14	736.34	738.55	740.75	742.96	745.16	747.37
340	749.57	751.78	753.98	756.19	758.39	760.59	762.80	765.00	767.21	769.41
350	771.62	773.82	776.03	778.23	780.44	782.64	784.85	787.05	789.25	791.46
360	793.66	795.87	798.07	800.28	802.48	804.69	806.89	809.10	811.30	813.51
370	815.71	817.91	820.12	822.32	824.53	826.73	828.94	831.14	833.35	835.55
380	837.76	839.96	842.17	844.37	846.57	848.78	850.98	853.19	855.39	857.60
390	859.80	862.01	864.21	866.42	868.62	870.83	873.03	875.23	877.44	879.64
400	881.85	884.05	886.26	888.46	890.67	892.87	895.08	897.28	899.49	901.69
410	903.90	906.10	908.30	910.51	912.71	914.92	917.12	919.33	921.53	923.74
420	925.94	928.15	930.35	932.56	934.76	936.96	939.17	941.37	943.58	945.78
430	947.99	950.19	952.40	954.60	956.81	959.01	961.22	963.42	965.62	967.83
440	970.03	972.24	974.44	976.65	978.85	981.06	983.26	985.47	987.67	989.88
450	992.08	994.28	996.49	998.69	1000.9	1003.1	1005.3	1007.5	1009.7	1011.9
460	1014.1	1016.3	1018.5	1020.7	1022.9	1025.1	1027.4	1029.6	1031.8	1034.0
470	1036.2	1038.4	1040.6	1042.8	1045.0	1047.2	1049.4	1051.6	1053.8	1056.0
480	1058.2	1060.4	1062.6	1064.8	1067.0	1069.2	1071.4	1073.7	1075.9	1078.1
490	1080.3	1082.5	1084.7	1086.9	1089.1	1091.3	1093.5	1095.7	1097.9	1100.1
500	1102.3	1104.5	1106.7	1108.9	1111.1	1113.3	1115.5	1117.7	1119.9	1122.2
510	1124.4	1126.6	1128.8	1131.0	1133.2	1135.4	1137.6	1139.8	1142.0	1144.2
520	1146.4	1148.6	1150.8	1153.0	1155.2	1157.4	1159.6	1161.8	1164.0	1166.2
530	1168.4	1170.7	1172.9	1175.1	1177.3	1179.5	1181.7	1183.9	1186.1	1188.3
540	1190.5	1192.7	1194.9	1197.1	1199.3	1201.5	1203.7	1205.9	1208.1	1210.3
550	1212.5	1214.7	1217.0	1219.2	1221.4	1223.6	1225.8	1228.0	1230.2	1232.4
560	1234.6	1236.8	1239.0	1241.2	1243.4	1245.6	1247.8	1250.0	1252.2	1254.4
570	1256.6	1258.8	1261.0	1263.2	1265.5	1267.7	1269.9	1272.1	1274.3	1276.5
580	1278.7	1280.9	1283.1	1285.3	1287.5	1289.7	1291.9	1294.1	1296.3	1298.5
590	1300.7	1302.9	1305.1	1307.3	1309.5	1311.8	1314.0	1316.2	1318.4	1320.6
600	1322.8	1325.0	1327.2	1329.4	1331.6	1333.8	1336.0	1338.2	1340.4	1342.6
610	1344.8	1347.0	1349.2	1351.4	1353.6	1355.8	1358.0	1360.3	1362.5	1364.7
620	1366.9	1369.1	1371.3	1373.5	1375.7	1377.9	1380.1	1382.3	1384.5	1386.7
630	1388.9	1391.1	1393.3	1395.5	1397.7	1399.9	1402.1	1404.3	1406.5	1408.8
640	1411.0	1413.2	1415.4	1417.6	1419.8	1422.0	1424.2	1426.4	1428.6	1430.8
650	1433.0	1435.2	1437.4	1439.6	1441.8	1444.0	1446.2	1448.4	1450.6	1452.8
660	1455.1	1457.3	1459.5	1461.7	1463.9	1466.1	1468.3	1470.5	1472.7	1474.9
670	1477.1	1479.3	1481.5	1483.7	1485.9	1488.1	1490.3	1492.5	1494.7	1496.9
680	1499.1	1501.3	1503.6	1505.8	1508.0	1510.2	1512.4	1514.6	1516.8	1519.0
690	1521.2	1523.4	1525.6	1527.8	1530.0	1532.2	1534.4	1536.6	1538.8	1541.0
700	1543.2	1545.4	1547.6	1549.8	1552.1	1554.3	1556.5	1558.7	1560.9	1563.1
710	1565.3	1567.5	1569.7	1571.9	1574.1	1576.3	1578.5	1580.7	1582.9	1585.1
720	1587.3	1589.5	1591.7	1593.9	1596.1	1598.4	1600.6	1602.8	1605.0	1607.2
730	1609.4	1611.6	1613.8	1616.0	1618.2	1620.4	1622.6	1624.8	1627.0	1629.2
740	1631.4	1633.6	1635.8	1638.0	1640.2	1642.4	1644.6	1646.9	1649.1	1651.3
750	1653.5	1655.7	1657.9	1660.1	1662.3	1664.5	1666.7	1668.9	1671.1	1673.3
760	1675.5	1677.7	1679.9	1682.1	1684.3	1686.5	1688.7	1690.9	1693.1	1695.4
770	1697.6	1699.8	1702.0	1704.2	1706.4	1708.6	1710.8	1713.0	1715.2	1717.4
780	1719.6	1721.8	1724.0	1726.2	1728.4	1730.6	1732.8	1735.0	1737.2	1739.4
790	1741.7	1743.9	1746.1	1748.3	1750.5	1752.7	1754.9	1757.1	1759.3	1761.5
800	1763.7	1765.9	1768.1	1770.3	1772.5	1774.7	1776.9	1779.1	1781.3	1783.5
810	1785.7	1787.9	1790.2	1792.4	1794.6	1796.8	1799.0	1801.2	1803.4	1805.6
820	1807.8	1810.0	1812.2	1814.4	1816.6	1818.8	1821.0	1823.2	1825.4	1827.6
830	1829.8	1832.0	1834.2	1836.5	1838.7	1840.9	1843.1	1845.3	1847.5	1849.7
840	1851.9	1854.1	1856.3	1858.5	1860.7	1862.9	1865.1	1867.3	1869.5	1871.7
850	1873.9	1876.1	1878.3	1880.5	1882.7	1885.0	1887.2	1889.4	1891.6	1893.8
860	1896.0	1898.2	1900.4	1902.6	1904.8	1907.0	1909.2	1911.4	1913.6	1915.8
870	1918.0	1920.2	1922.4	1924.6	1926.8	1929.0	1931.2	1933.5	1935.7	1937.9
880	1940.1	1942.3	1944.5	1946.7	1948.9	1951.1	1953.3	1955.5	1957.7	1959.9
890	1962.1	1964.3	1966.5	1968.7	1970.9	1973.1	1975.3	1977.5	1979.8	1982.0
900	1984.2	1986.4	1988.6	1990.8	1993.0	1995.2	1997.4	1999.6	2001.8	2004.0
910	2006.2	2008.4	2010.6	2012.8	2015.0	2017.2	2019.4	2021.6	2023.8	2026.0
920	2028.3	2030.5	2032.7	2034.9	2037.1	2039.3	2041.5	2043.7	2045.9	2048.1
930	2050.3	2052.5	2054.7	2056.9	2059.1	2061.3	2063.5	2065.7	2067.9	2070.1
940	2072.3	2074.5	2076.8	2079.0	2081.2	2083.4	2085.6	2087.8	2090.0	2092.2
950	2094.4	2096.6	2098.8	2101.0	2103.2	2105.4	2107.6	2109.8	2112.0	2114.2
960	2116.4	2118.6	2120.8	2123.1	2125.3	2127.5	2129.7	2131.9	2134.1	2136.3
970	2138.5	2140.7	2142.9	2145.1	2147.3	2149.5	2151.7	2153.9	2156.1	2158.3
980	2160.5	2162.7	2164.9	2167.1	2169.3	2171.6	2173.8	2176.0	2178.2	2180.4
990	2182.6	2184.8	2187.0	2189.2	2191.4	2193.6	2195.8	2198.0	2200.2	2202.4

Conversion of Temperature Units (Fahrenheit/Centigrade)

Examples: +23°F = −5.00°C; 99.4°F = 37.44°C; 117°F = 47.22°C; 1210°F = 654.4°C

Fahrenheit – Centigrade

−59 to +79°F (1°F intervals)

	0	1	2	3	4	5	6	7	8	9
−50	−45.56	−46.11	−46.67	−47.22	−47.78	−48.33	−48.89	−49.44	−50.00	−50.56
−40	−40.00	−40.56	−41.11	−41.67	−42.22	−42.78	−43.33	−43.89	−44.44	−45.00
−30	−34.44	−35.00	−35.56	−36.11	−36.67	−37.22	−37.78	−38.33	−38.89	−39.44
−20	−28.89	−29.44	−30.00	−30.56	−31.11	−31.67	−32.22	−32.78	−33.33	−33.89
−10	−23.33	−23.89	−24.44	−25.00	−25.56	−26.11	−26.67	−27.22	−27.78	−28.33
−00	−17.78	−18.33	−18.89	−19.44	−20.00	−20.56	−21.11	−21.67	−22.22	−22.78
+00	−17.78	−17.22	−16.67	−16.11	−15.56	−15.00	−14.44	−13.89	−13.33	−12.78
10	−12.22	−11.67	−11.11	−10.56	−10.00	− 9.44	− 8.89	− 8.33	− 7.78	− 7.22
20	− 6.67	− 6.11	− 5.56	− 5.00	− 4.44	− 3.89	− 3.33	− 2.78	− 2.22	− 1.67
30	− 1.11	− 0.56	0.00	+ 0.56	+ 1.11	+ 1.67	+ 2.22	+ 2.78	+ 3.33	+ 3.89
40	+ 4.44	+ 5.00	+ 5.56	+ 6.11	+ 6.67	+ 7.22	+ 7.78	+ 8.33	+ 8.89	+ 9.44
50	+10.00	+10.56	+11.11	+11.67	+12.22	+12.78	+13.33	+13.89	+14.44	+15.00
60	+15.56	+16.11	+16.67	+17.22	+17.78	+18.33	+18.89	+19.44	+20.00	+20.56
70	+21.11	+21.67	+22.22	+22.78	+23.33	+23.89	+24.44	+25.00	+25.56	+26.11

80.0 to 109.9°F ($^1/_{10}$°F intervals)

	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
80.	26.67	26.72	26.78	26.83	26.89	26.94	27.00	27.06	27.11	27.17
81.	27.22	27.28	27.33	27.39	27.44	27.50	27.56	27.61	27.67	27.72
82.	27.78	27.83	27.89	27.94	28.00	28.06	28.11	28.17	28.22	28.28
83.	28.33	28.39	28.44	28.50	28.56	28.61	28.67	28.72	28.78	28.83
84.	28.89	28.94	29.00	29.06	29.11	29.17	29.22	29.28	29.33	29.39
85.	29.44	29.50	29.56	29.61	29.67	29.72	29.78	29.83	29.89	29.94
86.	30.00	30.06	30.11	30.17	30.22	30.28	30.33	30.39	30.44	30.50
87.	30.56	30.61	30.67	30.72	30.78	30.83	30.89	30.94	31.00	31.06
88.	31.11	31.17	31.22	31.28	31.33	31.39	31.44	31.50	31.56	31.61
89.	31.67	31.72	31.78	31.83	31.89	31.94	32.00	32.06	32.11	32.17
90.	32.22	32.28	32.33	32.39	32.44	32.50	32.56	32.61	32.67	32.72
91.	32.78	32.83	32.89	32.94	33.00	33.06	33.11	33.17	33.22	33.28
92.	33.33	33.39	33.44	33.50	33.56	33.61	33.67	33.72	33.78	33.83
93.	33.89	33.94	34.00	34.06	34.11	34.17	34.22	34.28	34.33	34.39
94.	34.44	34.50	34.56	34.61	34.67	34.72	34.78	34.83	34.89	34.94
95.	35.00	35.06	35.11	35.17	35.22	35.28	35.33	35.39	35.44	35.50
96.	35.56	35.61	35.67	35.72	35.78	35.83	35.89	35.94	36.00	36.06
97.	36.11	36.17	36.22	36.28	36.33	36.39	36.44	36.50	36.56	36.61
98.	36.67	36.72	36.78	36.83	36.89	36.94	37.00	37.06	37.11	37.17
99.	37.22	37.28	37.33	37.39	37.44	37.50	37.56	37.61	37.67	37.72
100.	37.78	37.83	37.89	37.94	38.00	38.06	38.11	38.17	38.22	38.28
101.	38.33	38.39	38.44	38.50	38.56	38.61	38.67	38.72	38.78	38.83
102.	38.89	38.94	39.00	39.06	39.11	39.17	39.22	39.28	39.33	39.39
103.	39.44	39.50	39.56	39.61	39.67	39.72	39.78	39.83	39.89	39.94
104.	40.00	40.06	40.11	40.17	40.22	40.28	40.33	40.39	40.44	40.50
105.	40.56	40.61	40.67	40.72	40.78	40.83	40.89	40.94	41.00	41.06
106.	41.11	41.17	41.22	41.28	41.33	41.39	41.44	41.50	41.56	41.61
107.	41.67	41.72	41.78	41.83	41.89	41.94	42.00	42.06	42.11	42.17
108.	42.22	42.28	42.33	42.39	42.44	42.50	42.56	42.61	42.67	42.72
109.	42.78	42.83	42.89	42.94	43.00	43.06	43.11	43.17	43.22	43.28

110 to 299°F (1°F intervals)

	0	1	2	3	4	5	6	7	8	9
110	43.33	43.89	44.44	45.00	45.56	46.11	46.67	47.22	47.78	48.33
120	48.89	49.44	50.00	50.56	51.11	51.67	52.22	52.78	53.33	53.89
130	54.44	55.00	55.56	56.11	56.67	57.22	57.78	58.33	58.89	59.44
140	60.00	60.56	61.11	61.67	62.22	62.78	63.33	63.89	64.44	65.00
150	65.56	66.11	66.67	67.22	67.78	68.33	68.89	69.44	70.00	70.56
160	71.11	71.67	72.22	72.78	73.33	73.89	74.44	75.00	75.56	76.11
170	76.67	77.22	77.78	78.33	78.89	79.44	80.00	80.56	81.11	81.67
180	82.22	82.78	83.33	83.89	84.44	85.00	85.56	86.11	86.67	87.22
190	87.78	88.33	88.89	89.44	90.00	90.56	91.11	91.67	92.22	92.78
200	93.33	93.89	94.44	95.00	95.56	96.11	96.67	97.22	97.78	98.33
210	98.89	99.44	100.0	100.6	101.1	101.7	102.2	102.8	103.3	103.9
220	104.4	105.0	105.6	106.1	106.7	107.2	107.8	108.3	108.9	109.4
230	110.0	110.6	111.1	111.7	112.2	112.8	113.3	113.9	114.4	115.0
240	115.6	116.1	116.7	117.2	117.8	118.3	118.9	119.4	120.0	120.6
250	121.1	121.7	122.2	122.8	123.3	123.9	124.4	125.0	125.6	126.1
260	126.7	127.2	127.8	128.3	128.9	129.4	130.0	130.6	131.1	131.7
270	132.2	132.8	133.3	133.9	134.4	135.0	135.6	136.1	136.7	137.2
280	137.8	138.3	138.9	139.4	140.0	140.6	141.1	141.7	142.2	142.8
290	143.3	143.9	144.4	145.0	145.6	146.1	146.7	147.2	147.8	148.3

300 to 1890°F (10°F intervals)

	0	10	20	30	40	50	60	70	80	90
300	148.9	154.4	160.0	165.6	171.1	176.7	182.2	187.8	193.3	198.9
400	204.4	210.0	215.6	221.1	226.7	232.2	237.8	243.3	248.9	254.4
500	260.0	265.6	271.1	276.7	282.2	287.8	293.3	298.9	304.4	310.0
600	315.6	321.1	326.7	332.2	337.8	343.3	348.9	354.4	360.0	365.6
700	371.1	376.7	382.2	387.8	393.3	398.9	404.4	410.0	415.6	421.1
800	426.7	432.2	437.8	443.3	448.9	454.4	460.0	465.6	471.1	476.7
900	482.2	487.8	493.3	498.9	504.4	510.0	515.6	521.1	526.7	532.2
1000	537.8	543.3	548.9	554.4	560.0	565.6	571.1	576.7	582.2	587.8
1100	593.3	598.9	604.4	610.0	615.6	621.1	626.7	632.2	637.8	643.3
1200	648.9	654.4	660.0	665.6	671.1	676.7	682.2	687.8	693.3	698.9
1300	704.4	710.0	715.6	721.1	726.7	732.2	737.8	743.3	748.9	754.4
1400	760.0	765.6	771.1	776.7	782.2	787.8	793.3	798.9	804.4	810.0
1500	815.6	821.1	826.7	832.2	837.8	843.3	848.9	854.4	860.0	865.6
1600	871.1	876.7	882.2	887.8	893.3	898.9	904.4	910.0	915.6	921.1
1700	926.7	932.2	937.8	943.3	948.9	954.4	960.0	965.6	971.1	976.7
1800	982.2	987.8	993.3	998.9	1004	1010	1016	1021	1027	1032

Examples: −14°C = +6.8°F; 38.3°C = 100.9°F; 89°C = 192.2°F; 550°C = 1022°F

Centigrade – Fahrenheit

−59 to 0°C (1°C intervals)

	0	1	2	3	4	5	6	7	8	9
−50	−58.0	−59.8	−61.6	−63.4	−65.2	−67.0	−68.8	−70.6	−72.4	−74.2
−40	−40.0	−41.8	−43.6	−45.4	−47.2	−49.0	−50.8	−52.6	−54.4	−56.2
−30	−22.0	−23.8	−25.6	−27.4	−29.2	−31.0	−32.8	−34.6	−36.4	−38.2
−20	− 4.0	− 5.8	− 7.6	− 9.4	−11.2	−13.0	−14.8	−16.6	−18.4	−20.2
−10	+14.0	+12.2	+10.4	+ 8.6	+ 6.8	+ 5.0	+ 3.2	+ 1.4	− 0.4	− 2.2
−00	+32.0	+30.2	+28.4	+26.6	+24.8	+23.0	+21.2	+19.4	+17.6	+15.8

0 to 49.9°C ($^1/_{10}$°C intervals)

	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
+0.	32.00	32.18	32.36	32.54	32.72	32.90	33.08	33.26	33.44	33.62
1.	33.80	33.98	34.16	34.34	34.52	34.70	34.88	35.06	35.24	35.42
2.	35.60	35.78	35.96	36.14	36.32	36.50	36.68	36.86	37.04	37.22
3.	37.40	37.58	37.76	37.94	38.12	38.30	38.48	38.66	38.84	39.02
4.	39.20	39.38	39.56	39.74	39.92	40.10	40.28	40.46	40.64	40.82
5.	41.00	41.18	41.36	41.54	41.72	41.90	42.08	42.26	42.44	42.62
6.	42.80	42.98	43.16	43.34	43.52	43.70	43.88	44.06	44.24	44.42
7.	44.60	44.78	44.96	45.14	45.32	45.50	45.68	45.86	46.04	46.22
8.	46.40	46.58	46.76	46.94	47.12	47.30	47.48	47.66	47.84	48.02
9.	48.20	48.38	48.56	48.74	48.92	49.10	49.28	49.46	49.64	49.82
10.	50.00	50.18	50.36	50.54	50.72	50.90	51.08	51.26	51.44	51.62
11.	51.80	51.98	52.16	52.34	52.52	52.70	52.88	53.06	53.24	53.42
12.	53.60	53.78	53.96	54.14	54.32	54.50	54.68	54.86	55.04	55.22
13.	55.40	55.58	55.76	55.94	56.12	56.30	56.48	56.66	56.84	57.02
14.	57.20	57.38	57.56	57.74	57.92	58.10	58.28	58.46	58.64	58.82
15.	59.00	59.18	59.36	59.54	59.72	59.90	60.08	60.26	60.44	60.62
16.	60.80	60.98	61.16	61.34	61.52	61.70	61.88	62.06	62.24	62.42
17.	62.60	62.78	62.96	63.14	63.32	63.50	63.68	63.86	64.04	64.22
18.	64.40	64.58	64.76	64.94	65.12	65.30	65.48	65.66	65.84	66.02
19.	66.20	66.38	66.56	66.74	66.92	67.10	67.28	67.46	67.64	67.82
20.	68.00	68.18	68.36	68.54	68.72	68.90	69.08	69.26	69.44	69.62
21.	69.80	69.98	70.16	70.34	70.52	70.70	70.88	71.06	71.24	71.42
22.	71.60	71.78	71.96	72.14	72.32	72.50	72.68	72.86	73.04	73.22
23.	73.40	73.58	73.76	73.94	74.12	74.30	74.48	74.66	74.84	75.02
24.	75.20	75.38	75.56	75.74	75.92	76.10	76.28	76.46	76.64	76.82
25.	77.00	77.18	77.36	77.54	77.72	77.90	78.08	78.26	78.44	78.62
26.	78.80	78.98	79.16	79.34	79.52	79.70	79.88	80.06	80.24	80.42
27.	80.60	80.78	80.96	81.14	81.32	81.50	81.68	81.86	82.04	82.22
28.	82.40	82.58	82.76	82.94	83.12	83.30	83.48	83.66	83.84	84.02
29.	84.20	84.38	84.56	84.74	84.92	85.10	85.28	85.46	85.64	85.82
30.	86.00	86.18	86.36	86.54	86.72	86.90	87.08	87.26	87.44	87.62
31.	87.80	87.98	88.16	88.34	88.52	88.70	88.88	89.06	89.24	89.42
32.	89.60	89.78	89.96	90.14	90.32	90.50	90.68	90.86	91.04	91.22
33.	91.40	91.58	91.76	91.94	92.12	92.30	92.48	92.66	92.84	93.02
34.	93.20	93.38	93.56	93.74	93.92	94.10	94.28	94.46	94.64	94.82
35.	95.00	95.18	95.36	95.54	95.72	95.90	96.08	96.26	96.44	96.62
36.	96.80	96.98	97.16	97.34	97.52	97.70	97.88	98.06	98.24	98.42
37.	98.60	98.78	98.96	99.14	99.32	99.50	99.68	99.86	100.0	100.2
38.	100.4	100.6	100.8	100.9	101.1	101.3	101.5	101.7	101.8	102.0
39.	102.2	102.4	102.6	102.7	102.9	103.1	103.3	103.5	103.6	103.8
40.	104.0	104.2	104.4	104.5	104.7	104.9	105.1	105.3	105.4	105.6
41.	105.8	106.0	106.2	106.3	106.5	106.7	106.9	107.1	107.2	107.4
42.	107.6	107.8	108.0	108.1	108.3	108.5	108.7	108.9	109.0	109.2
43.	109.4	109.6	109.8	109.9	110.1	110.3	110.5	110.7	110.8	111.0
44.	111.2	111.4	111.6	111.7	111.9	112.1	112.3	112.5	112.6	112.8
45.	113.0	113.2	113.4	113.5	113.7	113.9	114.1	114.3	114.4	114.6
46.	114.8	115.0	115.2	115.3	115.5	115.7	115.9	116.1	116.2	116.4
47.	116.6	116.8	117.0	117.1	117.3	117.5	117.7	117.9	118.0	118.2
48.	118.4	118.6	118.8	118.9	119.1	119.3	119.5	119.7	119.8	120.0
49.	120.2	120.4	120.6	120.7	120.9	121.1	121.3	121.5	121.6	121.8

50 to 199°C (1°C intervals)

	0	1	2	3	4	5	6	7	8	9
50	122.0	123.8	125.6	127.4	129.2	131.0	132.8	134.6	136.4	138.2
60	140.0	141.8	143.6	145.4	147.2	149.0	150.8	152.6	154.4	156.2
70	158.0	159.8	161.6	163.4	165.2	167.0	168.8	170.6	172.4	174.2
80	176.0	177.8	179.6	181.4	183.2	185.0	186.8	188.6	190.4	192.2
90	194.0	195.8	197.6	199.4	201.2	203.0	204.8	206.6	208.4	210.2
100	212.0	213.8	215.6	217.4	219.2	221.0	222.8	224.6	226.4	228.2
110	230.0	231.8	233.6	235.4	237.2	239.0	240.8	242.6	244.4	246.2
120	248.0	249.8	251.6	253.4	255.2	257.0	258.8	260.6	262.4	264.2
130	266.0	267.8	269.6	271.4	273.2	275.0	276.8	278.6	280.4	282.2
140	284.0	285.8	287.6	289.4	291.2	293.0	294.8	296.6	298.4	300.2
150	302.0	303.8	305.6	307.4	309.2	311.0	312.8	314.6	316.4	318.2
160	320.0	321.8	323.6	325.4	327.2	329.0	330.8	332.6	334.4	336.2
170	338.0	339.8	341.6	343.4	345.2	347.0	348.8	350.6	352.4	354.2
180	356.0	357.8	359.6	361.4	363.2	365.0	366.8	368.6	370.4	372.2
190	374.0	375.8	377.6	379.4	381.2	383.0	384.8	386.6	388.4	390.2

100 to 990°C (10°C intervals)

	0	10	20	30	40	50	60	70	80	90
100	212	230	248	266	284	302	320	338	356	374
200	392	410	428	446	464	482	500	518	536	554
300	572	590	608	626	644	662	680	698	716	734
400	752	770	788	806	824	842	860	878	896	914
500	932	950	968	986	1004	1022	1040	1058	1076	1094
600	1112	1130	1148	1166	1184	1202	1220	1238	1256	1274
700	1292	1310	1328	1346	1364	1382	1400	1418	1436	1454
800	1472	1490	1508	1526	1544	1562	1580	1598	1616	1634
900	1652	1670	1688	1706	1724	1742	1760	1778	1796	1814

Other, often used weights and measures

Linear measures

one micron	= 0.001 millimeter
one decimeter	= 10 centimeters (about 4 inches)
one yard	= 0.9144 meter (3 feet)
one meter	= 100 centimeters (39.37 inches; 3.28 feet)
one rod	= 5.029 meters (16.5 feet)
one chain	= 20.116 meters (22 yards)

Square measures

one sq.centimeter	= 0.1550 sq.inch
one sq.inch	= 6.452 sq.centimeters
one sq.foot	= 0.093 sq.meter (144 sq.inches)
one sq.yard	= 0.8361 sq.meter (9 sq.feet)
one sq.meter	= 10,000 sq.centimeters (1550 sq.inches)
one Ar	= 100 sq.meters (119.6 sq.yards)
one acre	= 4047 sq.meters (0.4047 hectare; 43.560 sq.feet; 4840 sq.yards)
one hectare	= 10,000 sq.meters (2.471 acres)
one sq.mile	= 259.000 hectares (640 acres)
one Feddan	= 42-59 Ar

Cubic measures

one cubic inch	= 16.387 cubic centimeters
one cubic foot	= 28.316 liters or 1728 cubic inches; 29.922 U.S. liquid quarts; 7.48 gallons; 0.80357 U.S. bushels
one cubic yard	= 0.7645 cubic meter (27 cubic feet)
one cubic centim.	= 1 milliliter (cc, ml)
one cubic decimeter	= 1000 milliliters
one cubic meter	= 10,000 liters (353.157 cubic feet)

Capacity measures (liquid)

one tablespoonful	= 15 milliliters (about 1/2 fluid ounce)
one quart (Brit.)	= 1.1365 liters (40 fluid ounces Brit.)
one quart (U.S.)	= 0.9463 liters (32 fluid ounces Brit.)
one gallon (Imp. or Brit.)	= 4 quarts (Brit.) (160 fluid ounces Brit.)
one gallon (U.S.)	= 4 quarts or 128 fluid ounces
one pint (Brit.)	= 0.5683 l
one pint (U.S.)	= 0.473 l

Capacity measures (dry)

one liter	= 0.9081 quart (U.S.)
one bushel (Brit.)	= 36.368 liters (8 gallons)
one bushel (U.S.)	= 35.238 liters (32 quarts)
one quart (Brit.)	= 1.0320 quart (U.S.)
one quart (U.S.)	= 1.1012 liters
one quart (U.S.)	= 0.9690 quart (Brit.)

Weights

one microgram	= 0.001 milligram
one milligram	= 1000 micrograms
one gram	= 1000 milligrams (15.432 grains; 0.0353 ounce)
one hundredweight	= 50.8 kg
one short ton	= 0.907 metric tons
one ton	= 1000 kilograms (2204 pounds; 0.984 long ton; 1.1023 short ton)