Glands are small parts of our bodies that profoundly influence our physical and mental states. They make some of us tall and others short. They give some of us pleasant voices and others voices that should be controlled even in the shower. They put hair on some chests, affect our happiness or discouragements, influence the rhythms of life of both men and women, and much more besides.

Useful—and often vital—medicinal products are made from the glands of animals, an excellent example of the utilization of natural products as starting materials for the manufacture of other useful products.

Present-day glandular therapy is based on the assumption of scientists that conditions arising from a lack of glandular function in mankind could be corrected by the administration of glands or extracts of glands of animals. But first, of course, it was necessary to know the functions and composition of the different glands. That called for a program of sound experimentation and observation. As was to be expected, enthusiasm outran the slower-moving research, and claims of "miracles" were made that did not stand the test of time. Despite the claims and some failures, however, the record as a whole is good.

The process of living is a complex series of chemical reactions, in which the ductless glands, the ones we are considering, play an important part. The ductless glands, or glands of internal secretion, apparently have no ducts or connections with other parts of the body. Yet they govern much of the rest of the body.

How do we know this? How do we demonstrate that a part of the body belongs in this group?

One way is to remove from an animal the part of the body under study and observe any changes that follow. The next step is to administer to that animal the gland that has been removed, or an extract of it, and see if the changes have been reversed. On the basis of past research, it is now generally accepted that the following are ductless glands: Pituitary, thyroid, parathyroid, suprarenal, pancreas, liver, and the sex glands. From time to time, other glands have been included in this class, but on not too convincing evidence.

First, the pituitary. Of all the ductless glands, it is the top, not because of its highest position in the body (just below the brain and back of the nose), but because it controls the workings of so many of the other glands. Its name, of Greek origin, means a thick secretion in the nose, because, centuries ago, it was thought to have something to do with nasal affections. We know that is incorrect; it has more important duties. The pituitary gland is protected by the skull and also by a further bony housing, the sella turcica.

The anterior pituitary lobe (the front portion) apparently controls the activity of other glands. It secretes several principles, or hormones: Thyrotropic hormone, which governs the growth and activity of the thyroid; adrenocorticotropic hormone, which governs the growth and activity of the adrenal cortex; growth hormone,
which influences bone development and thus determines how big or small a person will be; gonadotropic hormone, which influences the growth, pubertal changes, and functions of the sex glands; mammotropic hormone, which has to do with mammary development and secretion; and pancreatropic hormone, which regulates growth and function of the pancreas. And the whole story is not yet told. All this is done by different chemical substances, secreted into the blood stream, by a gland that weighs about 1/222 of a pound.

We do not yet know how to use all the anterior pituitary principles in the treatment of human ailments. For example, growth-hormone preparations do not produce an increase in stature in human beings, although giant rats and dogs can be made with the same extracts. Likewise, the gonadotropic hormone, which has a profound effect on sex development and function in the lower species, has been disappointing in its effects on human females.

By contrast, the adrenocorticotropic hormone (commonly abbreviated to ACTH) does many astonishing things. It brings relief to sufferers from rheumatoid arthritis, rheumatic fever, asthma, and gout. It does not cure, however. How it works is still unknown.

The anterior pituitary lobes of various species contain the active principles in different amounts. The pituitary of cattle is a good source of the growth hormone, but not of ACTH. The pituitary of swine is a good starting material for ACTH; that of sheep is next best. Although millions of hogs are handled every year by the meat-packing industry, the supply of hog pituitaries will furnish ACTH for only a small proportion of the arthritics who need it. About 1,700 hogs are required to make 1 pound of raw pituitaries, and ACTH is only a small part of the gland. Some day, when the formula of the hormone is known (and we are far from knowing it today) and if it is not too complex, the chemist may be able to make it synthetically.

The growth hormone is one of the things that govern the size of an individual. Too little of it results in a certain type of pygmy, the kind whose body proportions are normal but whose height is below normal. They are normal persons, with their bodies scaled down. In Africa, there are tribes of such pygmies. It should be possible to make people taller through the use of growth hormone, but thus far the results have not been too good. There are authentic records of individuals more than 8 feet tall. Such unusual height is due to an oversecretion of the pituitary caused by a tumor on it. Thus, the giant and possibly the dwarf of the circus sideshow are examples of abnormal growth-hormone secretions by the pituitary. As will be seen later, lack of thyroid activity may also stunt a person's growth.

The posterior pituitary lobe (rear portion) provides an extract, official in the United States Pharmacopoeia, that is used extensively in childbirth, in surgery, and in the treatment of diabetes insipidus, which is not to be confused with diabetes mellitus, the more common kind. The extract has the property of contracting involuntary muscle, thus shortening childbirth. It also contains a substance capable of raising blood pressure and, presumably, another that regulates the volume of urine.

The thyroid, in the neck astride the Adam's apple, regulates the rate at which we burn up to furnish the heat and the energy that keep us alive. Iodine is involved in its action. The thyroid is capable of taking the minute amounts of iodine from our food and elaborating from them a chemical substance having about 65 percent iodine in its make-up. This chemical substance, thyroxin, in combined form with protein, circulates through the blood stream. A measure of thyroid activity is the metabolic (burning-up) rate. A low metabolic rate can be raised through the judicious use of thyroid powder, an official preparation in the
United States Pharmacopoeia. No glandular extract that will reduce an above-normal metabolic rate is known. The common symptoms of a low metabolic rate are obesity, a slow pulse, and sluggishness. Thyroid, under strict medical supervision, may be beneficial.

Deficiency of thyroid activity in infancy results in a condition known ascretinism, which is characterized by stunted, disproportionate size and retarded mental development. Many midgets of the circus are cretins. If thyroid therapy is instituted early enough and continued, marked improvement can be effected.

The hormones are powerful substances, to be thought of in terms not of pounds or ounces, but rather of small fractions of an ounce. The total amount of the active principle of the thyroid gland in a human being is probably not more than 1/1500 of an ounce. It is this amount, or perhaps one-half of it, that makes the difference between an idiot and a normal infant.

Iodine is in sea water, but not in fresh waters that are distant from the sea. Large areas of the United States therefore are naturally deficient in iodine. The lack is now supplied by judicious use of iodine in the form of iodized salt, or through the consumption of sea foods. As a result, the incidence of goiters caused by insufficient iodine in the system is decreasing.

The human being is not alone in the need for iodine. Animals also must have it for growth and well being. Once a large proportion of sheep were goiterous. Not so today, because of iodized salt and iodine in the feed. Pigs that receive too little iodine in the diet sometimes lose their hair, a condition that can be corrected by administering iodine.

Associated with the thyroid in human beings is another gland, the parathyroid. Its function is to keep a normal amount of calcium in the blood. Too little calcium causes tetanic convulsions and also retards the coagulation of the blood. Too much calcium causes death by the coagulation of the blood in the circulatory system. Removal of the parathyroid gland lowers the blood calcium, with the characteristic symptoms of too little calcium. Administration of parathyroid extract increases the blood calcium and alleviates the symptoms of too little calcium.

The process of living is a series of amazing chemical reactions. The human body is a far more complicated chemical factory than any that man has made. In a normal individual in good health, these chemical reactions take place in proper sequence and to a controlled degree. The glands of internal secretion have much to do with this orderly procession. Thus, to mention a few, the thyroid regulates the rate at which food is burned; the parathyroid, the amount of calcium in the blood; the suprarenal, among other things, the amount of sodium chloride in the blood; the pancreas, the amount of sugar in the blood.

The pancreas, often referred to in packing-house parlance as the liver sweetbread, is a gland of both internal and external secretion. The remarkable thing is that although the external secretion destroys the internal secretion when the two are in contact, both are present in the pancreas of the normal individual but are kept from coming into contact with each other.

The internal secretion is of great importance in maintaining the blood sugar (glucose) at the proper level. Too much sugar is bad; it indicates a diabetic condition. Too little is just as bad, if not worse, because it is more difficult to control. The story of the discovery of insulin, the pancreatic internal secretion, is too long to be told here. For 34 years or more before its successful extraction from the pan-
creas, it was known that something in the pancreas was involved in keeping the blood sugar at its proper level. Yet it remained for Frederick G. Banting and Charles F. Best to give to the world the clue to how a pancreatic extract could be used to treat diabetes. That was in 1922. Today, hundreds of thousands of diabetics owe their longer lives to insulin. Who can evaluate in dollars the value of this one chemurgic product? The annual market value of the raw pancreas alone, in 1950, was probably 5 million dollars greater than it would have been if insulin had not been discovered.

Insulin apparently is protein in nature. Because of its complex structure, chemists have not yet succeeded in synthesizing it.

The pancreas does more than furnish insulin. It secretes a liquid that runs into the intestines, where it acts upon the food to digest it. The enzymes of the pancreas are essential for life. The trypsin breaks protein down into small building blocks, the amino acids. The diastase converts starches into sugars. The lipase assists in the digestion of fat. Pancreatic products have been prepared to help overcome deficiencies in pancreatic secretion.

The two main portions of the suprarenal gland are embryologically different. The inner part, the medulla, secretes epinephrine, a powerful substance that raises the blood pressure. Doctors use it to treat asthma, allergies, and bleeding. Mixed with procaine it is used in dentistry.

The outer portion, the cortex, is necessary for life. Removal results in death. Once there was no hope for the unfortunate individuals afflicted with a diseased adrenal cortex. Now, through the administration of potent adrenal cortex extracts, persons suffering from Addison's disease can be kept alive and useful for years. The adrenal cortex secretes a number of substances, the full functions of which are not known. Some are involved in the maintenance of the proper amount of sodium chloride in the blood; others, in the amount of glycogen in the liver and its conversion into sugar.

Investigators throughout the world have devoted a vast amount of study to the chemistry and function of the adrenal cortex. In 1949, the Mayo Clinic in Rochester, Minn., announced that one of the chemical substances found in the adrenal cortex, compound E, now called cortisone, is effective in the treatment of arthritis, rheumatic fever, and other ailments. The amount of cortisone needed per person is in weight very little—300 milligrams the first day and 100 milligrams daily thereafter for a varied length of time. But in terms of the quantity of adrenal glands that would be required it is enormous. It would take about 1,000 pounds of beef adrenals, or the two glands from about 22,500 cattle, to obtain 300 milligrams of cortisone.

Obviously, the adrenal gland is not a practical source of cortisone. There is no natural source of it in the quantities needed by arthritic patients. It is being made synthetically from ox bile, but that is not the final answer to the problem, from the standpoint of either availability or cost, as the supply of bile is insufficient.

Before ox bile was used in the synthesis of cortisone, it served many other purposes. Bile is essential for life. Formed in the liver, it flows down a duct into the intestines, where it aids in the absorption of fat.

Bile is a complex product. The important constituents are compounds of the bile acids, of which there are many. Bile acids in man are like those in cattle and sheep. Those in hogs are quite different chemically and, unfortunately, cannot be as readily used as those of cattle for making cortisone. The bile acids belong to the same chemical family as cholesterol, the steroids of the adrenal cortex and of the sex glands.

The secretion of bile is only one of the many properties that have given such prominence to liver in recent years. Liver is valuable in the treatment of pernicious anemia. It contains vita-
min A and many components of the vitamin B complex. From liver has been isolated a crystalline substance, vitamin B_{12}, that is active in the treatment of pernicious anemia when as little as 1/28,000,000 of an ounce is injected daily.

Vitamin B_{12} is part of the animal-protein factor. The better digestibility and utilization of animal protein versus plant protein has been explained in part by the presence of something in animal protein, but not in vegetable protein. Vitamin B_{12} is involved. The liver is a veritable storehouse of important nutritional factors.

Cholesterol is present throughout the body as a constituent of cells. Its exact function has not been established. It serves as starting material for the synthesis of one of the female sex hormones, progesterone, and of the male hormone, testosterone. It is the starting material also for 7-dehydrocholesterol, which, on activation, becomes vitamin D_{3}, essential to the poultry and livestock industries. Thus from packing-house material that formerly was tanked now come many useful medicinals and vitamins.

The inside lining of the stomach is used in making pepsin and mucin, the latter important in the treatment of ulcers. The stomach of the normal human being and of certain animals secretes something called the intrinsic factor, which presumably combines with vitamin B_{12}, permitting the vitamin to be absorbed from the intestinal tract. The stomach of a person suffering from pernicious anemia apparently does not secrete the intrinsic factor; as a consequence, even the small amounts of vitamin B_{12} necessary for proper blood formation cannot be absorbed.

The milk-clotting enzyme, rennet, used in making junket and cheese, is prepared from the stomach of the young calf.

The sex glands, besides their procreative function, possess internal secretions, which govern the attributes associated with males and females, such as bodily contour, pitch of voice, and distribution of hair on the body and head. The active hormones have been isolated from both testes and ovaries, but their actual commercial production makes use of other starting material. Thus, the male hormone is made synthetically from cholesterol. Substances having physiological activity similar to that of one of the ovarian hormones are now prepared in large quantities from the urine of pregnant mares. Another ovarian hormone, progesterone, is prepared from cholesterol and plant steroids.

The various parts of the animal that I have mentioned are often referred to as byproducts. This has an unfavorable connotation as being something of low value, of minor importance. I submit that when a part of an animal has a commercial value well above that of the choicest beefsteak, it deserves respect. Market values change, but in June 1950, raw beef pituitaries cost about $4.50 a pound, and pork pituitaries $25 a pound. Beef parathyroids cost from $5 to $15 a pound, depending on quality. Beef suprarenals brought $1.50 a pound and pork suprarenals about $2.50.

To be sure, the tonnage of the commonly edible portions is greater. Yet, let us consider liver. Time was, within the life of those who will admit the years, when the butcher would throw in a piece of liver free, for the cat, with a purchase of meat. Those were the days when liver was figured on the basis of its tank value, about a half a cent a pound. Today, pork liver has a carload value of about 24 cents a pound; beef liver, one of about 45 cents a pound. Figures are not available, but probably 60 million pounds of liver is used annually for preparing medicinals.

Pancreas sells for between 40 and 50 cents a pound, depending on the species. The higher prices for glands over tank value mean higher prices for the live animals. No accurate values are available, but it is probable that the annual sales value of the products de-
rived from packing-house material of the type used medicinally in one form or another is more than 100 million dollars at the consumer level.

All applications of glands to medicinal purposes have not been mentioned. Even if they were, the story would not be finished, because, through further research, additional uses are being found. The possibilities have not been exhausted. Protein administration as amino acids is still an undeveloped area. The packing house, with its huge supplies of high-grade protein, is a logical source of starting material for the acids. Other lines of investigation are being studied. Those that become actualities will mean better health through utilization of the products of the soil, via the meat-packing industry, through applied science.

The raising of food animals is primarily a means of gaining a livelihood, but it carries a twofold satisfaction. It provides essential food; it alleviates sickness.

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Sawdust is used as a soil conditioner and as a source of humus in many southern forest-tree nurseries. The soils there are low in organic matter, which ranges from less than 1 percent to 2 percent, depending on the crop rotation employed and the physical structure of the soil. Seedlings grown on soils with a high organic content are more vigorous and have more fibrous roots. Likewise, tilth and moisture relationships are improved, all pointing toward the need for a higher soil-humus content.

Since 1945, decomposed sawdust has been added to soil at rates varying from 35 to 100 cubic yards an acre, together with 600 to 900 pounds of fertilizer. A legume soiling crop then is planted and plowed under, preparatory to a tree seedling crop the following year. Tests show that the soiling crop is heavier and contains more plant food than where sawdust is omitted.

An interval of 1 year between tree seedling crops is considered essential to permit the sawdust to decompose. The soil-fertility drain, particularly of nitrogen, is extremely heavy, and large quantities of raw humus cause mineral deficiencies in the seedling crop. A pine seedling crop requires three to five times as much nutrient volume as a good crop of cotton or corn.

It is expected that sawdust will be applied at least biennially for many years. To raise the soil organic content from 1 percent to 2 percent requires about 40,000 pounds of material per acre. Oxidation is rapid in the South; consequently, large quantities of sawdust will be used as a source of soil humus. Thus, a forest product is used indirectly to create more forests.—Floyd M. Cossitt, Forest Service, Atlanta, Ga.