and value—from their connexion with *arable* culture; and all the above researches may be considered to have reference, almost exclusively, to the improvement of this branch of practical agriculture. But there is another branch of little less importance, in which the quality or constitution, and the economical use and value, of the produce of the soil, are subjects of interest and of constant enquiry.

Corn and potatoes are direct food for man. Turnips and green herbage are only indirectly convertible to his use. The manufactory of these into such food as he can consume—into beef, mutton and pork, or into milk, butter, and cheese,—gives rise to important branches of rural economy, to which much rural industry is devoted, and a great breadth of the land. In these branches, it is as important to convert the raw vegetable material—the turnips and herbage—into the largest quantity of the manufactured article, beef or cheese, as it is, in arable culture, to raise the largest possible amount of grain with the smallest quantity of manure, and with the least injury to the land. Hence arise many questions as vitally affecting this *indirect*, as the doctrine of manures affects the *direct* method of raising human food.

Thus it was observed that one kind of herbage, or corn or root, fattened animals more quickly than another; or aided their growth more; or caused them to yield more milk; or made their milk richer, in butter or in cheese; that, from certain kinds of land, or after some modes of culture, or when raised by the aid of some kinds of manure, the same kind of produce was more nutritive; and that when given in some states, or under some known conditions, it went further, and was therefore more valuable in the feeding of animals.

How many curious questions are suggested by such observations as the following! Some varieties of wheat are better suited for the pastrycook; others, for the baker of bread. Some samples of barley refuse to *melt* in the hands of the brewer and distiller; and some yield more brandy; while others lay on more fat. The Scottish ploughman refuses bog oats for his *brose-meal*, or for his oaten-cake because they make it tough; and the cotter's family prefer Angus oats for their porridge-meal, because they swell, and become bulky and consistent in the pot, and go further in feeding the children at the same cost. The pea sometimes refuses to boil soft; and potatoes, on some soils and with some manures, persist in growing waxy. If Swedish turnips sell for thirty shillings a ton—as in large towns they often do—yellow turnips will bring only about twenty-five, and white globes, eighteen; while all the varieties cease to *feed well* as soon as a second growth commences.

What is the cause of such differences as these? How do they arise? Can they be controlled? Can we by cultivation remove them? Can we raise produce of this or that quality at our pleasure?

Such questions, constantly arising, have led to extended analysis of the food consumed by both cattle and man; and from these analysis—still far from being complete—most curious, most interesting, and most practically important results have already been obtained. Let us glance at some of the partial generalizations which have been arrived at, and which may be *provisionally* adopted, by practical men.

We have already seen that all vegetable productions contain from ninety to ninety-eight per cent of combustible or organic matter. Now, this organic part has been found, in all cases, to contain three different classes of substances:—

First, the *starch* class, which comprehends starch, gum, and sugar, and certain other substances of a similar kind.

Second, the *fatty* class, which comprehends solid and liquid oils of various kinds, of which the oils extracted from seeds and nuts are familiar examples.

Third, the *gluten* class, which comprehends the gluten * of wheat, vegetable albumen, vegetable casein and some other analogous substances, the distinctive characters of which have not as yet been thoroughly investigated.

These several classes of substances are always to be found in sensible quantity in all our cultivated crops; but their proportions vary in different plants, in different parts of the same plant, and in the same part when the plants are grown in different climates, on unlike soils or by the aid of different manures. Hence the occasional differences in the sensible qualities of the same vegetable, *under different circumstances*—the waxiness of the potato, the hardness of the pea, and the stubbornness of the barley—become intelligible. The several organic constituents of the grain and root crops are present in unlike proportions, and necessarily give rise to unlike qualities.

But their unlike effects, in the feeding of animals, suggested a further train of investigation. The parts of animals are known to be differently built up, or with different degrees of rapidity and success, by these different varieties of vegetable produce;—of what, then, do the parts of animals themselves consist? The answer to this question throws a new and beautiful light upon our path, clearing up obscure points on the way we have already trodden, and pointing out new tracks, which it will prove interesting hereafter still further to explore.

All animal substances—the flesh, bones, and milk, of all living creatures—consist, like the soil and the plant, of a combustible and an incombustible part. In dry muscle and blood, the incombustible or inorganic part does not exceed two per cent, and in milk evaporated to dryness, seven per cent; while in dry bone it amounts to about sixty-six per cent of the whole weight.

The combustible or organic part consists of fibrin—the fibrous part of lean meat is so called—and of fat. And rigorous analysis appears to show, that this fibrin is almost identical in constitution with the pure gluten of wheat; while the fat of some animals at least, is absolutely identical with the fatty oils contained in certain vegetable productions.

The incombustible part, again, consists of soluble saline substances, and of an insoluble earthly matter, the *earth of bones*. These two classes of inorganic substances exist also in the ash of all plants, though in variable proportions. The stems and leaves abound more in soluble saline matter, the seeds in bone-earth and other phosphates.

These things being discovered, the uses of the several constituents of the food became in some degree manifest. The fat of the animal was derived directly from the fat of the vegetables on which it lived—its muscular fibre directly from the gluten of its food—and the salts of its blood, and the earth of its bones, from the inorganic matters contained in the ash of the plants on which it fed. The plant produced the raw materials, the fat and gluten—the bricks and stones as it were—with which the animal, having received them into its stomach, proceeded directly to build up its several parts.

And as the proportion of fatty matter was greater in some vegetables than in others, some kinds of food would enable the animal to lay on more fat, or to produce more butter. Others again, in which gluten abounded, would favour the growth of muscle, or the production of cheese; while those of which the ash was richest in bone-earth, would enlarge and more rapidly increase the bones of growing animals. In so far also as the composition of the food was known to be modified by the soil on which it grew, so far might the fattening or growth of stock be considered as directly dependent upon the quality of the land on which they lived, or were fed; and in so far as the application of this or that manure was known to affect the quantity of gluten or fat in the crop, in so far would it be in our power, by varying our manures, to control the ordinary operations of nature, and to raise varieties of produce, fitted especially for this purpose or for that. These deductions opened up a wide field for experiments, both in the practical raising of varieties of food, and in the practical feeding of stock; upon which many zealous cultivators have already entered, and which, if they cultivate it with perseverance and accuracy, they are sure to cultivate with success.

How beautiful is the connexion thus established between the dead earth, the living plant, and the reasoning animal! The life and growth of the animal are dependant upon what it receives from the plant, those of the plant on what it receives from the soil on which it grows. The plant does not always produce, in equal quantity, those substances which the animal requires. It is dependent upon the nature of the soil, even for the proportion of gluten, or of fat, which it is capable of yielding to the wants of the animal; while the inorganic part of its substance is wholly drawn from the spot of earth on which it happens to be placed. It strikes us at first as a curious circumstance, that all vegetable food should contain bone-earth and common salt in some small proportion, and that useful plants should refuse to grow in a healthy manner where these substances are not present in the soil. But this arrangement appears absolutely beautiful when we learn, that without these substances the animal cannot live. The main purpose served by the vegetable is to feed the animal races. This they could not do, if they did not contain all that animals

* When wheaten flour is made into a dough with water, and this dough is washed with a stream of water upon a sieve, as long as the water passes through milky, a tenacious substance, like bird-lime, remains behind. This is the gluten of wheat. Albumen is the name given by chemists to the white of the egg; and casein, that applied to the curd of milk. Of both of these latter, an appreciable quantity is found in almost every kind of vegetable food.