

to be first in a hierarchy responsible for segmentation and segment specification. Gap mutants lack contiguous groups of segments, and *hunchback* mutants in particular lack anterior segments including head structures. The *hunchback* gene is expressed as a band at the anterior end of fruitfly embryos that is absent in *bicoid* mutants⁶.

Posterior system

The two other systems responsible for organizing pattern along the anteroposterior axis of fruitfly embryos have both been identified by small sets of genes that have very similar mutant phenotypes. One is the posterior-organizing centre, dependent on a set of genes of which the prototype is termed *oskar*, and the other is a system responsible for the formation of terminal structures dependent on the *torso* class of genes.

Cytoplasmic removal and transplantation experiments show that, like the anterior organizing centre, the posterior centre has a global role in the organization of embryonic pattern. There are significant differences between the two systems, however. One is that although the activity for the rescue of mutants of the *oskar* class is localized at the posterior embryonic pole, to rescue the mutants wild-type posterior cytoplasm must be transplanted into the prospective abdominal region, not the posterior pole itself. A second difference is the relative lack of influence of the site of transplantation of posterior cytoplasm on the position where posterior structures develop.

Genetic and transplantation experiments led to the view that the *oskar* group of genes cooperate to generate a signal at the posterior pole that is transmitted to the abdominal region where it acts, possibly by activating the expression of the gap gene *knirps*. The cooperation was inferred from the observation that posterior cytoplasm from mutants for one gene of the *oskar* group cannot rescue mutants for another gene of the same group (with one exception). Ruth Lehmann (Laboratory of Molecular Biology, Cambridge), however, has now discovered in experiments carried out in collaboration with Sander that rescuing activity is present in the nurse cells of all but one of these mutants. Mutants for the gene *nanos* are the exception, implicating the product of the *nanos* gene as the posterior signal itself. The other genes are thought to be involved in transporting the *nanos* signal to the posterior pole from the nurse cells, and later in transmitting a signal from the posterior pole to the abdomen.

The lack of influence of the site of transplantation of posterior cytoplasm on where the posterior structures develop, mentioned above, is revealed when double-mutants for the posterior and anterior organizing centres are transplanted

with the wild-type posterior cytoplasm: in this case, 'double-abdomen' embryos are formed with posterior poles at either end, just like *bicaudal* mutants, even if the posterior cytoplasm is transplanted into the middle of the mutant embryos. If, however, the transplanted embryo lacks not only the posterior and anterior but also the terminal organizing system, the result is different.

Lehmann reported that when posterior cytoplasm is transplanted into the middle of triple mutants for *bicoid*, *oskar* and *torso* then a posterior pole is formed at the site of transplantation, and a mirror-image embryo is formed that is the exact reverse of when *torso* activity is present. The implication is that there is some kind of interaction between the terminal and posterior systems. Such an interaction was in fact hinted at by some earlier work of Sander which led him to postulate that a kind of 'polar focusing' takes place to orient the posterior organizing centre with respect to the posterior terminus of the embryo. Whether this occurs directly at the level of the maternal gene products, or at a later stage involving interactions between the zygotic gap genes, is at present unclear.

As none of the genes of the *oskar* group has yet been sequenced, there are at present few clues as to how they work. The similarity of the phenotype of *oskar* mutants to that of mutants for the gap gene *knirps*, however, suggested that the signal from the posterior-organizing centre is needed to activate *knirps* expression in the prospective abdominal region of the embryo. Herbert Jackle (Max-Planck Institute for Developmental Biology, Tübingen) reported that the *knirps* gene has at last been cloned by his group, and the sequence of the gene reveals that its protein product has a domain that clearly puts it in the class of DNA-binding proteins characterized by the mammalian steroid-hormone receptors. This is a particularly exciting result in the wake of the recent finding that the receptor for retinoic acid, implicated in the specification of the anterior-posterior digit pattern of the chick wing, is a member of this class of proteins^{7,8}. Whether the signal from the posterior organizing centre of fruitfly embryos is a ligand that activates the *knirps* protein, rather than an activator of *knirps* gene expression as hitherto thought, is not known, but an answer to this question should not be long in coming. □

1. Sander, K. *Adv. Insect. Physiol.* **12**, 125 (1976).
2. Fröhnhoffer, H. G. & Nusslein-Volhard, C. *Nature* **324**, 120 (1986).
3. Nusslein-Volhard, C., Fröhnhoffer, H. G. & Lehmann, R. *Science* **238**, 1675 (1987).
4. Frigerio, G. *et al. Cell* **47**, 735 (1986).
5. Berleth, T., Noll, M. & Nusslein-Volhard, C. *EMBO J.* (in the press).
6. Tautz, D. *Nature* **332**, 281 (1988).
7. Petkovich, M. *et al. Nature* **330**, 444 (1987).
8. Giguere, V. *et al. Nature* **330**, 624 (1987).

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Daedalus

Cylinders of garbage

EVERYTHING burns completely in high-pressure oxygen. This is the principle of the oxygen-bomb calorimeter, which has burnt its way through the vast array of chemical substances in the thermochemical tables, and the huge variety of soggy and aqueous foodstuffs in dieters' calorie charts. Now Daedalus has a new use for the principle — waste disposal.

Almost all urban waste is combustible: paper, plastics, food residues, household grime, even aluminium and sheet-steel. Some urban authorities burn it already, under big, expensive, steam-raising boilers. But Daedalus will use the diesel principle. The cylinder of an oxygen-breathing diesel engine, reaching many tens of atmospheres and many hundreds of degrees Celsius on its compression stroke, would be an irresistibly oxidizing environment.

The diesel waste-combustor will need a special fuelling system. Refuse can hardly be ground up and injected into its cylinders as a fine spray. Daedalus's engine is inverted, with the cylinders at the bottom. A charge of rubbish is just pushed into a cylinder, where it rests on the cylinder-head floor; the entry port is sealed. At each compression stroke the engine takes a 'bite' at this fuel, burning as much as it can with one cylinderful of oxygen. So it runs continuously, breathing in oxygen and expelling burnt gas, until the whole charge of trash has been consumed. The entry port then opens and rams a fresh charge into the cylinder, while expelling any ash from the previous charge. Recharging each cylinder may take several revolutions, during which time the engine will be driven by the remaining cylinders. The brief loss of power should not be serious.

The diesel waste-combustor will be worn away rapidly by its abrasive fuel, and may also tend to burn its own structure. Fortunately, the advanced ceramic materials now being developed for military diesel engines may permit a design which is free of such troubles. The ash from the engine will be mainly glass, ceramics and metal oxides, probably as fine dust and clinker. It may turn out to be convenient to copy iron-smelting practice and add a limestone 'flux' to the fuel, to melt the ash to a liquid slag. It could even be blown by the engine-exhaust to that useful insulator, slag-wool.

Such refinement makes most sense for big municipal installations, burning a whole city's rubbish. But the diesel waste-combustor may make the whole idea of urban rubbish collection obsolete. A small household unit could enable each family to burn its own trash, and use the resulting power and waste heat itself. Daedalus has great hopes of his small 'diesel dustbin'.

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