were applied to the DNA strand. In such a case the strain of an untwisted helix could be relieved or accommodated by the formation of hairpin loops. This property might be important in the structure of chromosomes. The existence of such a loop at the *E. coli* lactose operator gene might be a simple explanation for the completely symmetrical genetic map determined for physiologically similar operator constitutive (O^c) mutants (*9*).

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Iodine Metabolism: Preferential Renal Excretion of Iodide Derived from Triiodothyronine Deiodination

Abstract. *Measurements were made in rats of the relative rates of accumulation in urine or in the thyroid of radioactive iodide derived from simultaneous injections of ^{131}I-labeled triiodothyronine and ^{125}I-labeled iodide. The data indicate that deiodination of triiodothyronine by the kidney results in a loss into the urine of iodine which does not enter the general body iodide pool. This renal "iodide leak" should be considered in kinetic models of iodine metabolism.*

Several mathematical treatments of the kinetics of iodine metabolism have been carried out in recent years. The major pathways have been considered to be relatively uncomplicated (*1*). In all these schemes it has been assumed that the iodide generated through deiodination of thyroid hormones or other iodoamino acids in extrathyroidal tissues has the same metabolic fate as that of iodide already present in the plasma or tissue.

The kidney is a particularly active organ in the deiodination of thyroid hormones (*2*). We considered it possible that a portion of the iodide generated there might enter the renal tubule lumen and not be readily absorbed. Instead of entering the plasma iodide pool by way of the renal venous effluent, some iodide generated de novo in the kidney might thus be excreted immediately and not enter the general body iodide pool. An analogy can be found in the effect of the parathyroid hormone on the adenyl cyclase system of the kidney. Parathormone causes a marked increase in the amount of adenosine 3′,5′-monophosphate (cyclic AMP) excreted by the kidney without inducing any significant rise in the concentration of cyclic AMP in the plasma or any change in the renal clearance of this nucleotide (*3*).

In an effort to evaluate the validity of our hypothesis, we simultaneously injected intraperitoneally tracer doses of carrier-free ^{125}I-labeled iodide and doses of ^{131}I-labeled triiodothyronine (T_3) (0.1 to 1 μg) (*4*) into male Sprague-Dawley rats weighing approximately 200 g each. Each animal thus served as its own control. The quantity of radioactivity was equal (1 to 50 μc) for both isotopes in each rat. Triiodothyronine was chosen rather than thyroxine (T_4) since metabolism of T_3 is much more rapid than that of T_4 so that a major fraction of T_3 would be expected to undergo deiodination in a few hours. We carried out five separate experiments with three to six rats in each experiment. We caused some animals to be made iodine-deficient by feeding them 0.15 percent (by weight) propylthiouracil in a low-iodine diet (LID) (*5*) for 1 week and then feeding them LID without propylthiouracil for 7 to 10 days before the studies were made. Other animals were fed a high-iodine diet of Purina Lab Chow (*6*).

After injection of the radioisotopes, the animals were placed in individual metabolism cages without food or water and urine samples were collected every 2 hours for 6 hours. The animals were then killed. The thyroids were removed, their content of both isotopes was determined, and they were digested and chromatographically analyzed in two different solvent systems as described earlier (*7*). The radioactivity in the urine was similarly analyzed, but in this case direct chromatography was carried out without digestion.

The results of all three LID experiments were similar, as were those of the Purina experiments. The data are pooled in Table 1. More than 95 percent of both ^{131}I and ^{125}I radioactivity in the urine was iodide except in one rat in which 70 percent of the urine ^{131}I radioactivity corresponded to T_3. The data from this animal have been excluded from Table 1. The urine volume remained constant at approximately 1.5 ml per rat for each 2-hour collection period throughout the experiment. The distribution of radioactivity in the chromatographs of the thyroid digests in each experiment was similar for both isotopes and indicated that there was no $[^{131}I]T_3$ in the thyroid beyond that which was due to the iodination of thyroglobulin with ^{131}I-labeled iodide.

The urine/thyroid (U/T) radioactivity ratios were used as the index of comparison of the two isotopes. Equality of the ratios would indicate that the iodide generated from T_3 deiodination was metabolized identically with that originally injected as iodide. Inequality would indicate that one iso-

Table 1. Percentage of radioactivity injected as $[^{131}I]T_3$ or as ^{125}I-labeled iodide accumulated in urine or thyroid in 6 hours. Results are given as the pooled mean ± the standard error of the mean of three LID and two Purina experiments. There was a pooled total of nine rats in each of the groups.

Diet	Label	Urine (% of dose)	Thyroid (% of dose)	^{131}I U/T / ^{125}I U/T
LID	^{131}I	2.7 ± 0.4	22.1 ± 3.2	1.90 ± 0.21
LID	^{125}I	5.9 ± 0.6	83.8 ± 3.2	
Purina	^{131}I	5.6 ± 0.7	1.3 ± 0.1	1.39 ± 0.08
Purina	^{125}I	28.7 ± 2.1	9.5 ± 0.5	

tope was preferentially excreted into the urine as compared to the other. The U/T ratio averaged 1.9 times higher for ^{131}I than for ^{125}I in the rats fed LID and 1.4 times higher in the rats fed the high-iodine diet. The lower value in the latter group is consistent with the well-known lower rate of extraction of iodide from the plasma by the thyroids of iodine-replete than of iodine-deficient animals (*8*). The kidney and the thyroid are the two principal competitors for iodide from plasma. Thus, a decrease in the rate of iodide uptake by the thyroid permits an increase in the quantity of iodide excreted in the urine. The higher the relative rate of urinary excretion of iodide from plasma compared to that of thyroid accumulation of iodide from plasma, the less difference there will be in the U/T ratios of iodide originating as plasma iodide or through renal deiodination of T_3.

These results support the validity of our hypothesis that a portion of the iodide derived from T_3 deiodination in the kidney can enter the renal tubule lumen and be excreted in the urine without being reabsorbed to mix with the body iodide pool. Presumably iodide derived from T_4 or iodotyrosine deiodination in this organ would be handled in a similar manner.

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4. Liothyronine ^{131}I was purchased from Abbott Laboratories, North Chicago, Illinois. Chromatographic analysis in our laboratory showed that 96 to 98 percent of all the radioactivity was contained in T_3.
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Fluorescent Banding Patterns of Rat Chromosomes in Normal Cells and Primary Hepatocellular Carcinomas

Abstract. *Quinacrine staining permits identification of rat chromosomes in metaphase that were formerly classified only in groups within the karyotype. This technique defined two types of abnormal chromosomes in cells of rat hepatomas.*

The binding of quinacrine compounds to chromosomes has been described for several species of plants and animals (*1*). The fluorescent banding patterns of these chromosomes complexed with quinacrine appear to be constant for a given species. This complexing technique is therefore a useful addition to standard karyotype analysis for identification of individual chromosomes. Its applications include: (i) identification of individual chromosomes (*2, 3*); (ii) characterization of structurally or numerically abnormal chromosomes (*3*); and (iii) identification of the species of origin of chromosomes in hybrid cells (*4*).

The fluorescent banding pattern for rat chromosomes has not yet been described. We have examined this pattern to make specific identifications within groups of rat chromosomes that are otherwise morphologically indistinguishable. We present here a description of this pattern, which we have used to analyze the chromosomes in cells of primary hepatocellular carcinomas (hepatomas) that were induced in rats by chemical carcinogens.

All cells examined came from several lines of Sprague-Dawley rats. Lymphocytes from males and females were examined after 4 days of culture in vitro with phytohemagglutinin. The hepatomas were induced in the rats by the ingestion of *N*-2-fluorenylacetamide (*5*). Cells in metaphase were obtained directly from the hepatomas, and the preparation of these cells and lymphocytes has been described (*6*).

Dividing fibroblasts (*7*) were examined at weekly intervals during 4 months of cultivation in vitro. These rat embryo cells, originally prepared from a single, minced, 18-day embryo, were maintained in cell culture in Dulbecco's 4X medium with 10 percent calf serum. Cul-

Fig. 1. A graphic representation of the chromosomes of the rat; haploid set +X+Y. The autosomes are numbered. The light bands within the chromosomal outlines represent the fluorescent bands produced by quinacrine staining. This diagram is based on a study of 61 cells with relatively extended chromosomes; some of the bands appear fused in contracted chromosomes.