can be certainly recognized is given in Table 1. Undercondensation alone permits recognition of the X in prophase, but in metaphase the undercondensation is often marginal, and the separation of chromosomes is generally incomplete (Fig. 3). However, characteristically the X lies away from the autosomes, and then even slight heteropycnosis can be diagnosed. Furthermore the daughter chromatids of the X are well separated distally at metaphase, and this is not seen in the autosomes until late metaphase or early anaphase (Fig. 3) (*3*). Labeling of the X alone was never seen, even in the labeled cells fixed at 4, 8, and 10 hours. Only the autosomes are labeled in 8 percent of the cells; this is a high estimate and at no time is there a large fraction of such cells. Hence it appears that the negatively heteropycnotic X chromosome of young spermatogonia undergoes DNA synthesis throughout the period of DNA synthesis, although at any time synthesis may be low or absent in the X of some cells. Certainly the typical pattern (92 percent of the cells) is as shown in Fig. 3. The density of silver grains in this series of slides is not consistently different from that in the materials fixed 25 minutes after injection of tritiated thymidine, an indication that the pulse duration is about half an hour as suggested by Lima de Faria (*1*). Thus the pulse duration is about 1/70 of the period of DNA synthesis; in other words—temporal resolving power is very high.

We conclude that in cell generations in which the X chromosome is negatively heteropycnotic, its replication is synchronous with autosomal replication, but in the last premeiotic interphase the X is both positively heteropycnotic and asynchronous in replication. Similar developmental alterations in the temporal sequence of replication are implicit in recent studies on mammalian cells (*10*); ours is the first direct demonstration. This study provides additional support for the view that late replication and positive heteropycnosis are intimately, perhaps causally, related and hence provides some basis in fact for hypotheses relating late replication to the genetic repression associated with heteropycnosis (*11*).

R. BRUCE NICKLAS
RICHARD A. JAQUA
Department of Biology, Yale University, New Haven, Connecticut

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Tylotrich (Hair) Follicle: Association with a Slowly Adapting Tactile Receptor in the Cat

Abstract. *The small raised tactile areas on the skin surface of the cat which evoke action potentials that convey both temporal and spatial information to the central nervous system are* Haarscheiben *or tylotrich pads. Each pad is an integral part of a tylotrich follicle, a skin appendage that is highly specialized for sensory function.*

Slowly adapting cutaneous mechanoreceptors with afferent nerves have been described in the cat, dog, and primates (*1–4*). Iggo (*2*) and Tapper (*4*) have shown that in the cat the receptors are contained within specialized structures called touch spots, which are raised hemispherical domes on the skin surface. Touch spots are richly vascularized and contain specialized cells in the epidermal layer (*3*). Thus the touch spot seems strikingly similar in morphology to the well-known *Haarscheibe* (*5, 6*) or tylotrich pad (*7*).

We describe here the tylotrich pad in the skin of the cat and suggest that the pads are the structures seen by Winkelmann (*8*), as well as the structures also called "touch spots" or "touch corpuscles" (*1–4, 9*).

Three adult female cats were anesthetized and the hair was clipped from the right dorsa, venters, and hind limbs; the remaining hair stubble was removed with barium sulfide. Erected tylotrich pads were visible to the eye immediately after depilation, and this erectile response lasted 5 to 10 minutes. The pads ranged from 0.16 to 0.42 mm in diameter, and they were larger on the caudal venter than on the caudal dorsum (Table 1). Similar results are reported for the mouse and sheep (*10*).

About 60 tylotrich pads with some surrounding tissue were excised from the various skin areas. For study of nerve endings, some specimens were impregnated with gold chloride or were fixed in chloral hydrate and impregnated with silver nitrate (*11*). The remaining tissues were appropriately processed, then stained with alum hematoxylin and eosin, Weigert's hematoxylin and eosin, or van Gieson's picric acid–fuchsin stain and alum hematoxylin.

Each tylotrich pad is composed of a thickened and distinctive epidermis underlaid by a convex area of fine connective tissue that is highly vascularized and well innervated (Fig 1, *a* and *b*). Along the base of the pad epidermis,

Table 1. Diameter of tylotrich pads in the cat.

Caudal area	Pads		*t**	*P*†
	Observed (No.)	Diam. M ± S.E. (mm)		
Dorsum	23	.256± .007	3.16	<0.01
Venter	21	.300± .012		

* Based on Fisher's small sample *t*-test.
† Probability that the difference between the means is due to chance alone.

there are large cells with clear cytoplasm which are similar in structure to the tactile cells of Merkel (*6*). These cells are closely associated with nerve endings (Fig. 1, *a* and *b*). Above this is a layer of elongate epidermal cells (Fig. 1*a*).

Slightly caudal, caudal lateral, or, infrequently, cephalic to each pad in the cat is the orifice of the large and richly innervated tylotrich follicle (*7*). In many, but not all mammals, the pad completely surrounds and extends into the tylotrich follicle. Thus the pad is anatomically an integral part of a larger sensory structure (*7, 10*). Tylotrich follicles of the cat are larger than their neighboring pelage follicles, and they characteristically have sweat glands, which are missing in small follicles. At about the level of the sebaceous glands, the tylotrich follicle is surrounded by a specialized area of tissue, called the annular complex, that consists of several concentric structures. The inner component is a distinct bilaminar arrangement of nerve fibers (Fig. 1*c*). This is encircled by the annulus, a connective tissue band that is composed of elongate cells, and of elongate fibers that stain deeply with eosin (Fig. 1*d*). Above and below the annulus are areas of randomly oriented connective tissue-like cells (Fig. 1*e*). All of these structures are surrounded by a thickened and highly vascularized area of the connective tissue capsule (Fig. 1*e*). There is a large nerve at the side of each tylotrich follicle (Fig. 1*f*). One branch of the nerve comes from the bilaminar arrangement of nerve fibers in the annular complex, and another branch from the pad (Fig. 1*b*).

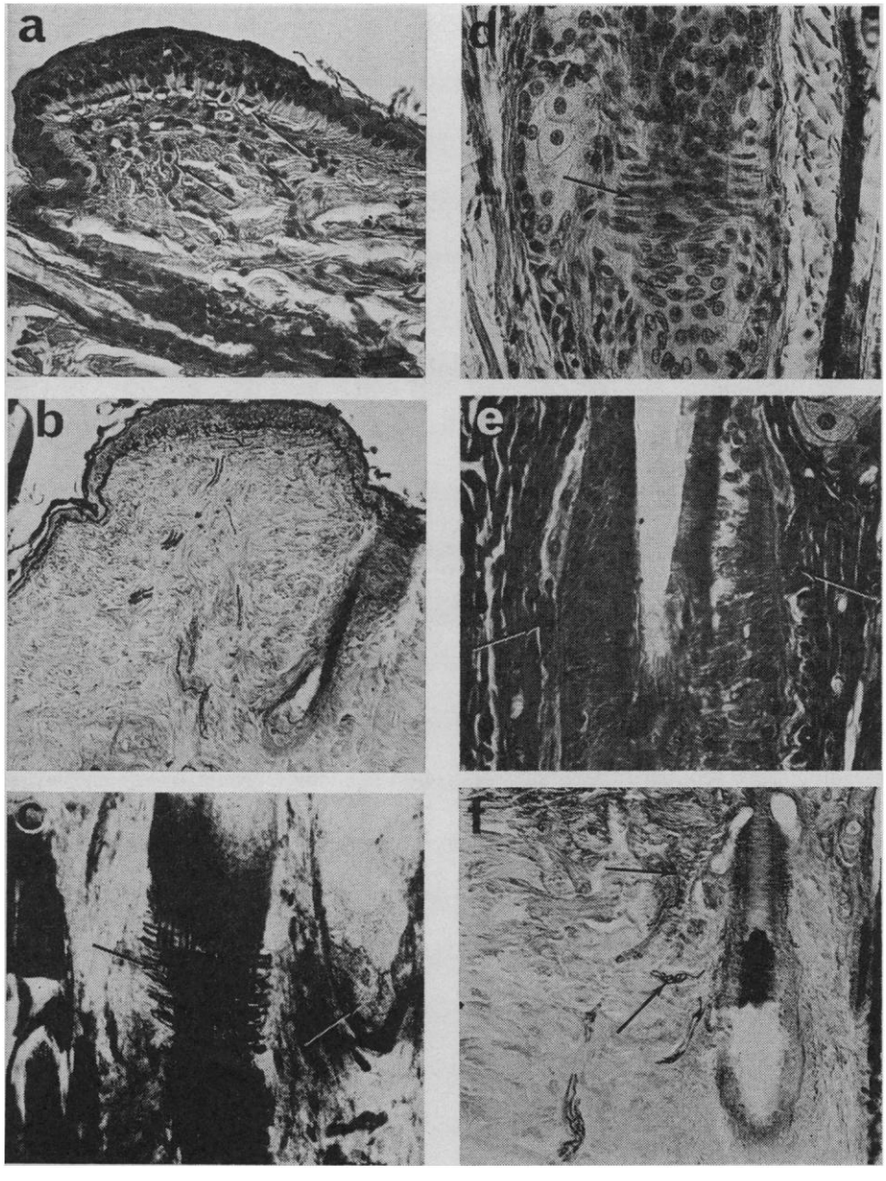

Fig. 1. *a*, Tylotrich pad from the caudal dorsum of the cat. The epidermis is thickened and there is an underlying area of fine connective tissue. The lower arrow marks a nerve, and the upper arrow marks one of the large cells with clear cytoplasm near the base of the epidermis. Weigert's hematoxylin and eosin stains (× 220). *b*, Nerve fibers (fine black lines) associated with the tylotrich pad and large cells at the base of the epidermis. Silver stained (× 125). *c*, Nerve network (left arrow) surrounding a tylotrich follicle. The right arrow marks the sebaceous gland. Gold chloride stained (× 290). *d*, Connective tissue band or annulus (arrow) surrounding a tylotrich follicle. Van Gieson's and alum hematoxylin stains (× 240). *e*, Longitudinal section of a tylotrich follicle showing the connective tissue band or annulus in cross section (arrows). Notice the more lightly stained areas of randomly oriented connective tissue cells above and below the annulus. These structures are surrounded by a dark stained area of the connective tissue capsule that contains blood vessels. Three of the vessels appear as small, round, clear areas in the capsule at the right side of the follicle. Van Gieson's and alum hematoxylin stains (× 295). *f*, Innervation of a tylotrich follicle. The nerve trunk at the lower left of the photomicrograph comes from the annular complex (lower arrow) and from the tylotrich pad (upper arrow). Silver stained (× 115).

Slowly adapting firing patterns were first observed in vibrissa follicles of the cat (*12*), and Straile has suggested that a similar neural physiology should be expected in tylotrich follicles (*7*). The demonstration (*2, 4*) that such patterns are associated specifically with touch spots (pads of tylotrich follicles) raises many questions, such as (i) whether mechanical stimulation of the pad also stimulates nerve fibers around the neck of the follicle; (ii) whether both the receptors in the pad and the receptors in the annular complex evoke slowly adapting responses, or whether there are distinct differences in their firing patterns; and (iii) since the pad and the annular complex contain vascular areas of tissue easily dilated upon mechanical stimulation, is there a relation between the degree of vascular dilation and the pattern of discharge from the nerve receptors?

Although a slowly adapting firing pattern is produced by direct mechanical stimulation of the pad, a similar response is likely evoked by specific directional movement of the tylotrich itself. Evidence to support this idea is supplied by examination of the cat vibris-

sa follicle, which is similar in morphology to the tylotrich follicle (*7*). Forward or upward movement of the vibrissa produces a slowly adapting response, whereas pulling or pushing of this hair often fails to produce a discharge (*12*). Furthermore, Iggo (*2*) reports that an occasional discharge of impulses can be elicited if the hair nearest the touch spot (tylotrich pad) of the cat is moved in a particular direction. Possibly an effective directional movement is one that depresses the larger area of the pad. In the cat the tylotrich must be moved cephalad if it is to press against the pad. In other mammals, such as the rabbit, most of the pad is caudal to the orifice of the tylotrich follicle (*7*), and thus a caudad movement of the hair should be more effective.

The growing tylotrich follicle of the cat differs markedly from the resting follicle. For example, when the hair is growing, the annular complex appears compressed and is difficult to observe. This suggests that changes in neurophysiology may occur during the growth cycle of the tylotrich follicle. Unfortunately, such changes would be difficult to study in the cat because the pelage follicles grow asynchronously (*13*). In the rabbit, hair cycle staging can be assessed accurately by timing the waves of synchronous growth or by use of the plucking stimulus (*14*). The rabbit tylotrich follicle should provide better material for neurophysiological studies because the components of the annular complex are large and show extreme physiological and morphological specialization (*7*).

STANLEY J. MANN
WILLIAM E. STRAILE
Biological Station, Roswell Park Memorial Institute, New York State Department of Health, Springville

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Ionizing Radiation: Effect of Irradiated Medium on Synthetic Processes

Abstract. *The incorporation of uracil-C^{14} into macromolecules in* Escherichia coli *cells is decreased by doses of ionizing radiation when the cells are in very dilute suspension. The decrease results from an action of irradiated medium on the cells, and a similar reaction is observed during the incorporation of thymine (indication of DNA synthesis) and of proline and valine (indicative of protein synthesis). Irradiated medium reduces the formation of β-galactosidase but does not cause the degradation of DNA.*

Studies on the effect of ionizing radiation on the incorporation of labeled metabolites into macromolecules of bacterial cells show that the processes of synthesis are sensitive to ionizing radiation. However, the conditions of irradiation seem to produce striking differences in sensitivity. The incorporation of a radioactive label either as uracil-C^{14} or phosphate-P^{32} into cells of *Escherichia coli* is reduced by ionizing radiation, but only at relatively high doses, 50,000 roentgens or higher (*1*, *2*). On the other hand, at much lower doses there is a striking effect on *E. coli* DNA; it is synthesized at a reduced rate after irradiation and also degraded to very small fragments (*3*, *4*).

We now report two seemingly separate effects of radiation: first, an effect which is produced primarily by a radiochemical action on the medium in which the cells are subsequently grown, and second, an effect which requires radiation of the cells themselves. Both effects are greater in the presence of oxygen.

In a representative uptake experiment (Fig. 1) the culture was oxygenated before irradiation, and the time of exposure to a Co^{60} source is indicated by the shaded region. For 12,000 roentgens there is clearly a cessation of uptake, this period lasting for about 20 minutes. The results of the same experiment carried out after nitrogenation of the medium indicates that a dose ten times larger produces, if anything, less effect than is produced in the presence of oxygen. In experiments similar to this for doses of 6,000 r, 12,000 r, and 30,000 r in the presence of oxygen, incorporation was only observed for 6,000 r, and in that case there was a 50 percent decrease.

The foregoing experiments were performed at cell concentrations of less than 10^8 cells per milliliter. At concentrations of 5×10^8 cells per milliliter and upward the sensitivity of incorporation was much less. In this range our results agree with those of Frampton (*2*). However, two experiments imply that radiation affects the medium as well as the cells. The effects of exposing cells which had not been irradiated to medium which had been irradiated (Fig. 2) is almost as great as would be produced by irradiation of a dilute culture of cells in the presence of oxygen. The medium is Roberts C minimal medium (NH_4Cl, 2 g; Na_2HPO_4, 6 g; KH_2PO_4, 3 g; NaCl, 3 g; $MgCl_2 \cdot 6H_2O$, 62 mg; Na_2SO_4, 80 mg; glucose, 5 g per liter), and separate irradiation of distilled water indicated that the significant component is water. When bovine serum

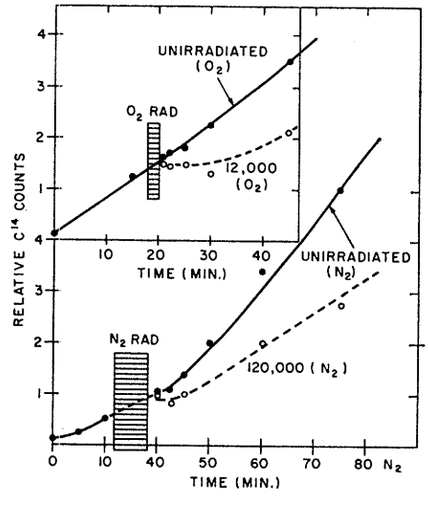

Fig. 1. Uracil-C^{14} in the macromolecular fraction (insoluble in trichloroacetic acid) for unirradiated cells and cells irradiated in oxygen and nitrogen (count/min). Upper curve, effect of 12,000 r in oxygen and the lower for ten times that dose in nitrogen. Irradiation in oxygenated medium halts the incorporation of uracil.