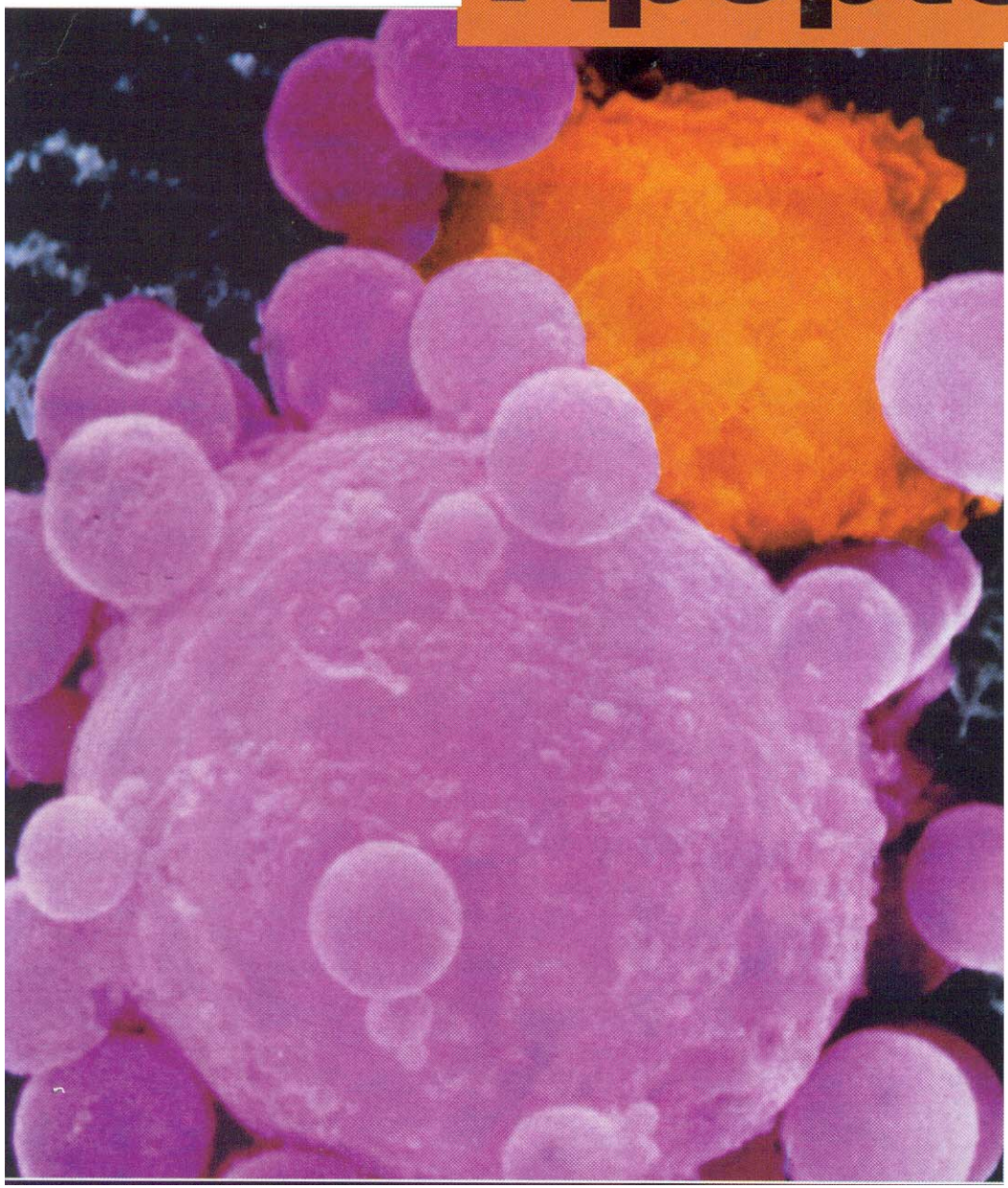
Apoptosis



Nature, 407, II. 2000

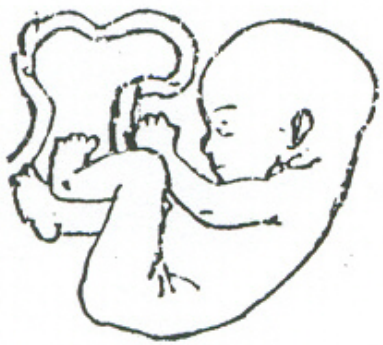
- 1842 VOGT DESCRIPCIÓN MORFOLÓGICA
- 1890 BOINET CÉLULAS MUEREN DURANTE EL TRANSCURSO NORMAL DE LA VIDA
- 1972 KERR APOPTOSIS
- 1980 HORNVITZ MUERTE CELULAR PROGRAMADA

DIVISION CELULAR

Número células

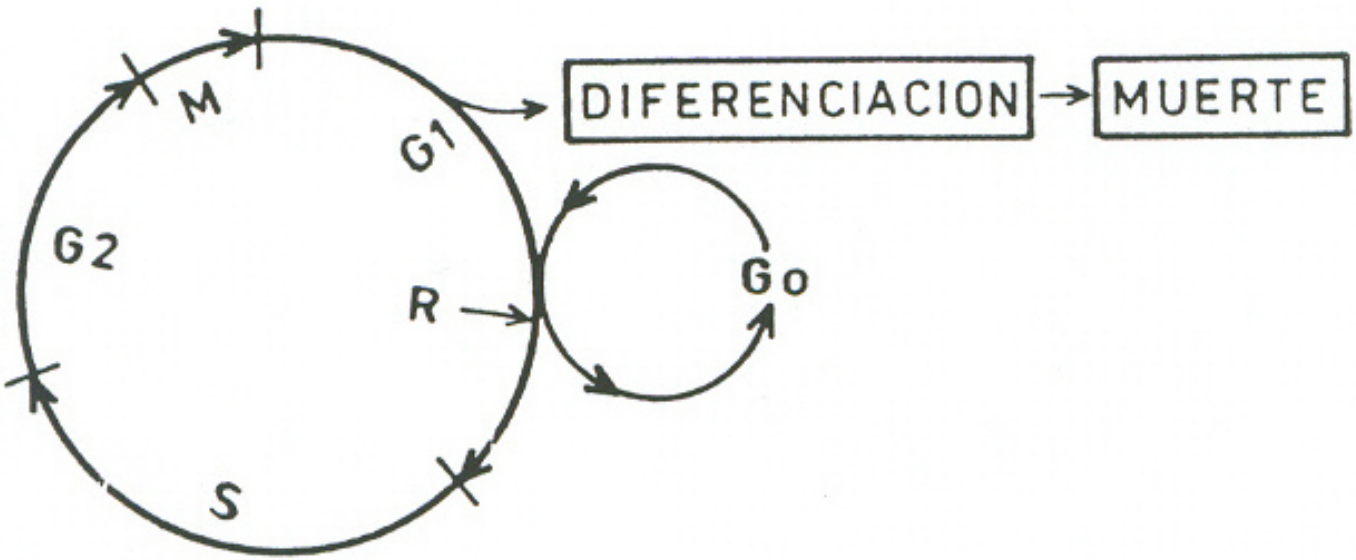
↑ División Celular

↓ Muerte Celular Programada
Apoptosis



División Celular > Apoptosis
Nº Células ↑

División Celular = Apoptosis
Nº Células constante



Esquema del Ciclo Celular

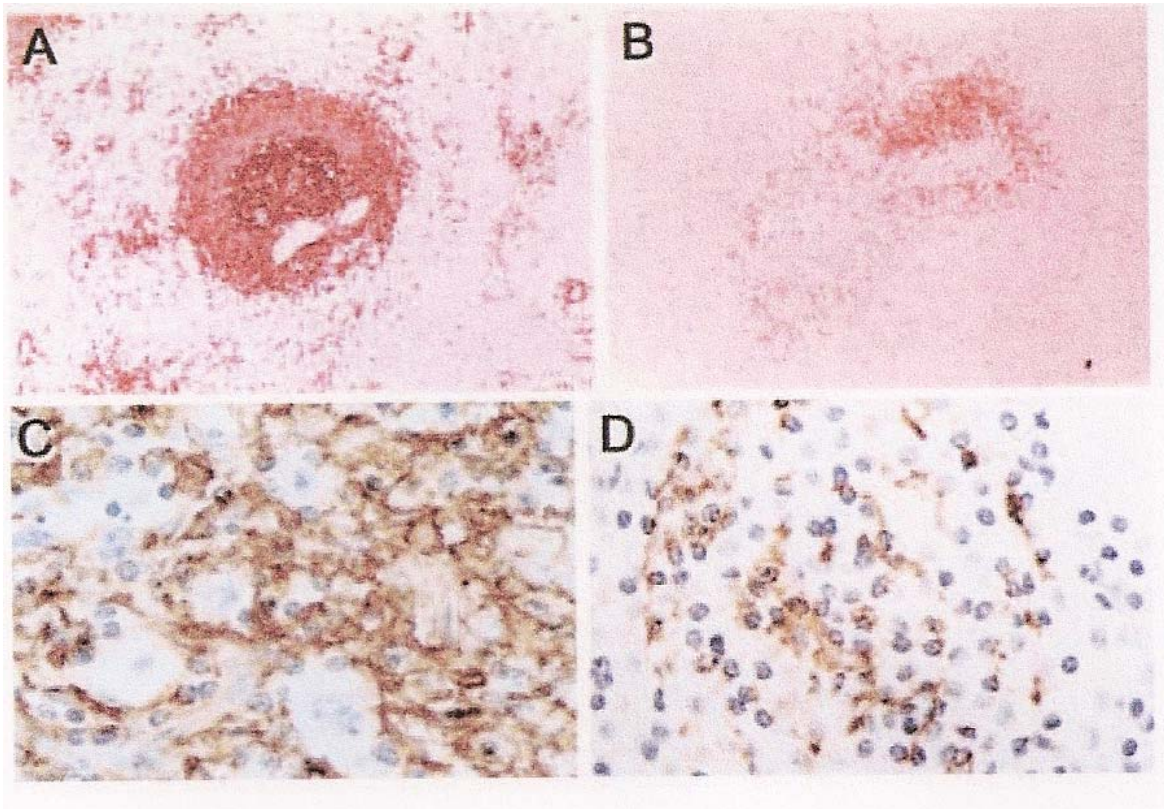


Figure 2. Immunohistochemical identification of B cells and follicular dendritic cells in spleens of patients dying of trauma or sepsis. Total B cells are decreased in the spleen of a patient with sepsis (B) compared with that of a trauma patient (A) (magnification ×400). Similarly, follicular dendritic cells are decreased in the spleen of a patient with sepsis (D) compared with that of a trauma patient (C) (magnification ×600).

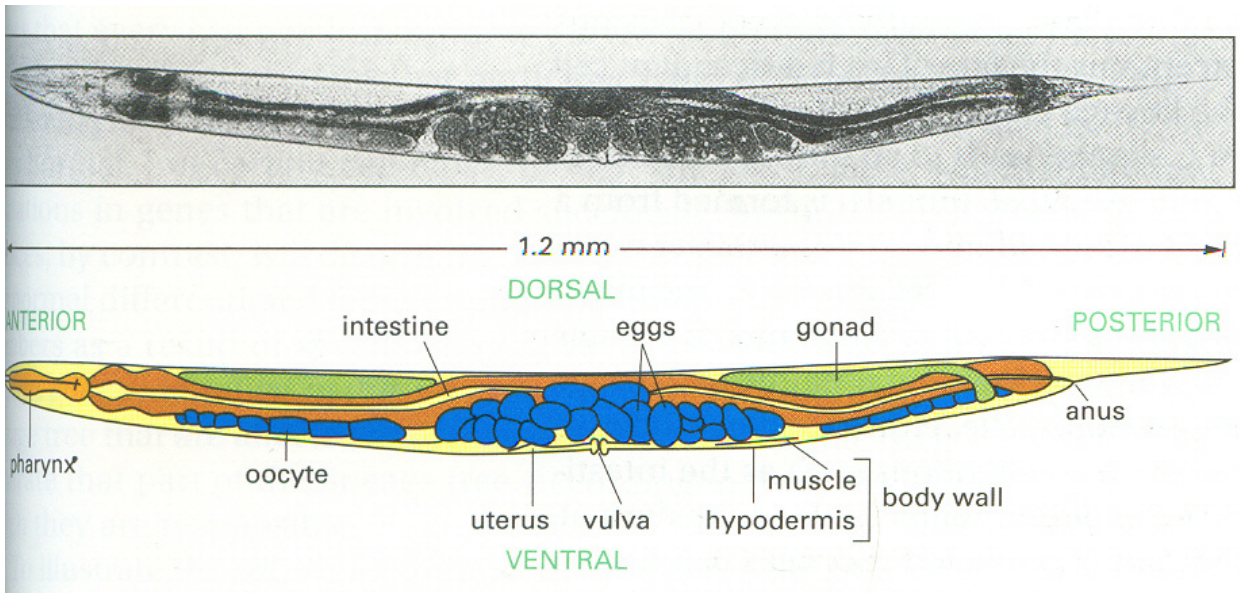


Figure 21–39 ***Caenorhabditis elegans.*** A side view of an adult hermaphrodite is shown. Note that the tissue called hypodermis in the nematode corresponds to the epidermis of other animals. (From J.E. Sulston and H.R. Horvitz, *Dev. Biol.* 56:110–156, 1977.)

Alberts

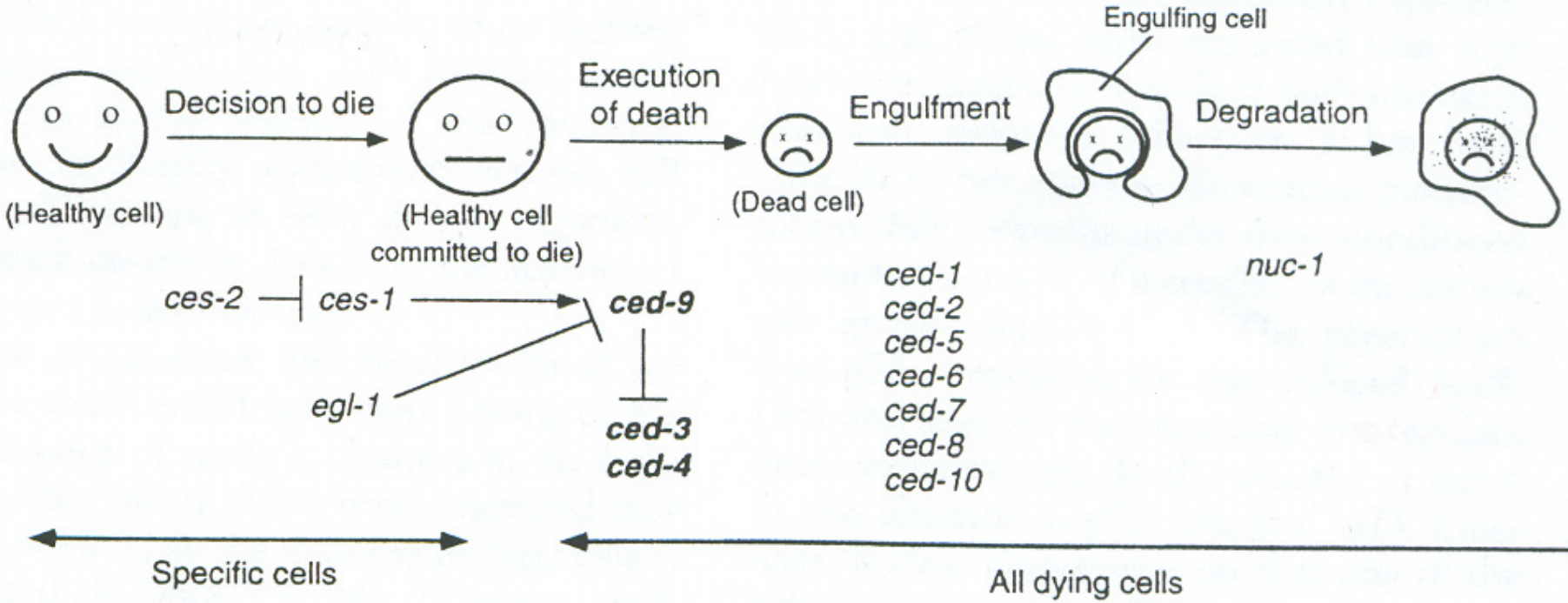


Fig. 1. Genetic pathway for programmed cell death in *C. elegans*. Mutations in 14 different genes have been isolated that affect specific stages of programmed cell death in *C. elegans*. Mutations that influence the decision to die affect only a small number of cells. In contrast, genes involved in all subsequent stages of cell death are common to all somatic cell deaths in this organism. Three genes, *ced-3*, *ced-4*, and *ced-9*, affect the execution of the death program. The activity of *ced-3* and *ced-4* promotes cell death, and *ced-9* activity prevents this process. The epistatic relationship among these genes has been deduced from double-mutant combinations. Symbols: → (positive regulation); ——| (negative regulation). [Adapted from (*14*)]

Science, 267, 1995

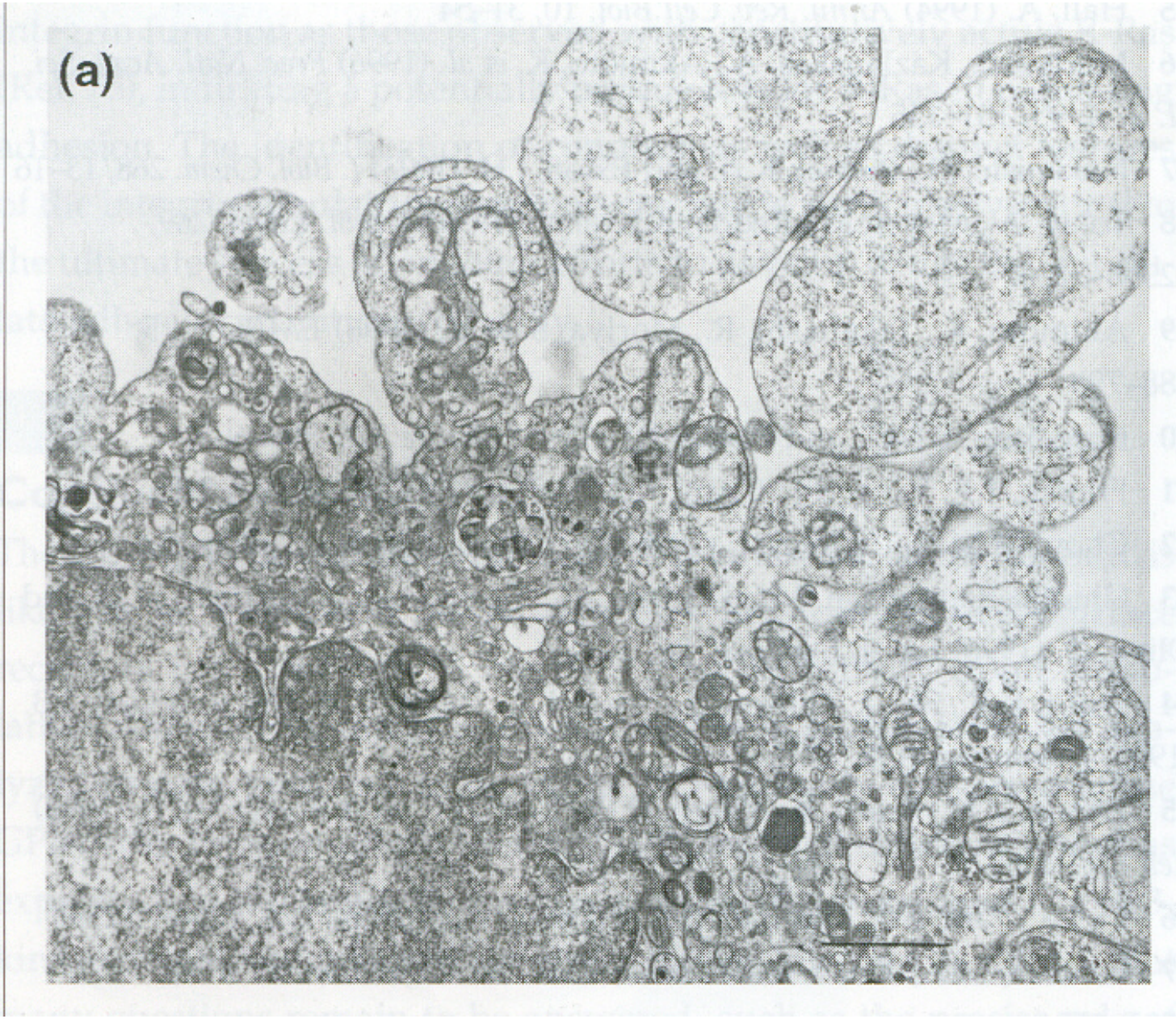
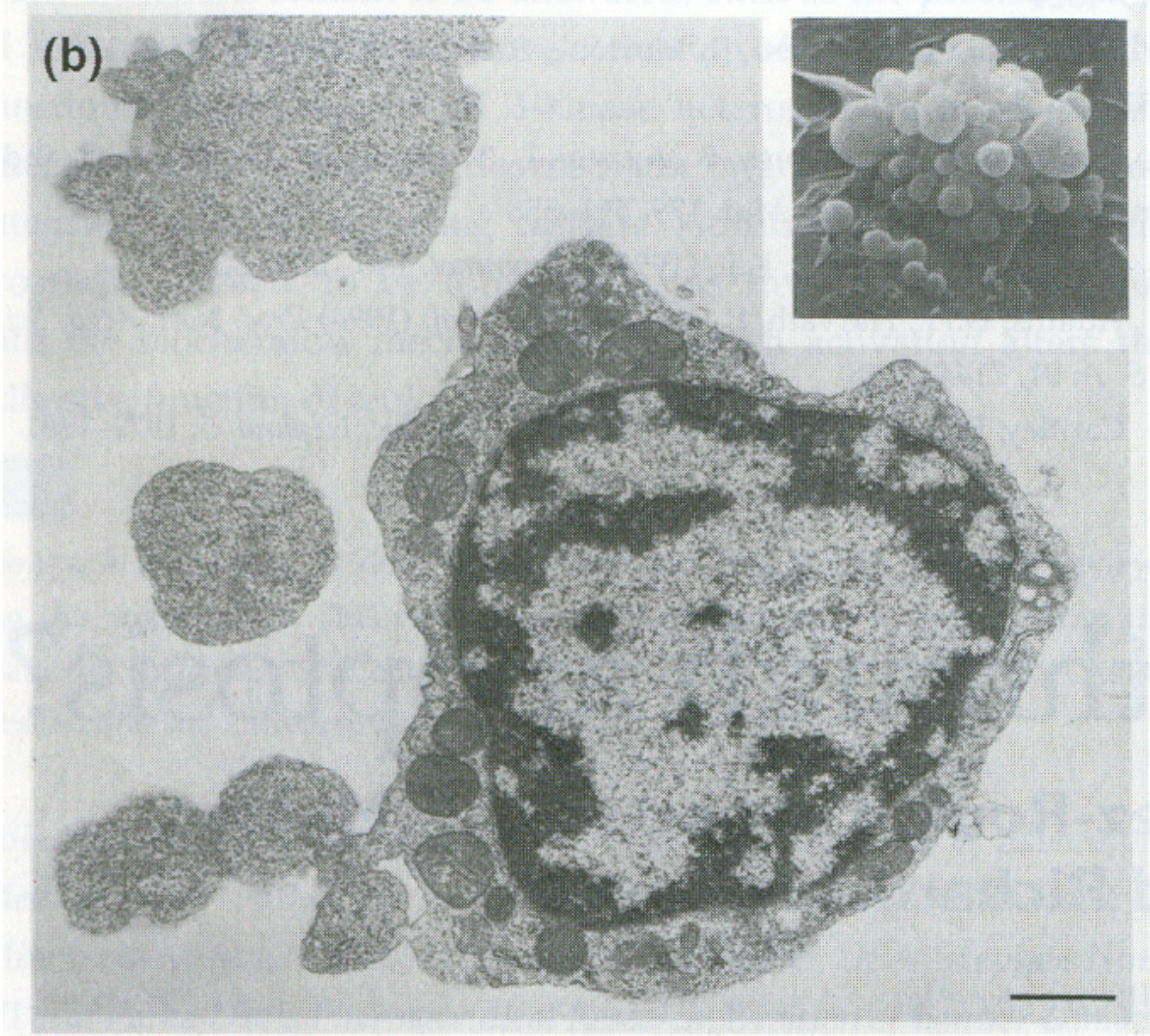


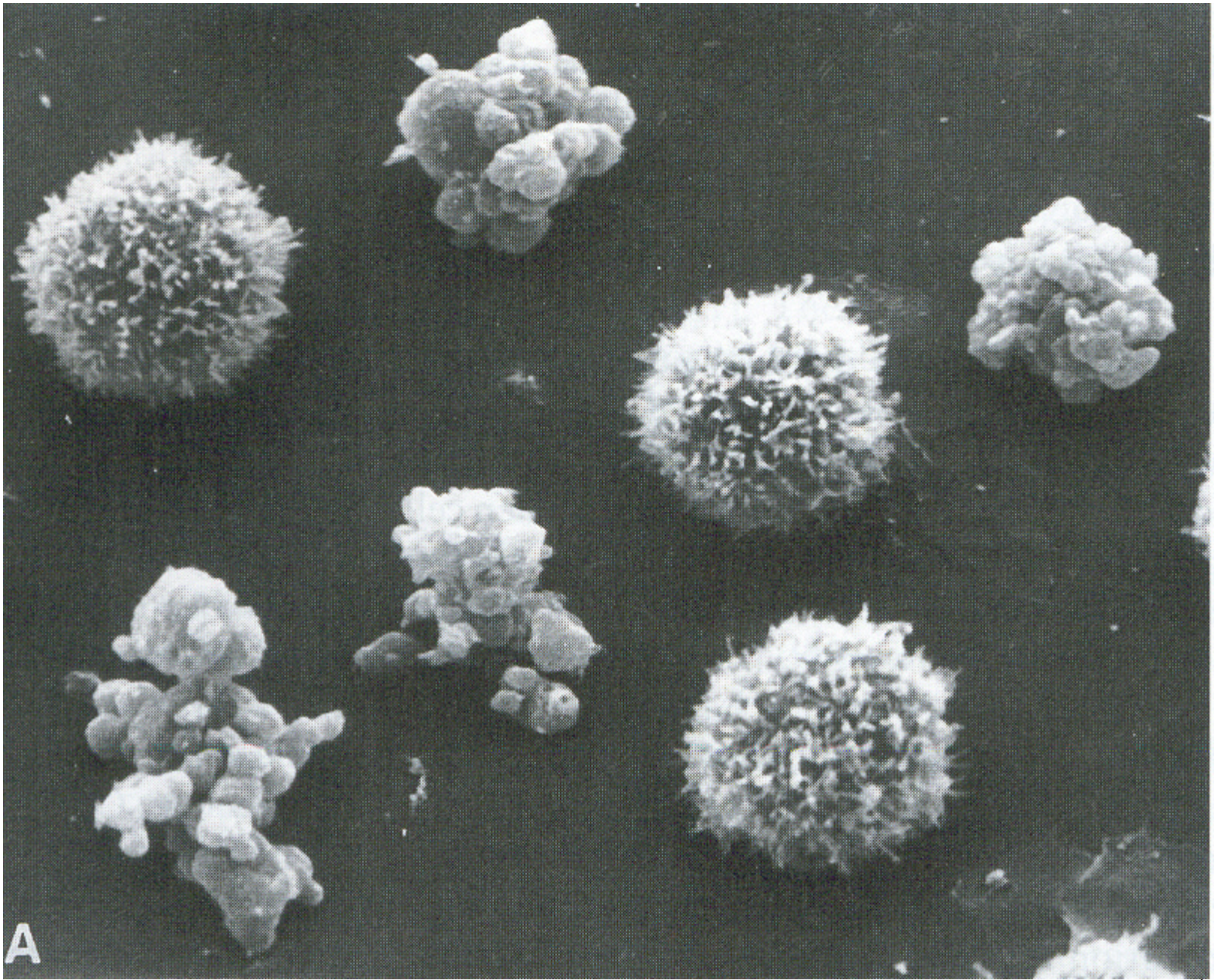
Fig. 1. *Apoptotic morphology in the cytotoxic targets of macrophages. (a) A mouse L cell displaying membrane blebbing typical of apoptosis*[6].

Immunology Today, 17, 12, 1996



(b) SL2 lymphoma cell in a macrophage cytotoxicity assay with the chromatin condensation characteristic of apoptosis[11]; inset, SL2 lymphoma cell showing apoptotic surface convolutions[11].

Immunology Today, 17, 12, 1996



Apoptosis,
Kaufmann

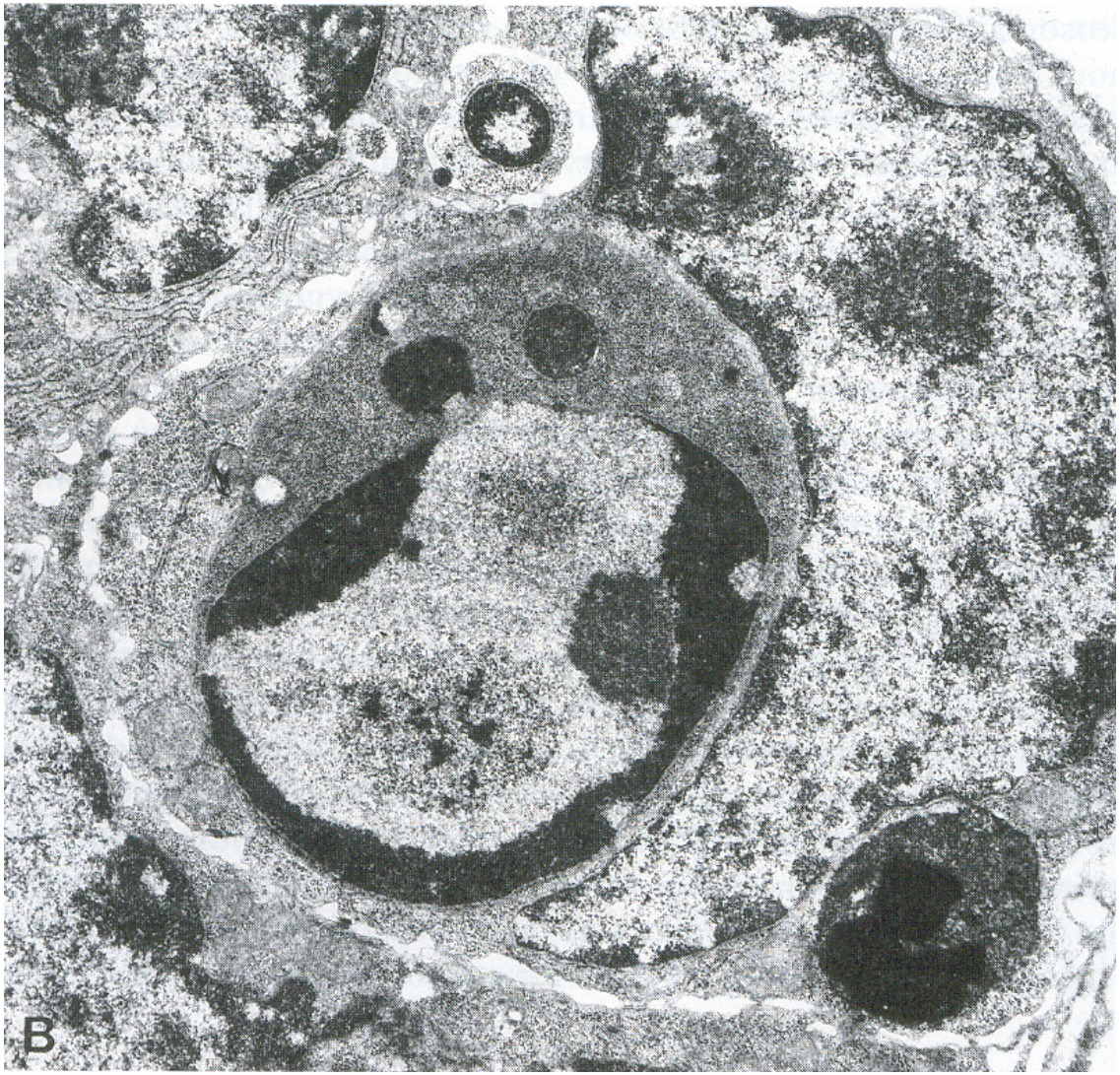


FIGURE 1 Cytoplasmic and nuclear changes characteristic of apoptosis. (A) Viable and apoptotic mouse sarcoma 180 cells growing as ascites tumors that were treated with actinomycin D 18 h previously. The viable, intact cells are covered with microvilli, whereas cells undergoing apoptosis display protuberances of the plasma membrane, or "blebbing," which are devoid of microvilli (courtesy of C. Bishop, published with permission of *Int. Rev. Cytol.*). (B) Apoptotic remnants of epithelial cells of mouse small intestinal crypts 4 h after exposure to 400 rads X rays which have been phagocytosed by an adjacent epithelial cell. The chromatin of the large nuclear remnant has condensed and collapsed along the nuclear periphery. Note also the characteristic nucleolar changes (courtesy of J. F. R. Kerr, published with permission from *Int. Rev. Cytol.*).

Apoptosis,
Kaufmann

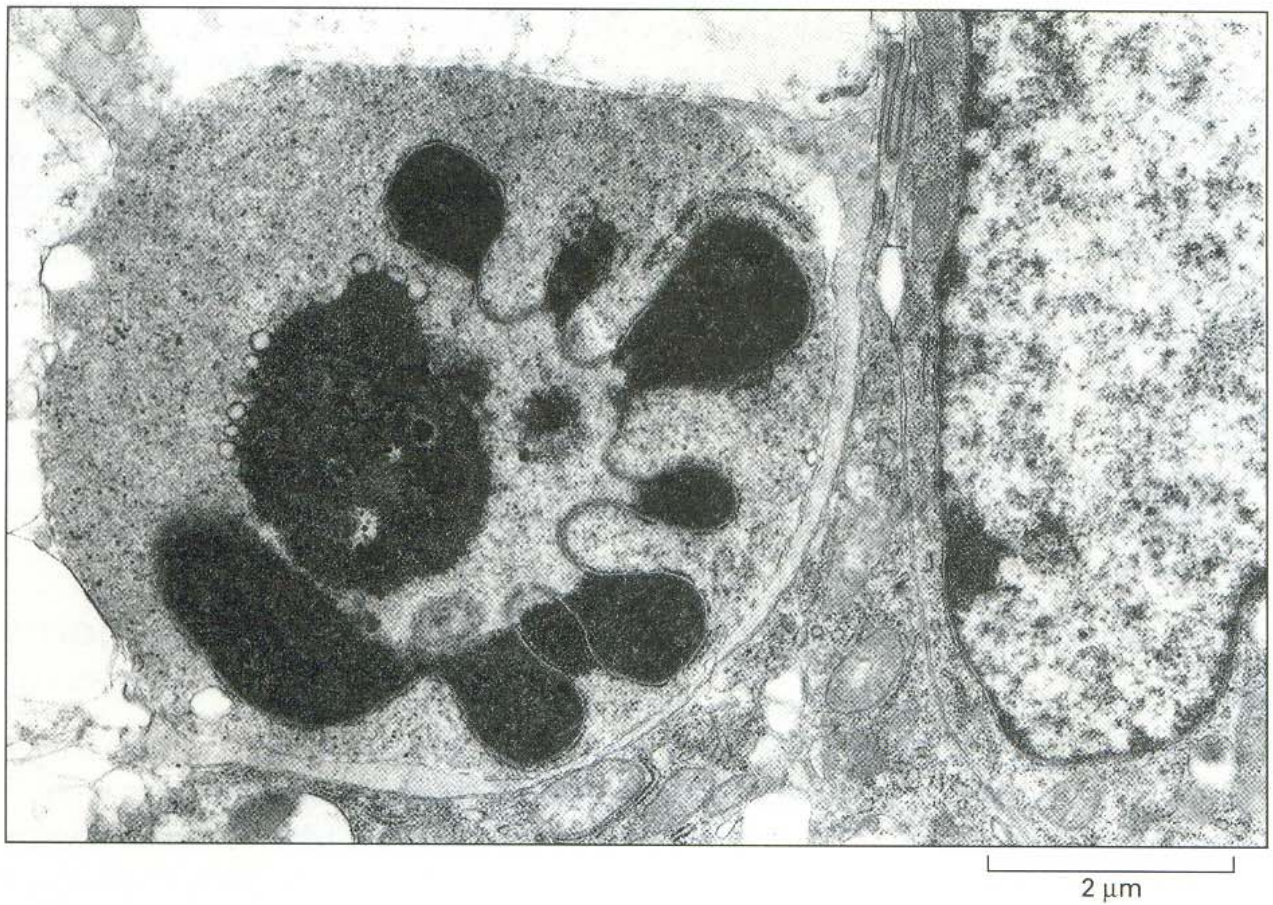
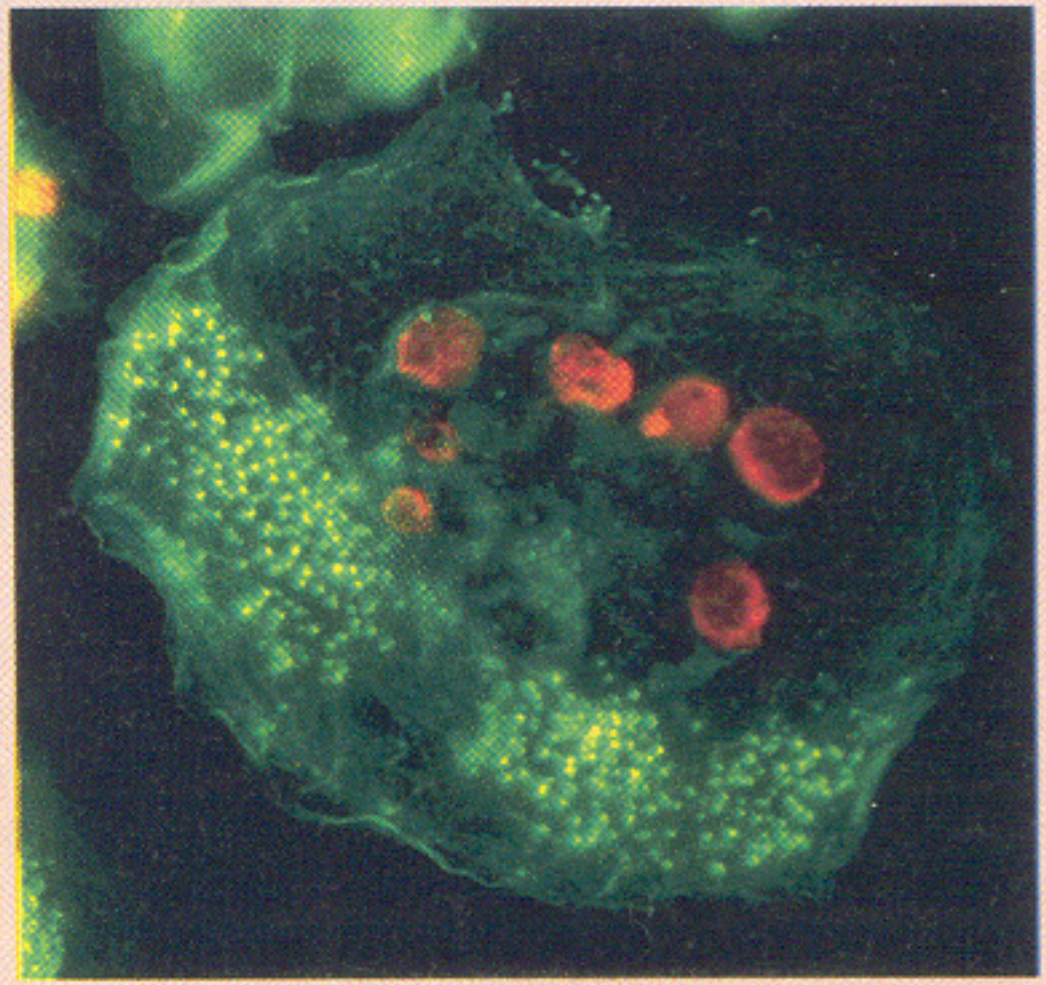


Figure 22–35 Cells dying by apoptosis. The electron micrograph shows an apoptotic cell in the mammary gland. Apoptotic cell death is a normal occurrence here, balancing the proliferation of mammary epithelial cells that occurs in each menstrual cycle. Note the disintegrating nuclear envelope and the dark clumps of condensed chromatin. For comparison, part of a normal cell is visible to one side of the picture. (Courtesy of David Ferguson.)

Alberts

Figure 2 A human monocyte-derived macrophage ingests multiple apoptotic bodies. Jurkat T-cell targets were labelled with 5-(and 6)-carboxytetramethylrhodamine succinimidyl ester and irradiated to induce apoptosis. The macrophages were stained with fluorescein isothyocyanate-conjugated phalloidin to identify actin filaments. (Photograph courtesy of M. Janes and P. Henson).



Nature 407,

II, 2000

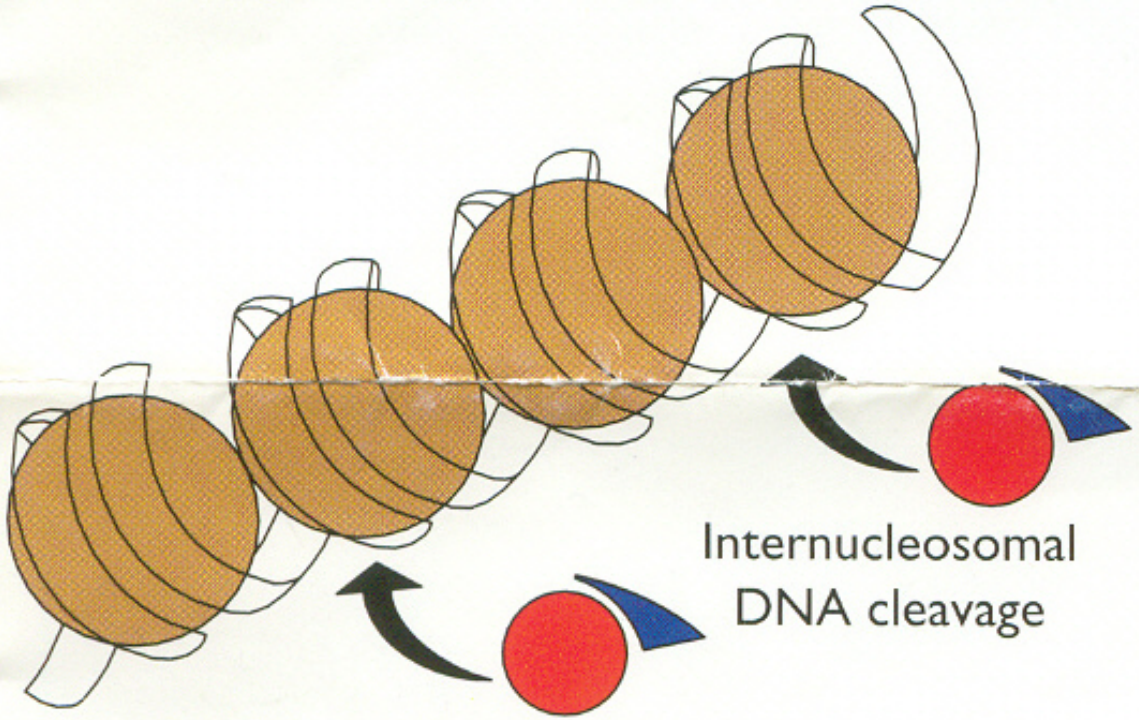
APOPTOSIS
MUERTE CELULAR PROGRAMADA

- CONDENSACIÓN NUCLEAR Y CITOPLASMÁTICA
- ALTERACIONES EN LA ESTRUCTURA DE LA MEMBRANA
- VARIACIÓN EN LA COMPOSICIÓN DE LÍPIDOS.
  TRANSLOCACIÓN DE LA FOSFATIDILSERINA
- BURBUJEO O BLEBBING DE LA MEMBRANA CELULAR
- RÁPIDA DESTRUCCIÓN DEL GENOMA
- ACTIVACIÓN DE ENDONUCLEASAS QUE CLIVAN EL DNA GENÓMICO EN MÚLTIPLES FRAGMENTOS INTERNUCLEOSOMALES
- FRAGMENTACIÓN DE LA CÉLULA EN CUERPOS APOPTÓTICOS
- ELIMINACIÓN DE LOS FRAGMENTOS CELULARES POR CÉLULAS FAGOCÍTICAS

NECROSIS
DAÑO IRREVERSIBLE Y MUERTE RÁPIDA

- DILATACIÓN O SWELLING DEL NÚCLEO
- DILATACIÓN DE ORGANELAS CITOPLASMÁTICAS
- RUPTURA DE LA MEMBRANA PLASMÁTICA
- DESINTEGRACIÓN CELULAR
- LIBERACIÓN DE MATERIAL CITOPLASMÁTICO
- RESPUESTA INFLAMATORIA

DNA fragmentation

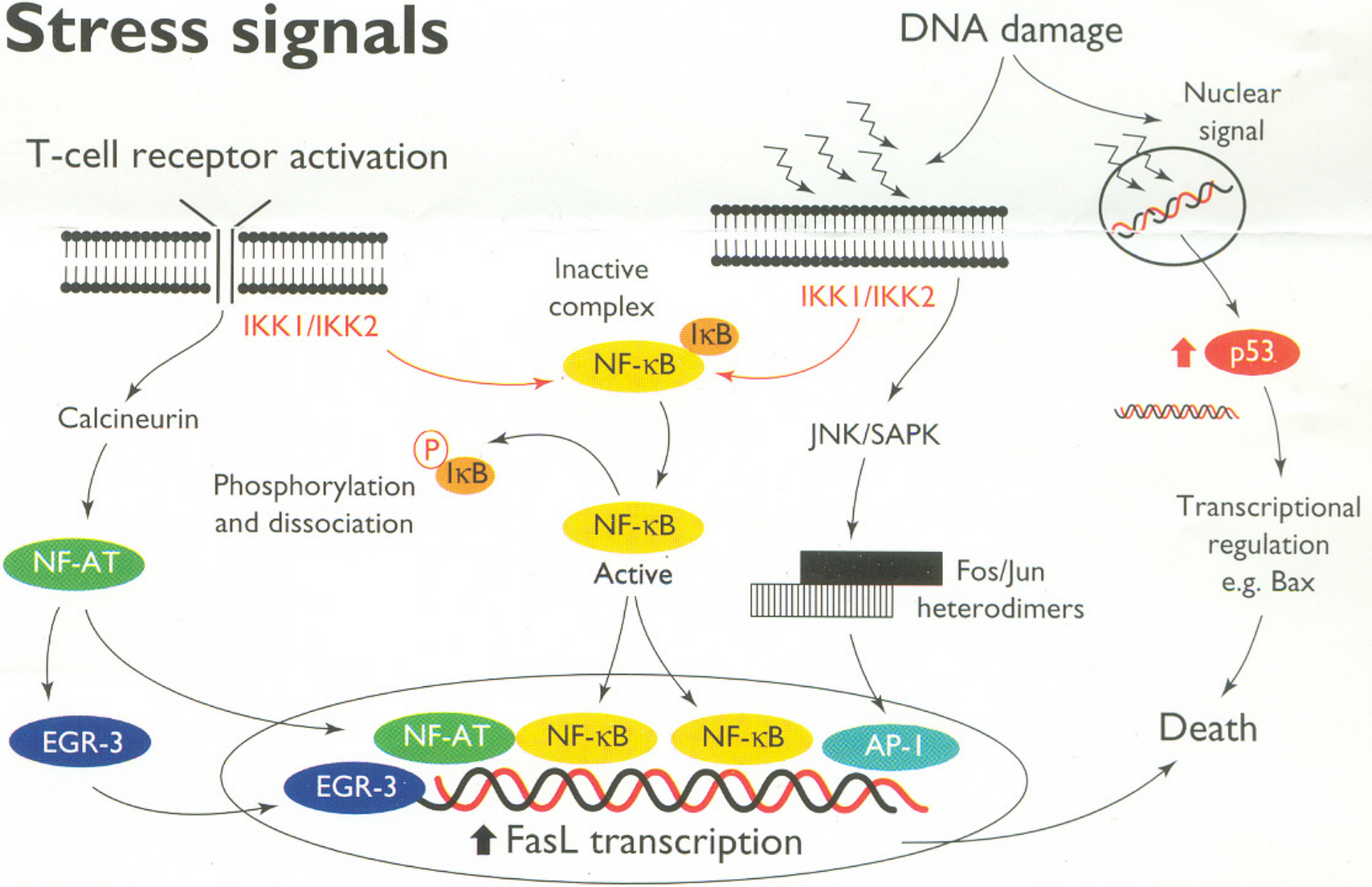


Internucleosomal
DNA cleavage

Active
caspase-3

iCAD/
DFF45

CAD/
DFF40/
CPAN

Active
nuclease

Stress signals