



(11) (21) (C) **2,160,666**
(86) 1995/06/05
(87) 1995/12/09
(45) 2000/12/05

(72) Tankovich, Nikolai I., US

(72) Tang, Kenneth Y., US

(72) Hunter, Allen M., US

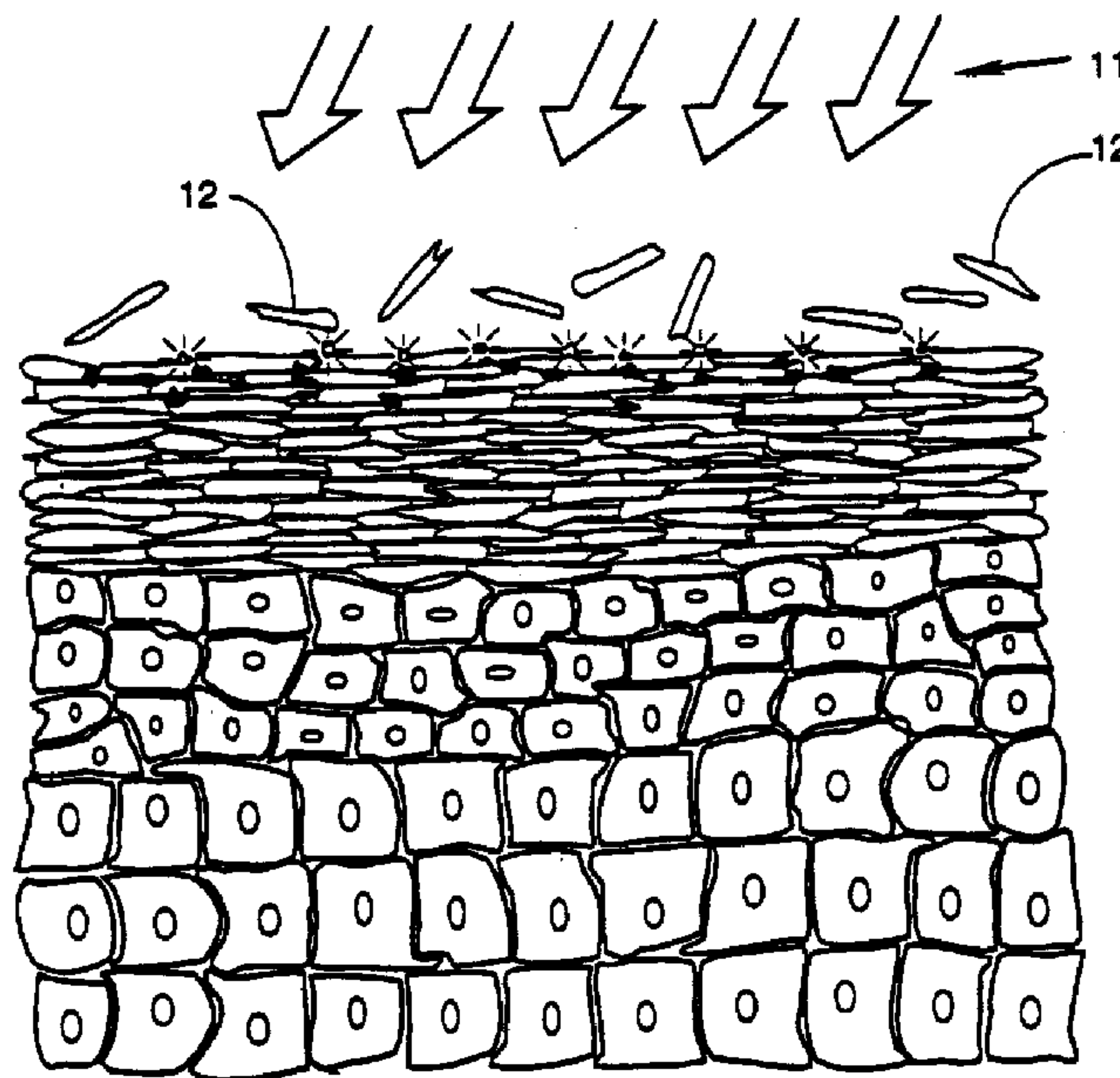
(73) THERMOTREX CORPORATION, US

(51) Int.Cl.⁶ A61B 17/322

(30) 1994/06/08 (08/257,021) US

(54) **PROCEDE DE PEELING DE LA PEAU EN SURFACE A L'AIDE
D'UN LASER**

(54) **SKIN SURFACE PEELING PROCESS USING LASER**



(57) Cette invention se rapporte à un procédé pour éliminer les cellules (1) de l'épiderme à la surface de la peau chez l'homme. A cet effet, un agent contaminant (6) ayant un pouvoir d'absorption élevée à au moins une longueur d'onde de l'énergie lumineuse est appliqué de façon topique sur la surface de la peau. Une partie de cet agent contaminant est amenée de force à s'infiltrer dans les espaces situés entre les cellules de l'épiderme en surface. La partie de la peau en question est éclairée par de courtes impulsions laser (7) à la longueur d'onde mentionnée ci-dessus, au moins l'une de ces impulsions ayant une énergie suffisante pour amener certaines desdites particules à exploser, détachant ainsi les cellules de la peau en surface. Dans un mode de réalisation préféré, des particules de graphite de 1 micron et un laser Nd:YAG sont utilisés.

(57) A process for the removal of superficial epidermal skin cells (1) in the human skin. A contaminant (6) having a high absorption at at least one wavelength of light is topically applied to the surface of the skin. Some of the contaminant is forced to infiltrate into spaces between the superficial epidermal cells. The skin section is illuminated with short laser pulses (7) at the above wavelength, with at least one of the pulses having sufficient energy to cause some of the particles to explode, tearing off the superficial skin cells. In a preferred embodiment 1 micron graphite particles and a Nd:YAG laser are used.

2160666

ABSTRACT

A process for the removal of superficial epidermal skin cells in the human skin. A contaminant having a high absorption at at least one wavelength of light is topically applied to the surface of the skin. Some of the contaminant is forced to infiltrate into spaces between the superficial epidermal cells. The skin section is illuminated with short laser pulses at the above wavelength, with at least one of the pulses having sufficient energy to cause some of the particles to explode tearing off the superficial epidermal skin cells. In a preferred embodiment we use 1 micron graphite particles and a Nd:YAG laser.

SKIN SURFACE PEELING PROCESS USING LASER

BACKGROUND OF THE INVENTION

The epidermis of the human skin comprises several distinct layers of skin tissue. The deepest layer is the stratum basale layer which consists of columnar cells. The next layer up is the stratum spinosum composed of polyhedral cells.

Cells pushed up from the stratum spinosum are flattened and synthesize keratohyalin granules to form the stratum granulosum layer. As these cells move outward they lose their nuclei and the keratohyalin granules fuse and mingle with tonofibrils. This forms a clear layer called the stratum lucidum. The cells of the stratum lucidum are closely packed.

As the cells move up from the stratum lucidum they become compressed into many layers of opaque squamas. These cells are all flattened remnants of cells which have become completely filled with keratin and have lost all other internal structure, including nuclei. These squamas constitute the outer layer of the epidermis, the stratum corneum. At the bottom of the stratum corneum the cells are closely compacted and adhere to one another strongly, but higher in the stratum they become loosely packed and eventually flake away at the surface. For example, in the cheek skin of a 50 year old face the outer layer of the corneum stratum typically consists of about 15 layers and the layers flake away at the rate of about one or two layers per month. So we naturally get a completely new stratum corneum about twice per year.

It is well known that the removal of a few surface layers of a person's skin will generally result in younger looking skin. Many techniques have been tried to produce this effect. A mild sunburn will cause slight blistering of the skin after which an outside layer of the skin peels off. This generally leaves a younger looking skin surface. Similar results can be

obtained by abrasion processes such as actually scraping away the surface layer with an abrasive material such as fine sand paper.

Recent attempts have been made to utilize laser beams to "cook" the surface layer of skin. This cooking causes the skin to blister after which the surface layers can be scraped away. Also, people have been experimenting with lasers which vaporize the outside surface. These prior art processes present some beneficial results but also provide potential risk to the patient. The slight sunburn presents a risk of underlying long term damage to the skin. Abrasion processes often result in bleeding and pain and sometimes infection, scabbing, and slight scarring. Laser treatments can result in pain and undesired burning, and if not applied properly can result in bleeding and scarring.

In one aspect, the present invention provides a process for the removal of superficial epidermal skin cells in human skin comprising the steps of:

- a. topically applying to a section of said skin a contaminant having a high absorption at at least one frequency band of light which penetrates the outer layers of human epidermis,
- b. forcing some of said contaminant to infiltrate into spaces between said superficial epidermal skin cells, and
- c. illuminating said section of skin with pulses of said at least one frequency band of light, at least one of said pulses having sufficient energy to cause at least a portion of said contaminant to explode so as to tear off some of said superficial epidermal skin cells.

In a preferred embodiment we use 1 micron graphite particles and a Nd:YAG laser.

In a further aspect, the invention provides a composition for topical cosmetic application to the epidermis comprising a contaminant having high absorptivity to at least one frequency band of light, suspended in a pharmaceutically acceptable diluent or excipient.

A still further aspect of the invention provides use of a composition comprising a contaminant having high absorptivity to at least one frequency band of light, to remove superficial epidermal skin cells in human skin wherein the composition is topically applied to a section of the skin and forced to infiltrate spaces between the superficial epidermal skin cells, and the section of skin is illuminated with pulses of the at least one frequency band of light causing at least a portion of the contaminant to explode so as to tear off some of the superficial epidermal skin cells.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic representation showing layers of skin tissue of the human epidermis.

Figures 2-13 are schematic representations of a cross-section of the top three strata of the human epidermis which illustrate various aspects of the present invention.

Preferred embodiments of the present invention can be described by reference to the drawings.

FIRST PREFERRED EMBODIMENT - Nd:YAG

A first preferred embodiment of the present invention can be described by reference to Figures 2 through 10. Figure 2 shows a typical cross-section of a section of the outer portion (the top three strata) of the human epidermis such as that in the skin of a 50 year old female's cheek. Shown is a representation of a 15-cell thick stratum corneum 1, and a 3-cell thick stratum lucidum 2, and a 3-cell thick stratum granulosum 3. The total thickness shown is about 100 microns (0.10 mm).

Individual cells of the stratum corneum have dimensions of about 10 to 15 microns long, about 5 microns wide and up to 2 microns thick. The cells of the upper layers are loosely stuck together. Spaces between the cells range from zero distance to about 1 or 2 microns.

The first step of this preferred embodiment is to topically apply a layer of carbon solution 4 to the skin surface as shown in Figure 3. The solution is comprised of 1 micron graphite powder in baby oil. The graphite-oil ratio is 20 percent graphite suspended in 80 percent oil by weight. The next step Figure 4 is to force some of the carbon particles down below the surface of the stratum corneum 1. We prefer to do this with an ultrasound unit operating at 0.2 watts per cm² and 10 MHz.

We use a Hewlett Packard* Model 3325A pulse generator and a Parametrics* transducer model A5525. We have found that approximately 5 minutes of ultra sound treatments at this frequency will force a significant number of carbon particles down through several layers of the stratum corneum 1. The result 5 of the ultrasound treatment is shown in Figure 5. This distribution of carbon particles has been demonstrated on pig skin. Microscopic examination of biopsy samples from the pig skin show the distribution depicted in Figure 5. As shown in Figure 5, two layers of graphite particles are left on the surface and a portion of the particles 6 are distributed below the surface.

The next step is to irradiate the skin surface with Nd:YAG laser pulses of about 3 J/cm² at a wavelength of 1.06 μ m. Pulse frequency is about 5 Hz but we scan the beam so that each location is subjected to pulses at a frequency of about 1 Hz. Graphite is very absorptive of laser energy at the 1.06 μ m

* Trade Mark

wavelength. The latent heat of vaporization is about 10^4 J/cm³ for cold solid graphite. Thus, to vaporize a 1 micron cube (10^{-12} cm³) would require approximately 10^{-8} J. The energy falling on the surface of the 1 micron particle (1×10^{-8} cm²) in a 3 J/cm² pulse is 3×10^{-8} J, about three times the energy needed to vaporize the particle. The energy is deposited in a few nanoseconds so there is no time for the heat to diffuse therefore it explodes violently upon being illuminated by the pulse. The effect of one pulse is to vaporize some of the graphite (especially smaller particles) and to break larger graphite particles into smaller particles which fly apart with high energy. (Subsequent pulses will vaporize the smaller particles created by the earlier pulses.)

Thus, as a result of the first pulse 7 the first layer of graphite particles is exploded as shown at 8 in Figure 6. The second layer and the skin surface is effectively shielded from the first pulse 7 by the first layer. Some of the carbon particles above the skin have been pushed into the skin as a result of the shockwaves resulting from the explosion of the particle in the first layer. The second pulse 9 coming one second later, vaporizes the second layer as shown at 10 in Figure 7. As before, additional particles are pushed into the skin. The skin is fairly effectively shielded from pulse 9 by the second layer. But the third pulse 11 interacts with the skin and the carbon particle below the skin. Laser energy at 1.06 wavelength has an extinction length in human skin of several cm so very little of the energy of the pulse is absorbed in the skin tissue but it is highly absorbed in the graphite particles below the surface and upon absorption of the energy from third pulse 11 as shown in Figure 8, the particles explode violently ripping off the dead cells 12, 14 of the stratum corneum which lay above the exploding cells all as shown in Figure 8. A few particles may be shielded from pulse 11 but three of four additional pulses 13 will assure that

essentially all graphite particles are exploded as shown in Figure 9.

Figure 10 shows a cross-section view of the skin surface after the laser irradiation. This drawing is based on pig skin biopsy results of skin treated as described above. The skin is washed lightly with an alcohol soaked cloth and allowed to dry resulting in a surface as shown in Figure 11. The depiction as shown in Figure 11 can be compared with that of Figure 2. We see that about three layers of the dead cells in the stratum corneum have been removed. There is no pain, no feeling of heat and no significant injury to the skin tissue.

The Nd:YAG laser energy which was not absorbed in the carbon is harmlessly dissipated in the skin and tissue below the skin. It is preferable to provide a slight diverging beam to assure that it spreads after it hits the skin. In our preferred embodiment the spot size at the surface is 0.5 cm (diameter) and is spreading at 10 degrees.

SECOND PREFERRED EMBODIMENT (WITH CONFINEMENT)

A second preferred embodiment is the same as the first preferred embodiment except that after the carbon-oil suspension is placed on the skin surface, a thin flat piece of glass (such as a microscope glass) is placed firmly over the suspension in order to confine the small explosion and several pulses (preferably about 1 or 2) of the laser beam are applied through the glass onto each section of suspension. Also we do not use the ultrasound unit. The effect is to greatly enhance the subsurface contamination of the upper layers of the epidermis with small particles of graphite. The effect is shown in Figures 12 and 13. One or two pulses is sufficient to produce substantial subsurface contamination with small carbon particles. After this application the glass is removed and the process as explained above for the first embodiment is

continued until essentially all of the graphite has been vaporized. In an alternate embodiment a disposable plastic plate, transparent to the laser beam could be used instead of the glass plate. The disposable plastic plate could be made a part of an articulated arm of the laser or a part of a hand piece attached to the articulated arm.

This method of forcing matter into the skin tissue can be utilized to tattoo the skin or to administer drugs through the skin.

THIRD PREFERRED EMBODIMENT - CO₂

A third preferred embodiment utilizes a CO₂ pulse laser. Preferred operating parameters are: wavelength 10.6 micron, energy density per pulse 2.5 Joule/cm², pulse diameter 1 cm, pulse duration 50 ns. Laser beams at 10.6 micron have an extinction length in skin of about 40 micron because the pulse energy is highly absorbed in water. It is much more highly absorbed in carbon. We estimate an extinction length of 1 to 2 microns.

The process is very similar to that described above. Graphite is applied as above using the ultrasound to force some of the carbon below the surface. The laser pulses are applied as above and to the first two pulses produce similar results cleaning off the two layers of carbon. The third pulse however will in addition to vaporizing carbon below the skin surface will vaporize a thin surface of tissue. Therefore, we get the combined effect of (1) mechanical removal of tissues due to the explosion of particles below the surface and (2) vaporization of a surface layer of epidermal tissue about 2-3 microns thick.

FOURTH PREFERRED EMBODIMENT - LIQUID CONTAMINANT

Prepare a solution of warm water colored with black food coloring at one part color per fifty parts water. Apply to skin surface with gauze for 10 minutes. The warm black water will infiltrate into the space in the upper layers of the corneum stratum. (These spaces are normally filled with air.) Remove gauze and illuminate with about 1 or 2 pulses per site using a CO₂ laser operating at 10.6 microns and 50 nano second duration pulses with an energy density of 2 Joules per cm². These short pulses will deposit sufficient energy selectively to the colored water solution to vaporize instantly the water tearing off the upper most corneum stratum cells in the skin section.

An alternative to this embodiment is to add indocyanine green to the warm water instead of the black food coloring. Indocyanine green absorbs infrared light such as that produced by the Nd:YAG, CO₂, Alexandrite, Ti: Sapphire and Ga:As diode lasers. Since water is an excellent absorber of CO₂ laser energy, many water based skin lotions could be used with the CO₂ laser.

Persons skilled in the laser-medicinal art will recognize that many other lasers-contaminant combination could be used to practice this invention. The important attributes of the combinations are:

- 1) The contaminant must be very highly absorptive of energy at the wavelength of the laser beam.
- 2) The laser beam must be a pulsed beam with very short pulses (pulse duration of less than 1 microsecond).
- 3) The contaminant must be capable of being infiltrated into the upper layers of the epidermis.

- 4) The contaminant must explode with sufficient energy to tear off epidermis cells upon absorption of the laser energy.

Applicants have tested acrylic tattoo inks which have been approved by the U.S. Food & Drug Administration for tattoo use. Black and blue tattoo inks marketed by Spaulding* and Rogers* appear to work well with a Nd:YAG laser operating at 1 Hz, 1.06 micron with an energy density of about 3 J/cm². We had less success with other colors.

While the above description contains many specifications, the reader should not construe these as limitations on the scope of the invention, by merely as exemplifications of preferred embodiments thereof. Those skilled in the art will envision many other possible variations are within its scope. Accordingly the reader is requested to determine the scope of the invention by the appended claims and their legal equivalents, and not by the examples which have been given.

* Trade Mark

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A process for the removal of superficial epidermal skin cells in human skin comprising the steps of:
 - a. topically applying to a section of said skin a contaminant having a high absorption at at least one frequency band of light which penetrates the outer layers of human epidermis,
 - b. forcing some of said contaminant to infiltrate into spaces between said superficial epidermal skin cells, and
 - c. illuminating said section of skin with pulses of said at least one frequency band of light, at least one of said pulses having sufficient energy to cause at least a portion of said contaminant to explode so as to tear off some of said superficial epidermal skin cells.
2. A process as in Claim 1 wherein said contaminant comprises a large number of carbon particles.
3. A process as in Claim 2 wherein an ultrasound device is utilized to force said some of the carbon particles to infiltrate into said spaces.
4. A process as in Claim 1 wherein at least one forcing explosion of a portion of said contaminant is utilized to force said some of the contaminant to infiltrate into said spaces.
5. A process as in Claim 1 wherein a confinement means, transparent to said at least one frequency band of light is placed firmly over said topically applied contaminant for the duration of said forcing explosion for the purpose of confining said forcing explosion.

6. A process as in Claim 5 wherein said confinement means is a glass plate.
7. A process as in Claim 5 wherein confinement means is a plastic plate.
8. A process as in Claim 7 wherein said plastic plate is part of an articulated arm.
9. A process as in Claim 2 wherein said carbon particles are graphite particles.
10. A process as in Claim 9 wherein said graphite particles are mixed with an oil.
11. A process as in Claim 10 wherein said oil is baby oil.
12. A process as in Claim 2 wherein said carbon particles have a major dimension of about 1 micron.
13. A process as in Claim 2 wherein said pulses are pulses from a Nd:YAG laser.
14. A process as in Claim 2 wherein said pulses are pulses from a CO₂ laser.
15. Use of a composition comprising a contaminant having high absorptivity to at least one frequency band of light, to remove superficial epidermal skin cells in human skin wherein said composition is topically applied to a section of said skin and forced to infiltrate spaces between said superficial epidermal skin cells, and said section of skin is illuminated with pulses of said at least one frequency band of light causing at least a portion of said contaminant to explode so as to tear off some of said superficial epidermal skin cells.

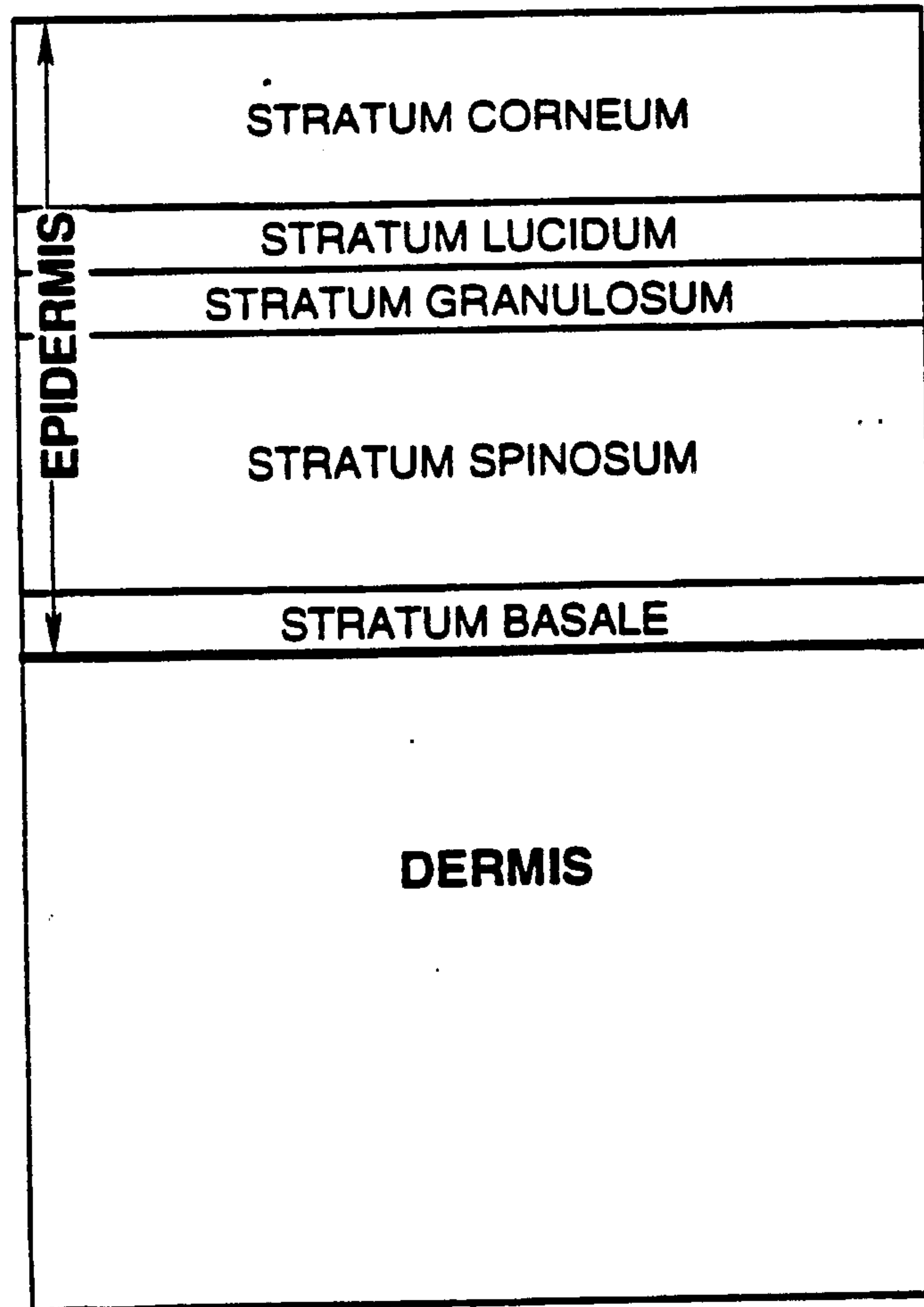


FIG. 1

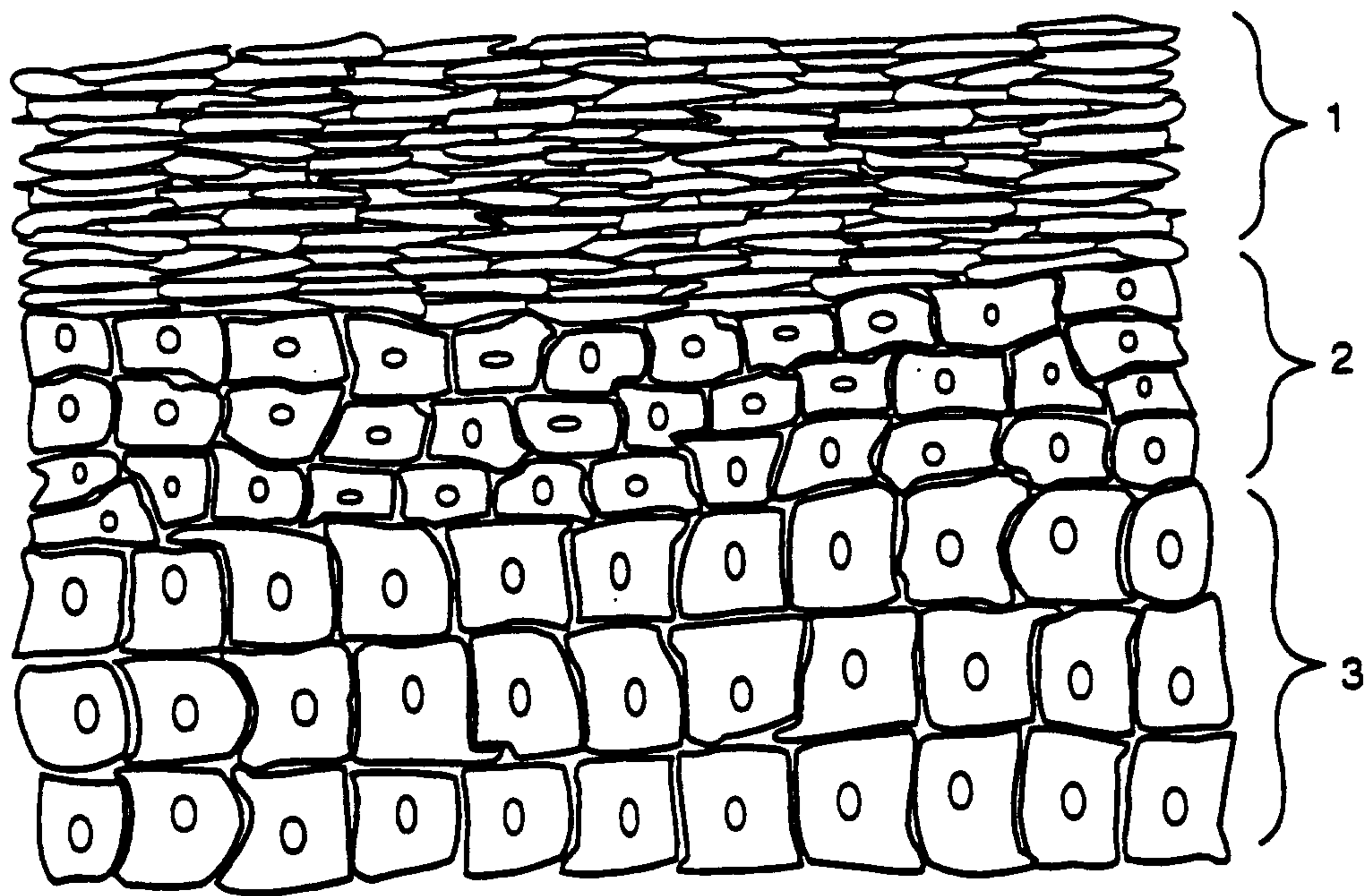


FIG. 2

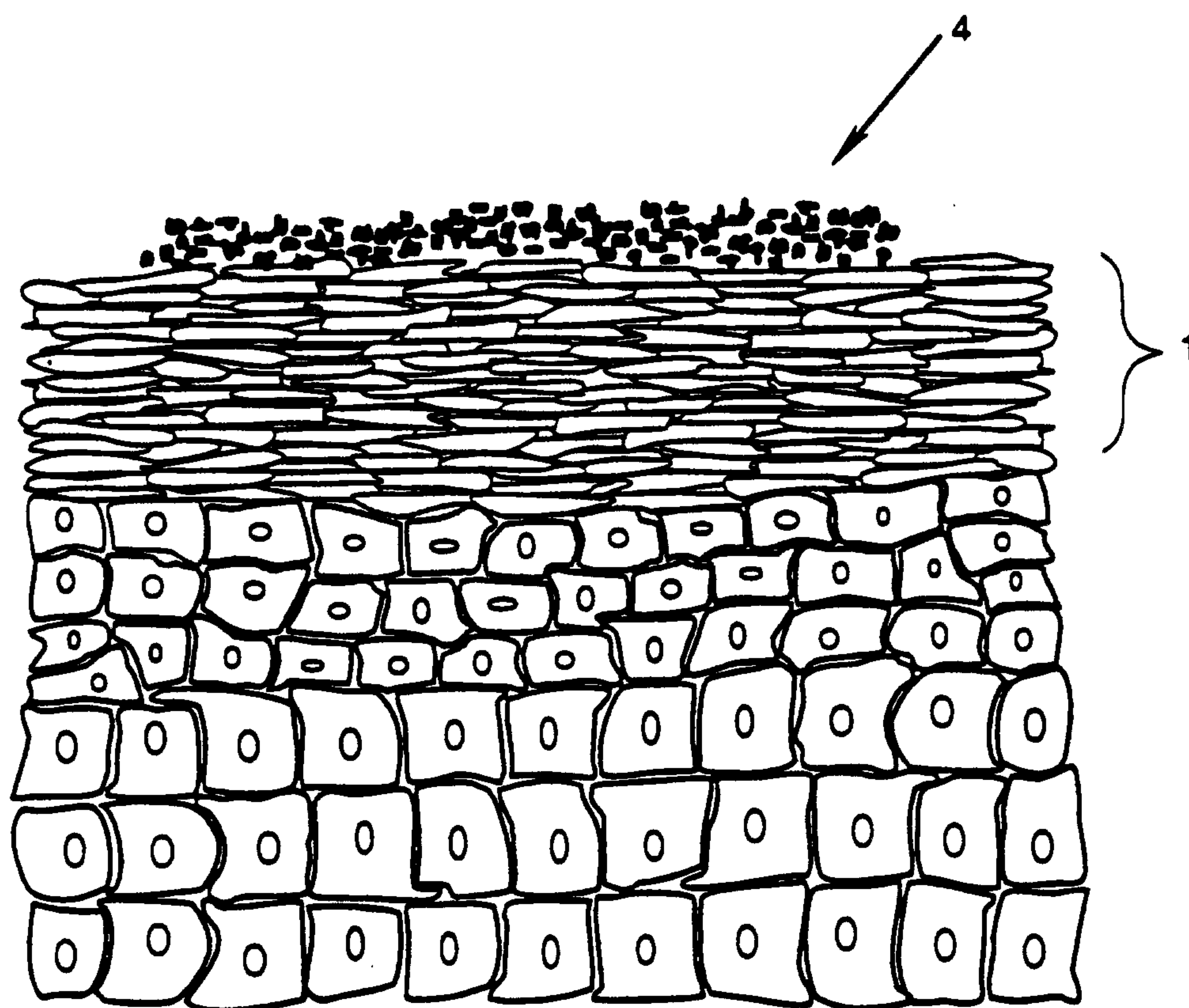


FIG. 3

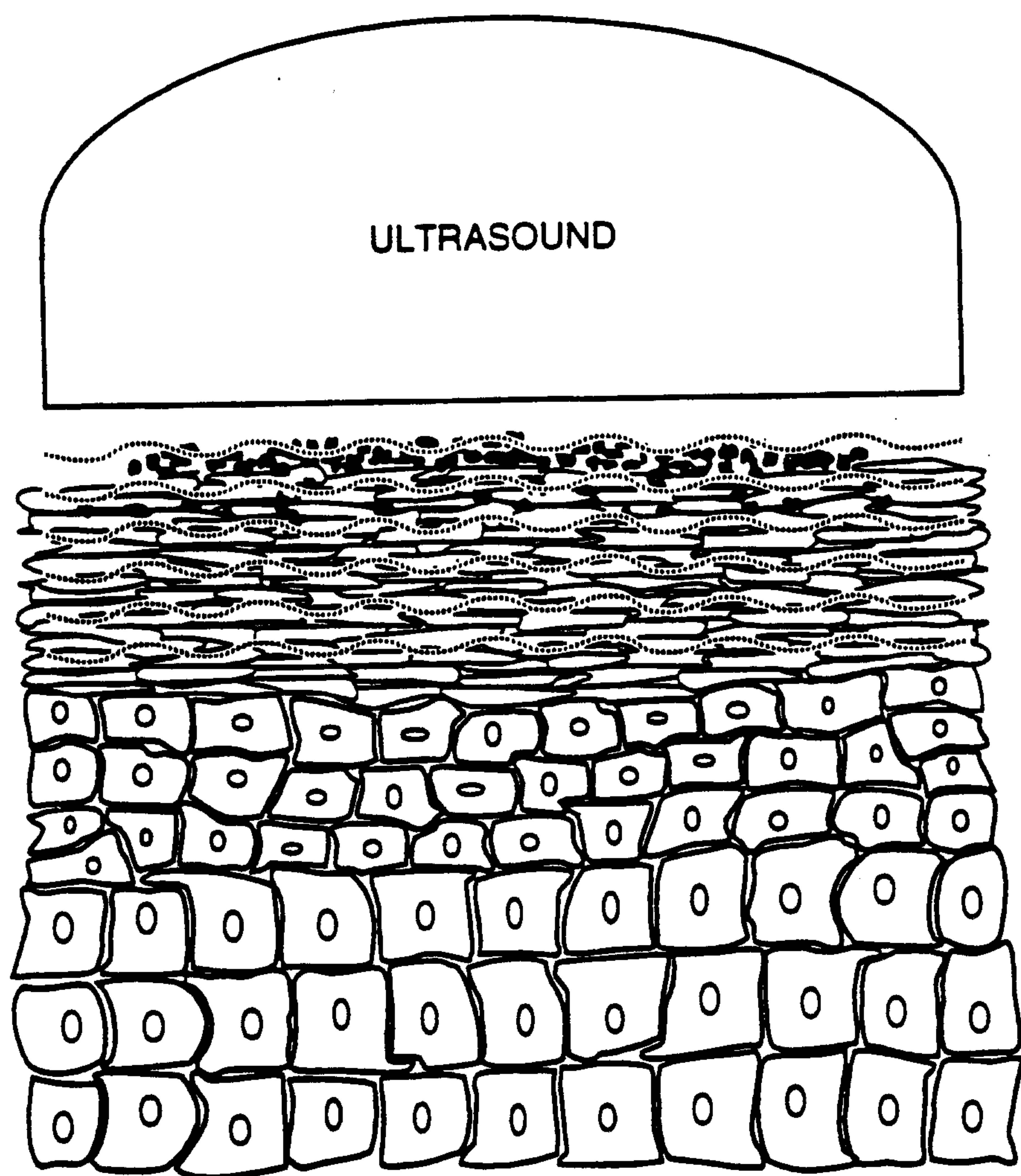


FIG. 4

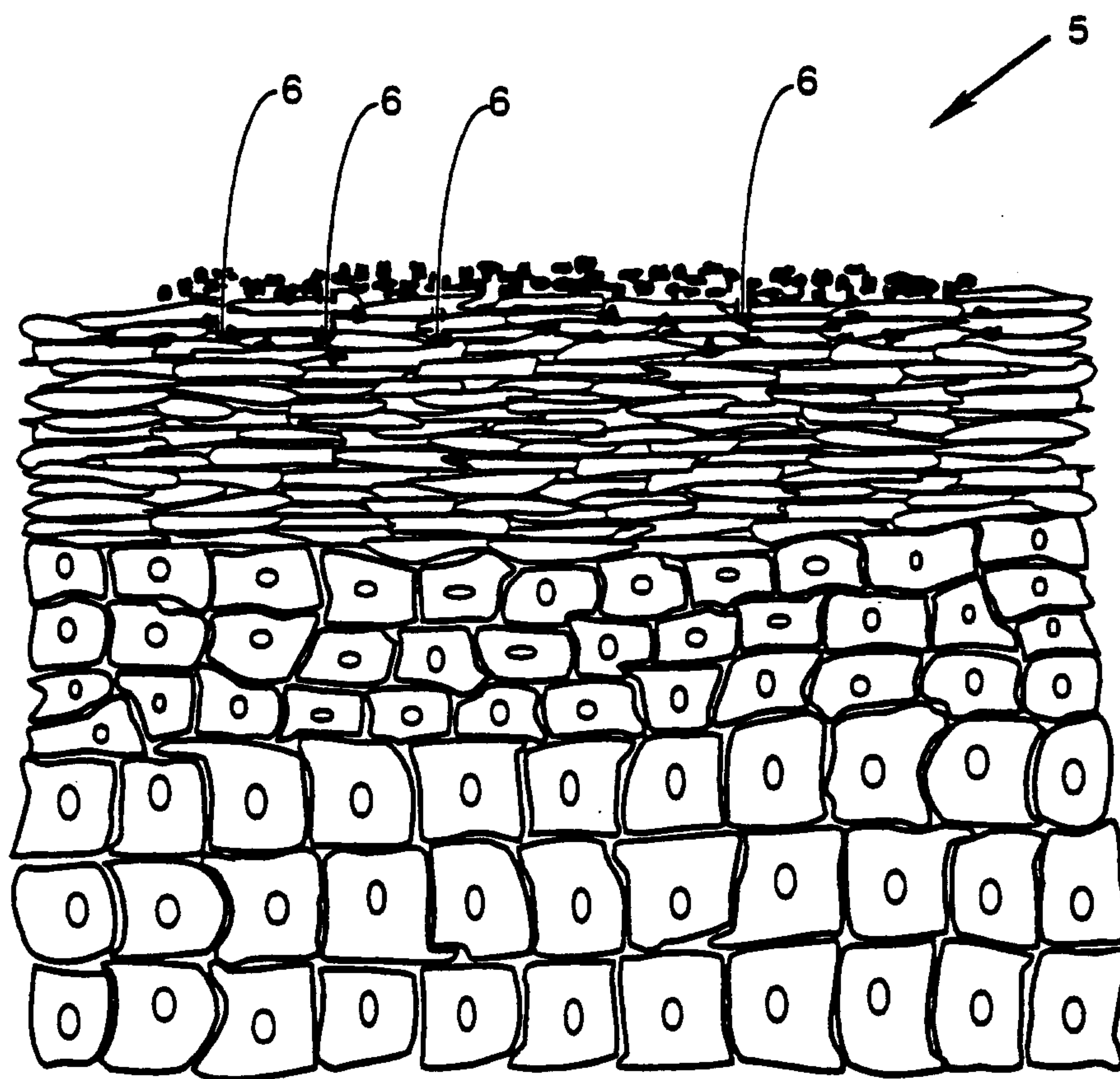


FIG. 5

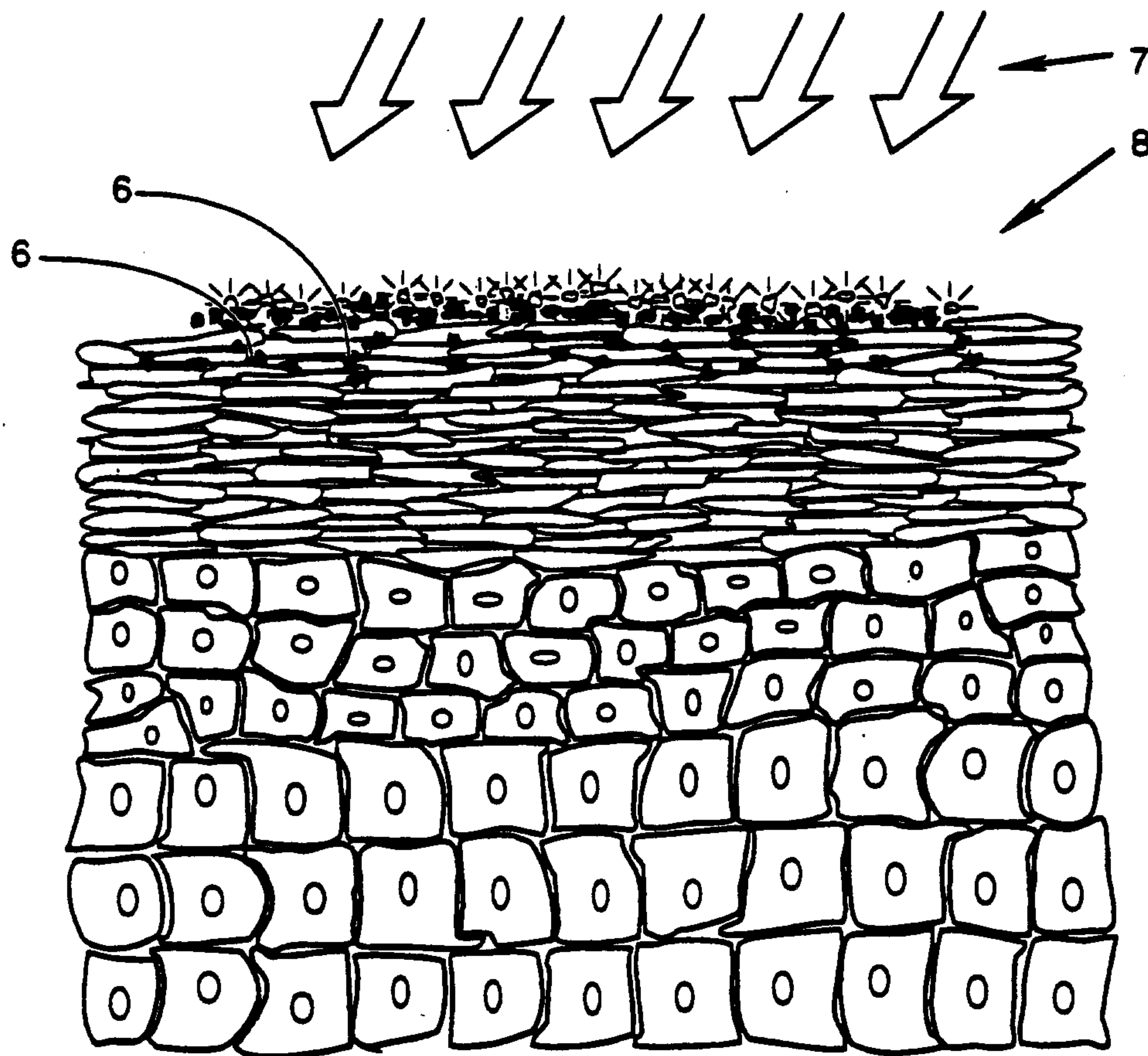


FIG. 6

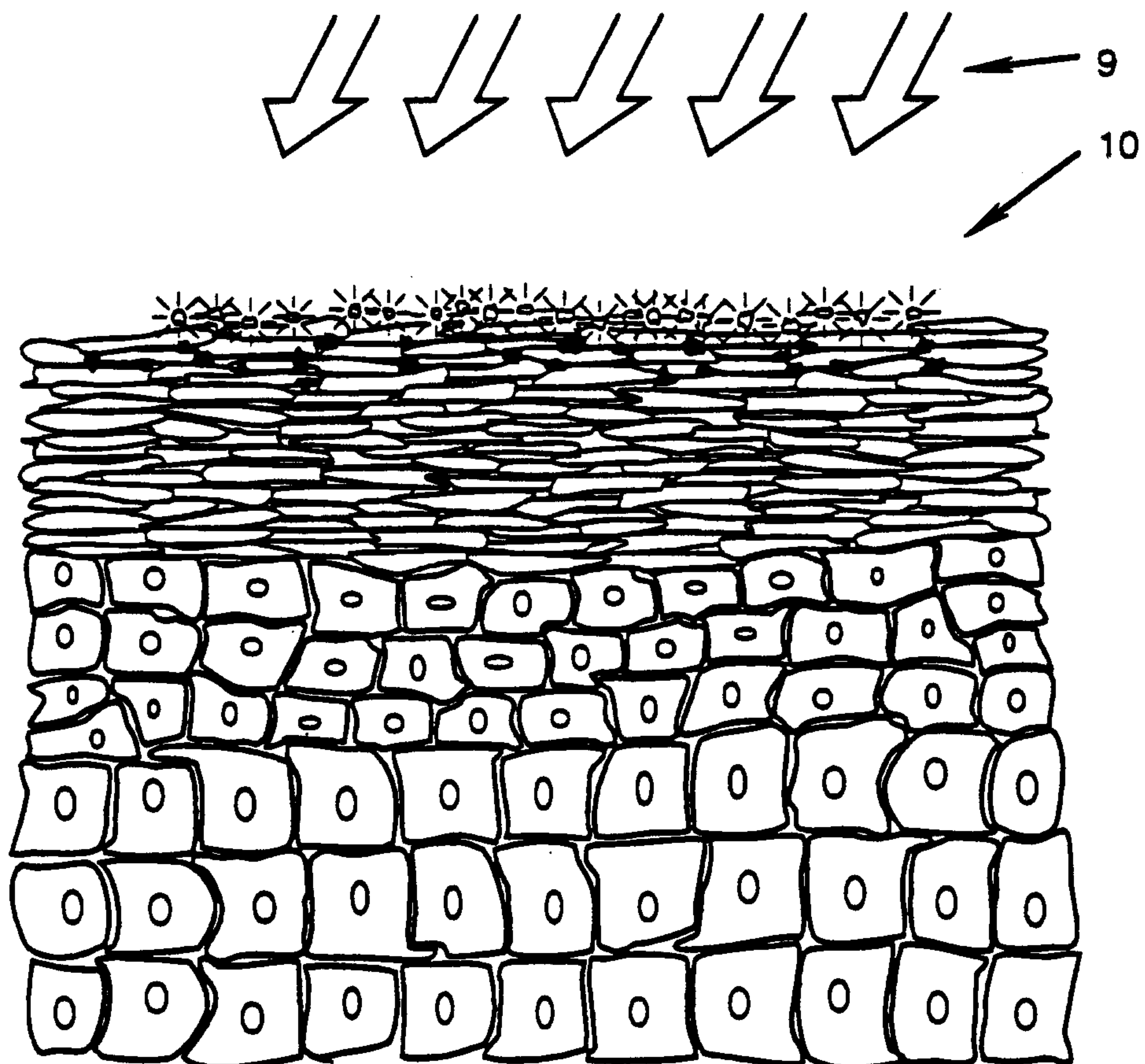


FIG. 7

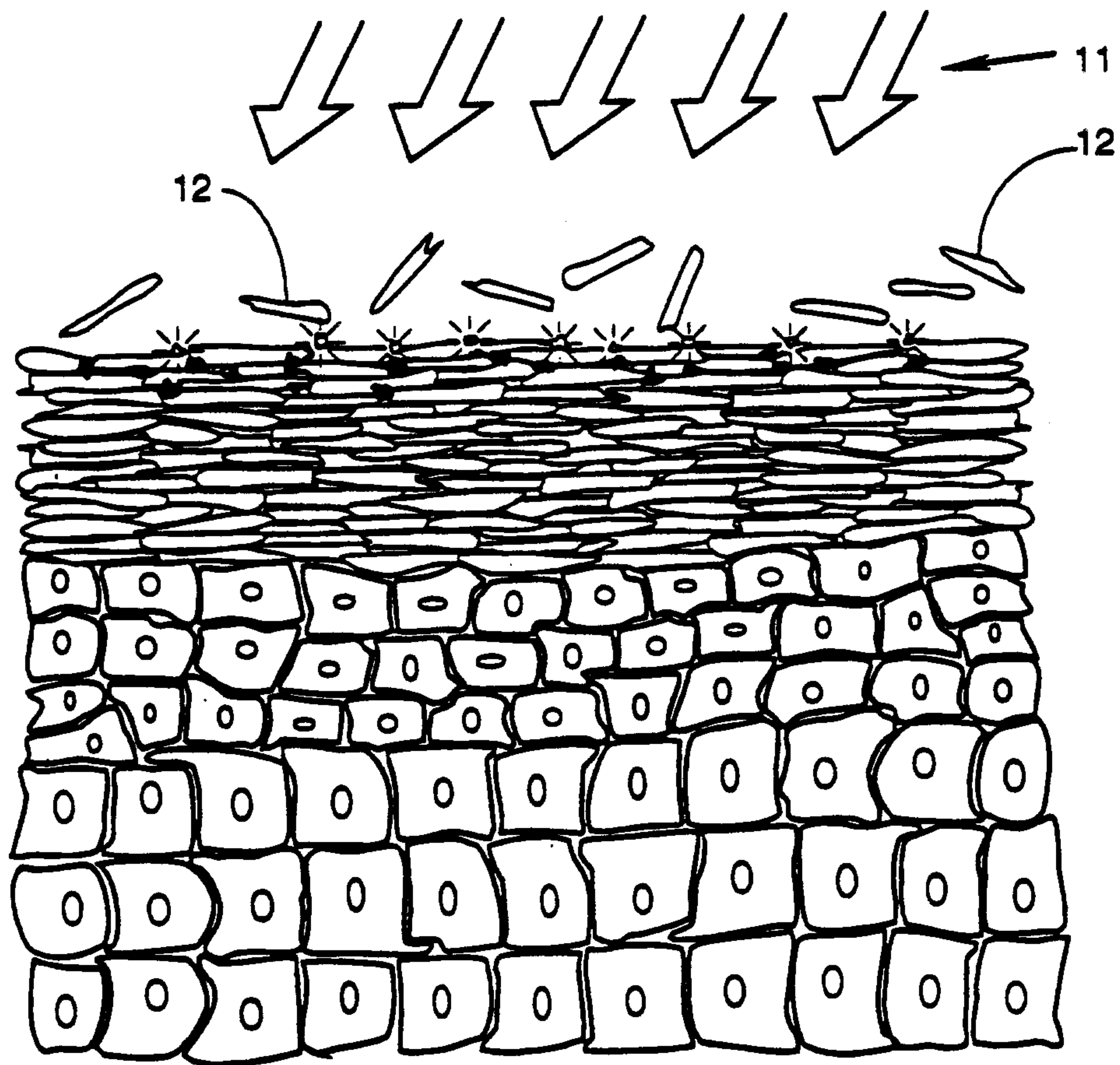


FIG. 8

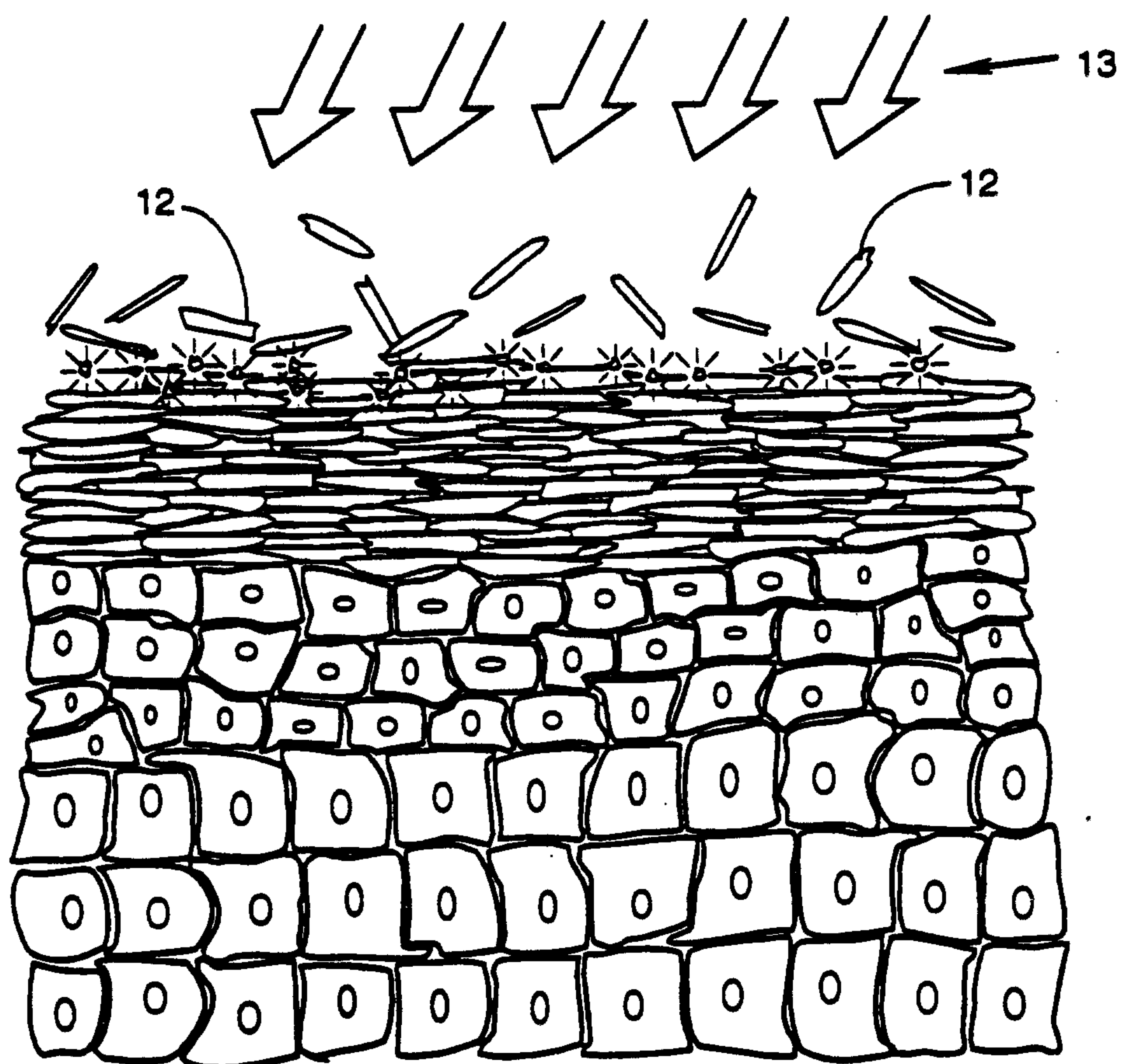


FIG. 9

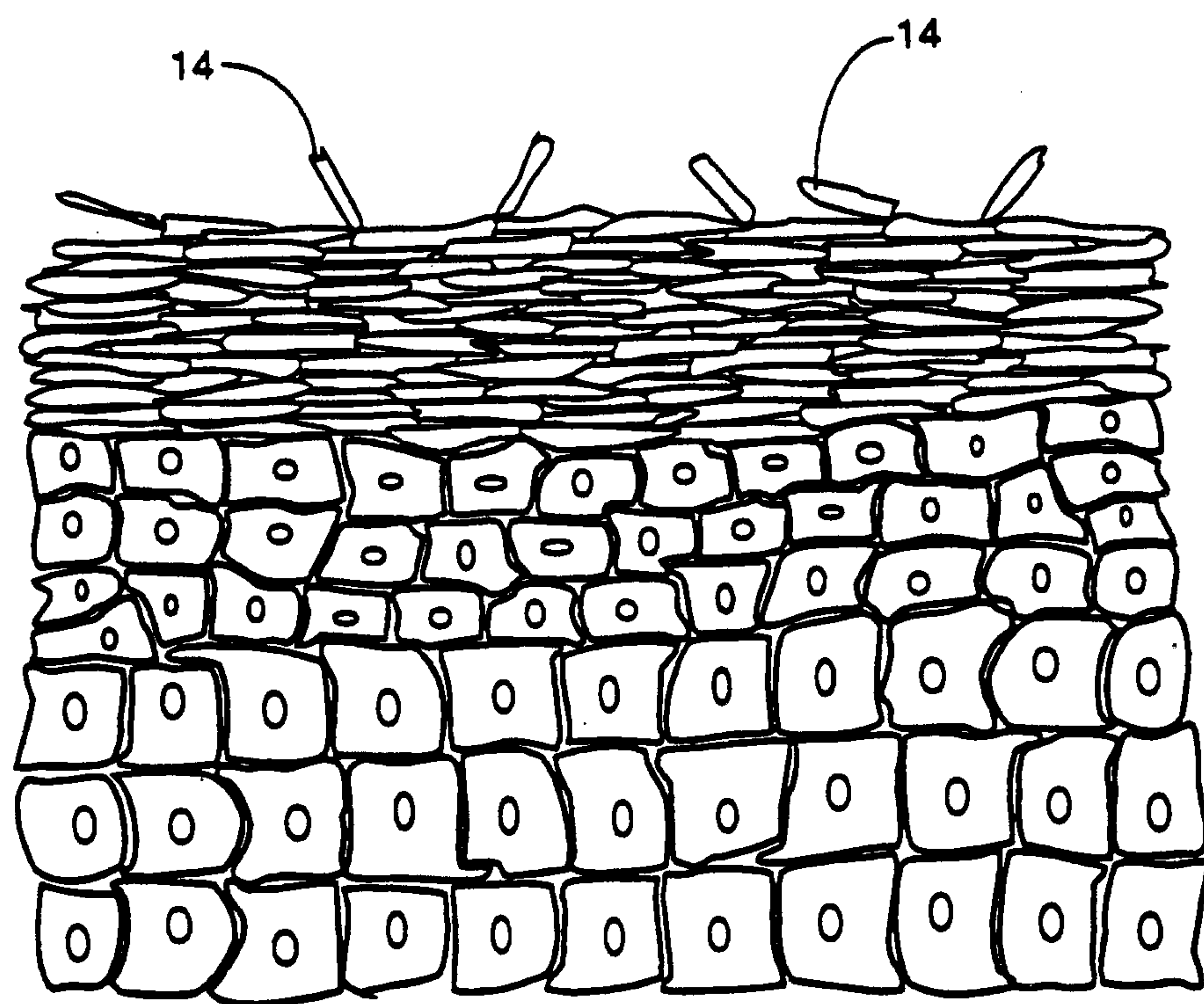


FIG. 10

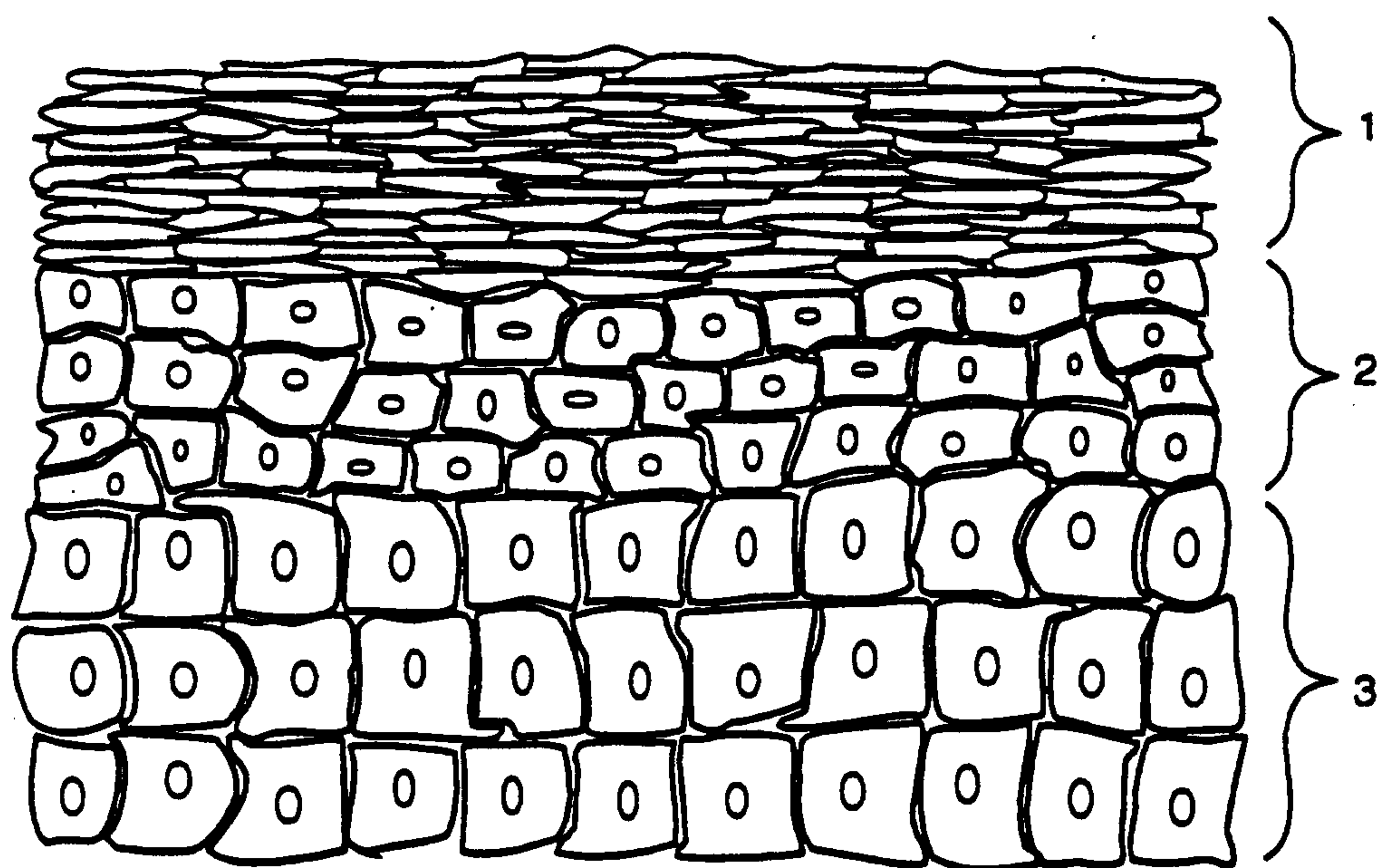


FIG. 11

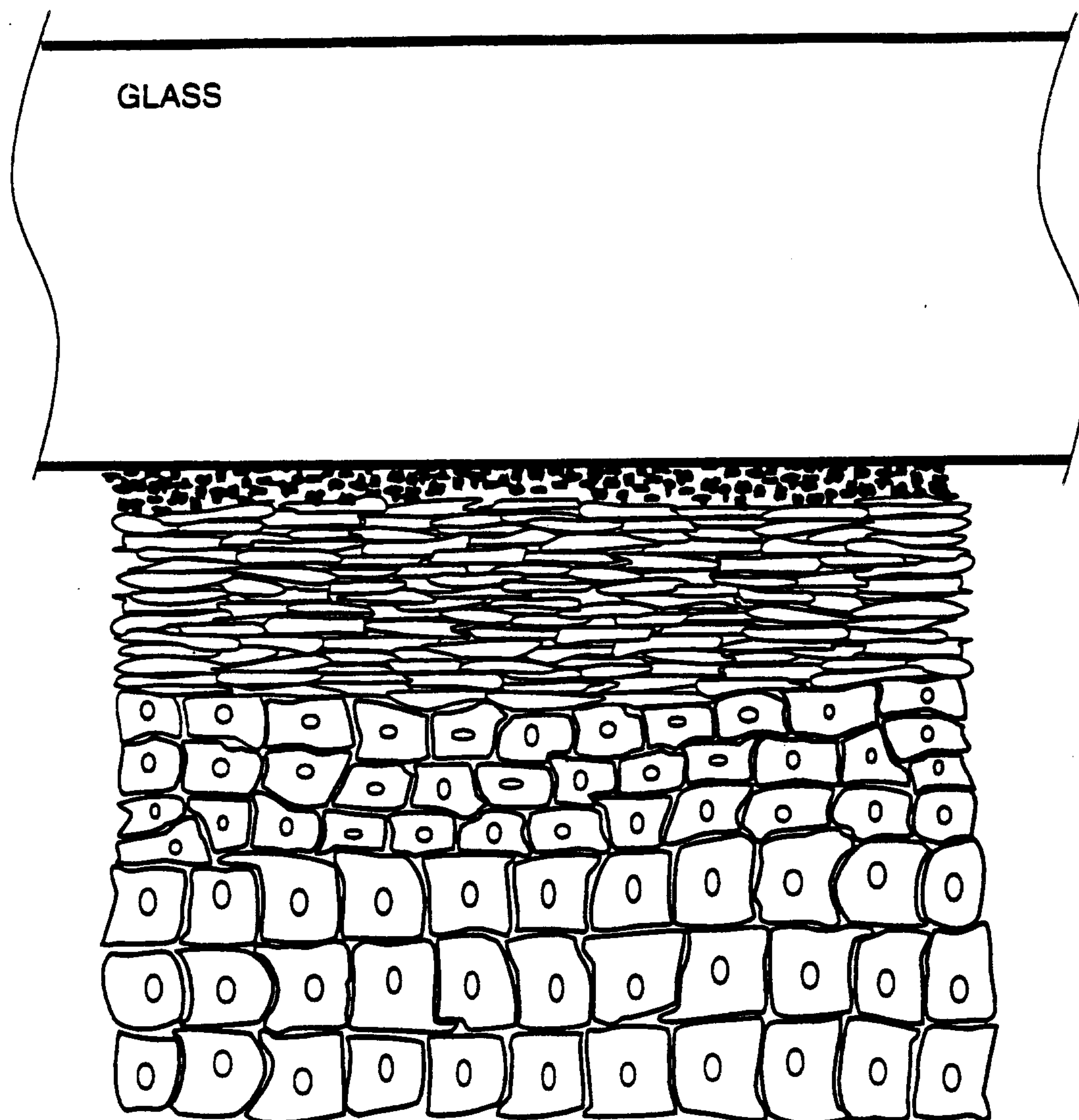


FIG. 12

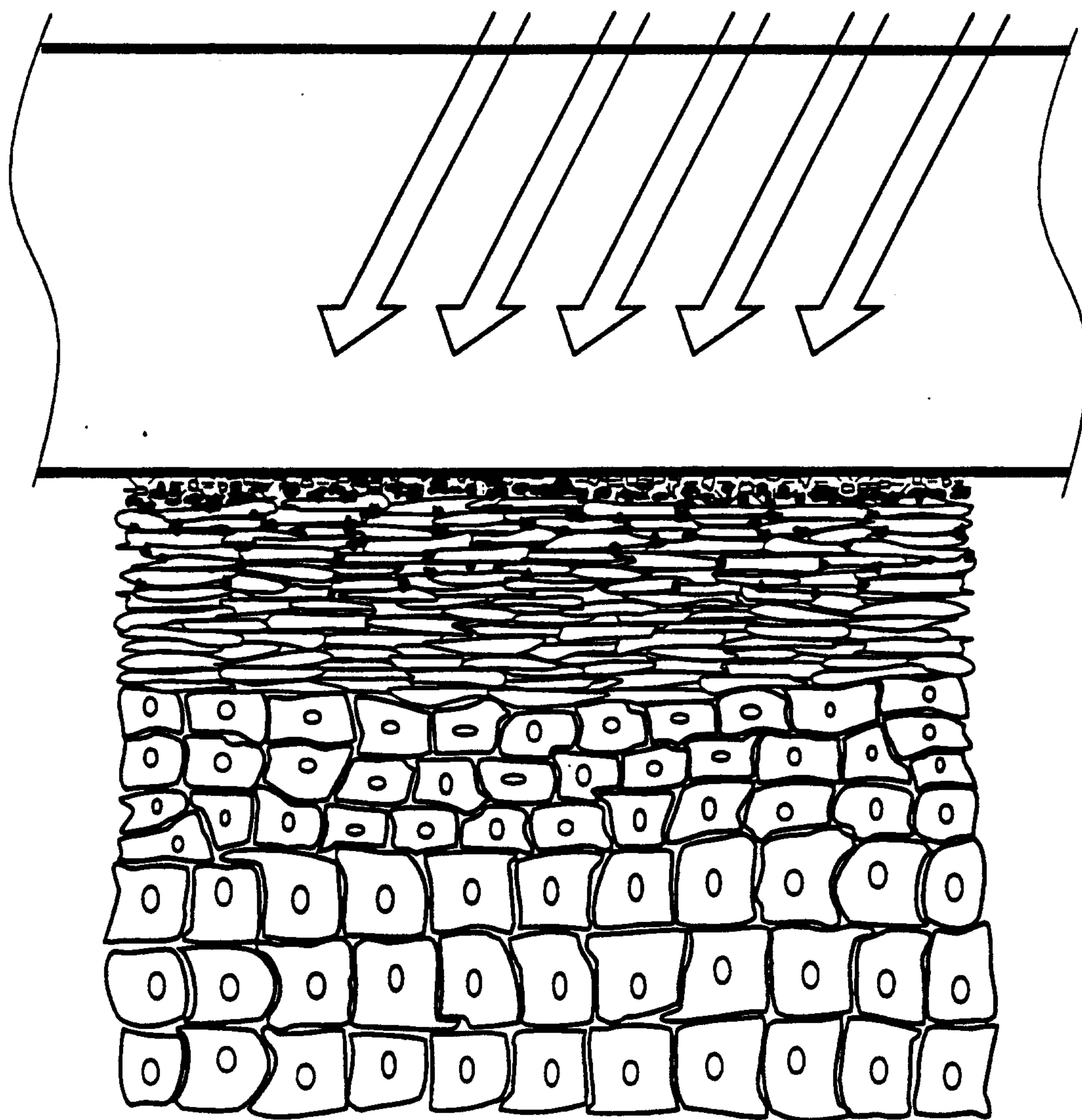


FIG. 13

