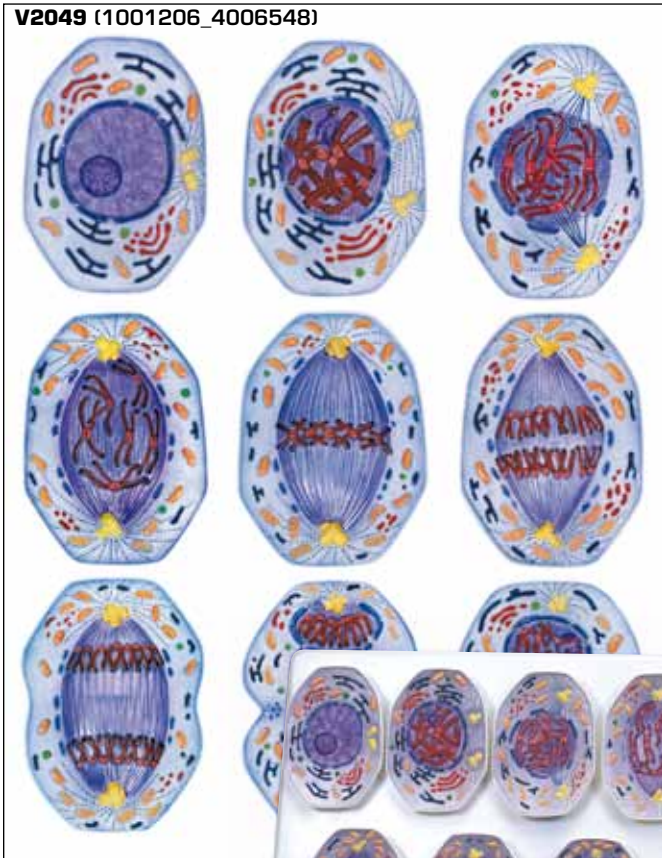




*...going one step further*

**V2049 (1001206\_4006548)**



**R01/1 (1013868)**

**R01/1**

**V2049**

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Mitosis, also referred to as indirect nuclear division or equational division, is the most widespread type of cell reproduction. In this process, one cell (mother or parent cell) is divided into two daughter cells with identical DNA (=genes containing hereditary information) and the same number of chromosomes. Mitosis is vital for the growth and preservation of all living organisms.

The human organism is made up of approx.  $10^{15}$  to  $10^{16}$  cells. In fast-growing tissues (e.g. intestinal epithelium) cells are divided by mitosis approx. every 12-35 hours, in slower-growing tissues (e.g. tendons) only approx. every 3-6 months.

In the cycle of a cell, a basic distinction is made between the **interphase**, referring to the period between two cell divisions, and the phase of actual division, called **mitosis**.

A further phase not forming part of this cycle is referred to as the  $G_0$  phase. This is a phase of cell growth or differentiation without preparations for a division. In this phase the cell can irreversibly lose its power of division (e.g. muscle cells), or, after a  $G_0$  phase of variable length, it can re-enter the cell cycle which then begins with the  $G_1$  phase.

#### The interphase comprises 3 stages:

- **$G_1$  phase (presynthesis)**  
In this phase the cell begins to prepare for the forthcoming mitosis. The growth of all parts of the cell is activated and the centrioles are duplicated. In fast growing cells the duration of this phase is approximately 3 hours.
- **S phase (synthesis)**  
In this phase the amount of DNA is doubled by replication as a further preparation for the forthcoming cell division. In fast growing cells the duration of this phase is approximately 8 hours.
- **$G_2$  phase (postsynthesis)**  
At this stage the last preparations for entering into mitosis are made. The chromosomes are condensed and the DNA is "proofread". At the end of this phase, cells in human/animal tissue cut off the cell contacts with neighbouring cells, round off and frequently increase their volume through the intake of fluid. In fast-growing cells the duration of this phase is approx. 4 hours.

#### The mitotic cycle comprises the following phases:

- **Prophase**
  - **Early prometaphase**
  - **Later prometaphase**
  - **Metaphase**
  - **Early anaphase**
  - **Later anaphase**
  - **Telophase**
  - **Cytokinesis**
- Duration of all phases in fast-growing cells: approx. 1 hour

The 3B Scientific® model series on Mitosis (product no. R01) and the wall chart on mitosis (V2049M, V2049U) show a typical mammal cell at an enlargement of approximately 10,000 times. In the lower third of the models/illustrations the cell organelles are shown as if opened up. As this is a 2 dimensional model not all chromatids will be shown in the visible plane.

The 3B Scientific® model series on mitosis is supplied in a storage system, which is equipped with a hanging device. The model series can thus be simply hung on a wall in order to save space. The models also have magnets at the rear so that they can be arranged on magnetic boards in the classroom for teaching purposes.

# Mitosis

English

At the end of this description you will find illustrations of the 9 phases included. You can use these to make photocopies for your lessons. By colouring, labelling and correctly arranging the individual phases your students can easily review and memorize what they have learned.

Free colour illustrations of the individual stages are also available on the Internet at <http://www.3bscientific.com>

## 1. Interphase, Stage of the G<sub>1</sub> Phase

Inside the cell the nucleus with the nucleolus (1) and its nuclear membrane (2) can be seen. The nucleus also contains the not yet helical DNA (3) with the genetic information.

The cell itself receives its stability and shape from very fine tubes, the so-called microtubules (4) extending through the cytoplasm. The microtubules control, among other things, the cell movements and the intracellular transport processes.

In the cytoplasm, the endoplasmic reticulum (5) can be seen. This is an intertwined tube system mainly in charge of the intercellular transport of water and ions. The membrane of the endoplasmic reticulum has ribosomes attached to it, whose function is the production of proteins.

The Golgi complex (or apparatus) (6) can also be referred to as “cell gland”. It is made up of stacks of layered hollow sacs (Golgi cisternae), which swell up to vesicles and “pinch off” (Golgi vesicles) (7). The Golgi complex receives membrane components and enzymes from the endoplasmic reticulum and its main function is to collect and distribute secretions and produce lysosomes (digestion vesicles) (8).

The main job of the lysosomes is breaking down cell components. This can occur either from within the cell towards the outside (= exocytosis) or within the cell (= intracellular digestion). The organelles in charge of producing energy for the cell are the mitochondria (9).

The job of the centrioles (10) is to build up the cleavage spindle. They are hollow cylinders made up of longitudinally arranged tubes (microtubules).

## 2. Prophase

The cell prepares for division and abandons its functions. The cytoplasm becomes less glutinous as the stabilizing microtubules are broken down. The permeability of the cell surface is increased in order to allow the intake of liquid from the surroundings. The microtubular complex, the basis of the cytoskeleton, dissolves. The nuclear membrane (1) and the nucleolus (2) also begin to dissolve. In the nucleus, the DNA begins to condense and form precisely defined chromosomes. Each chromosome has been replicated in the preceding S phase and now consists of two sister chromatids (3). Each of these sister chromatids contains a specific DNA sequence, the so-called centromere (4), which is in charge of the separation of the daughter cells. The pairs of centrioles (5), which were duplicated in the interphase, begin to move away from one another in the direction of the two cell poles. They form the so-called central spindle (6) between themselves, which consists of many microtubules. The mitochondria (7) and lysosomes (8) present in this area are pushed aside.

## 3. Early Prometaphase

In the early prometaphase the nucleolus dissolves and the nuclear membrane dissolves into membrane vesicles (1). The chromosomes (2) inside the nucleus can be clearly seen.

The two centrioles (3) continue on their path towards the poles. The microtubules (4) of the central spindle, which were so far located outside the nucleus, can now penetrate into the area of the nucleus and attach to the kinetochores (5) located in the middle of each duplicated chromosome. The kinetochores are protein complexes, which have formed for this purpose at the centromeres.

The endoplasmic reticulum (6) and the Golgi complex (7) begin to dissolve.

## 4. Later Prometaphase

Now the nuclear membrane (1) has dissolved almost completely and the centriole pairs (2) have reached the two poles of the cell opposite each other. The microtubules (3) of the central spindle begin to align the chromosomes (4) which are connected to them.

The mitochondria (5) and lysosomes (6) that were pushed aside line up evenly within the cytoplasm again.

The endoplasmic reticulum (7) and the Golgi complex (8) are almost completely dissolved now.

## 5. Metaphase

The microtubules of the central spindle (1) have now attached precisely to the kinetochores (2) of each doubled chromosome (3). During the metaphase the chromosomes become shorter and align exactly in the middle between both poles of the central spindle. They form the so-called metaphase plate. Viewed from the top, they have a star-like shape (monaster or “mother” star).

## 6. Early Anaphase

In the early anaphase the previously duplicated chromatids (1) separate. In this process, the sister chromatids containing the same genetic information are precisely separated, forming independent chromosomes. This separation begins at the pairs of kinetochores (2), which is where the traction fibres of the central spindle are attached. From here, the chromosomes are pulled slowly towards the centrioles (4) located at the cell poles, moving along the microtubules (3) which create a traction effect as they become shorter.

## 7. Later Anaphase

In the later anaphase the chromosomes (1) have reached the cell poles and now form two “daughter” stars. The microtubules (2) of the central spindles connected with the kinetochores at the two centrioles (3) opposite of each other recede and disconnect. The microtubules (4) that are not connected to chromosomes now become longer, thus increasing the distance between the centrioles and elongating the cell. At the equator level, the beginning stage of a cleavage furrow (5) becomes visible.

## 8. Telophase

In the telophase the microtubules connected with the kinetochores dissolve completely. The only remaining microtubules (1) are those connecting the two cell poles with each other. A new nuclear membrane (2) begins to form around the two separated chromosome pairs at the cell poles. The condensed DNS (3) begins to elongate again and a new nucleolus begins to form.

The cleavage furrow at the equator level is condensed and constricts to form a ring (4), which actively condenses the cytoplasm and leads to a further division of the new cells which are about to form.

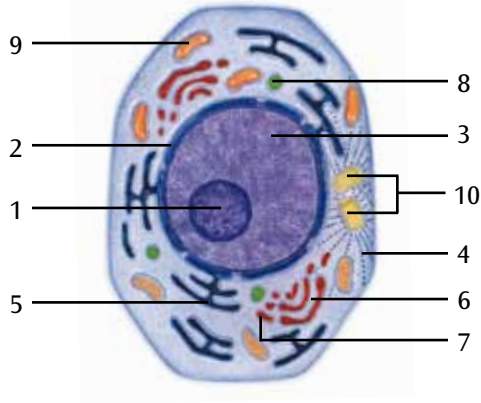
## 9. Cytokinesis

The chromosomes (1) become even thinner and longer. The endoplasmic reticulum (2) and the Golgi complex (3) are redeveloped.

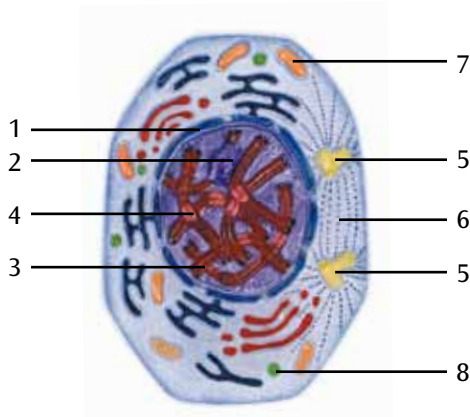
The body of the cell is now divided exactly in the middle, at the ring constriction (4) between the two new daughter nuclei. During cytokinesis, a thin cytoplasm bridge frequently remains between the two newly created cells. Once both daughter cells have separated completely, cytokinesis has been completed.

The two newly created daughter cells are smaller than the mother cell and reach their final size through growth. The daughter cells enter the interphase again, before duplicating once more through mitotic division.

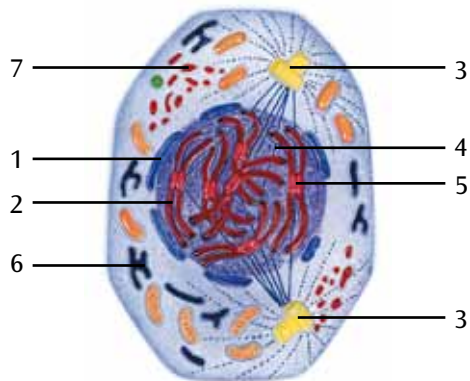
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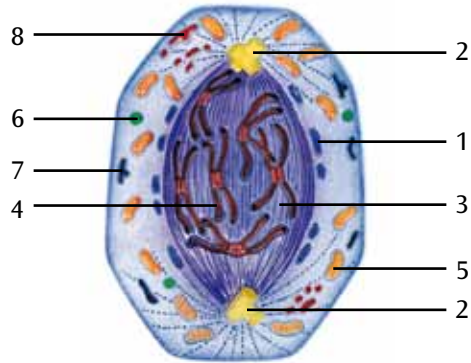
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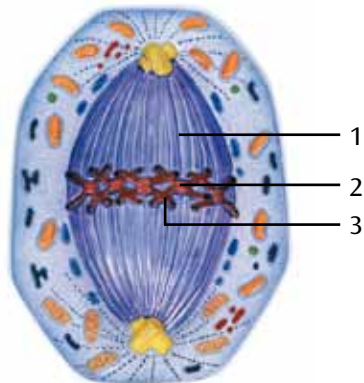
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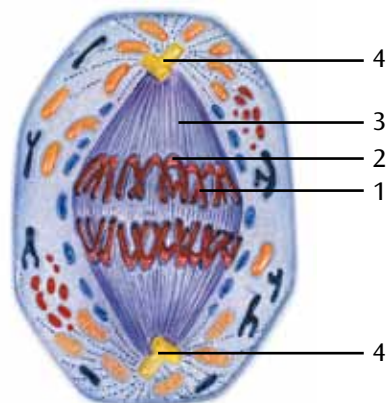
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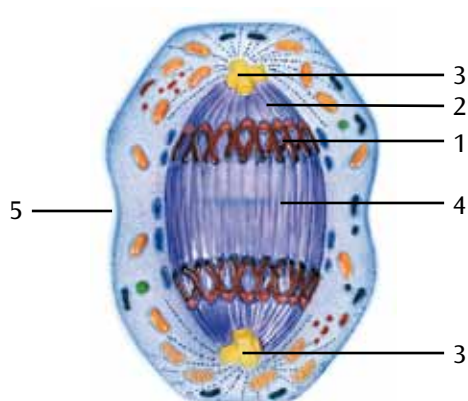
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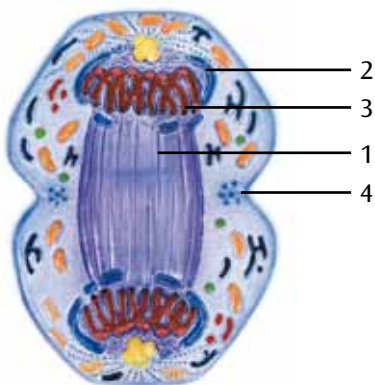
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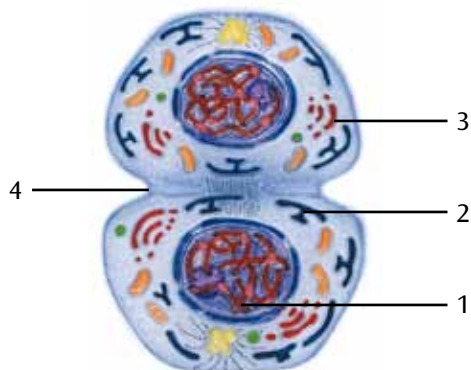
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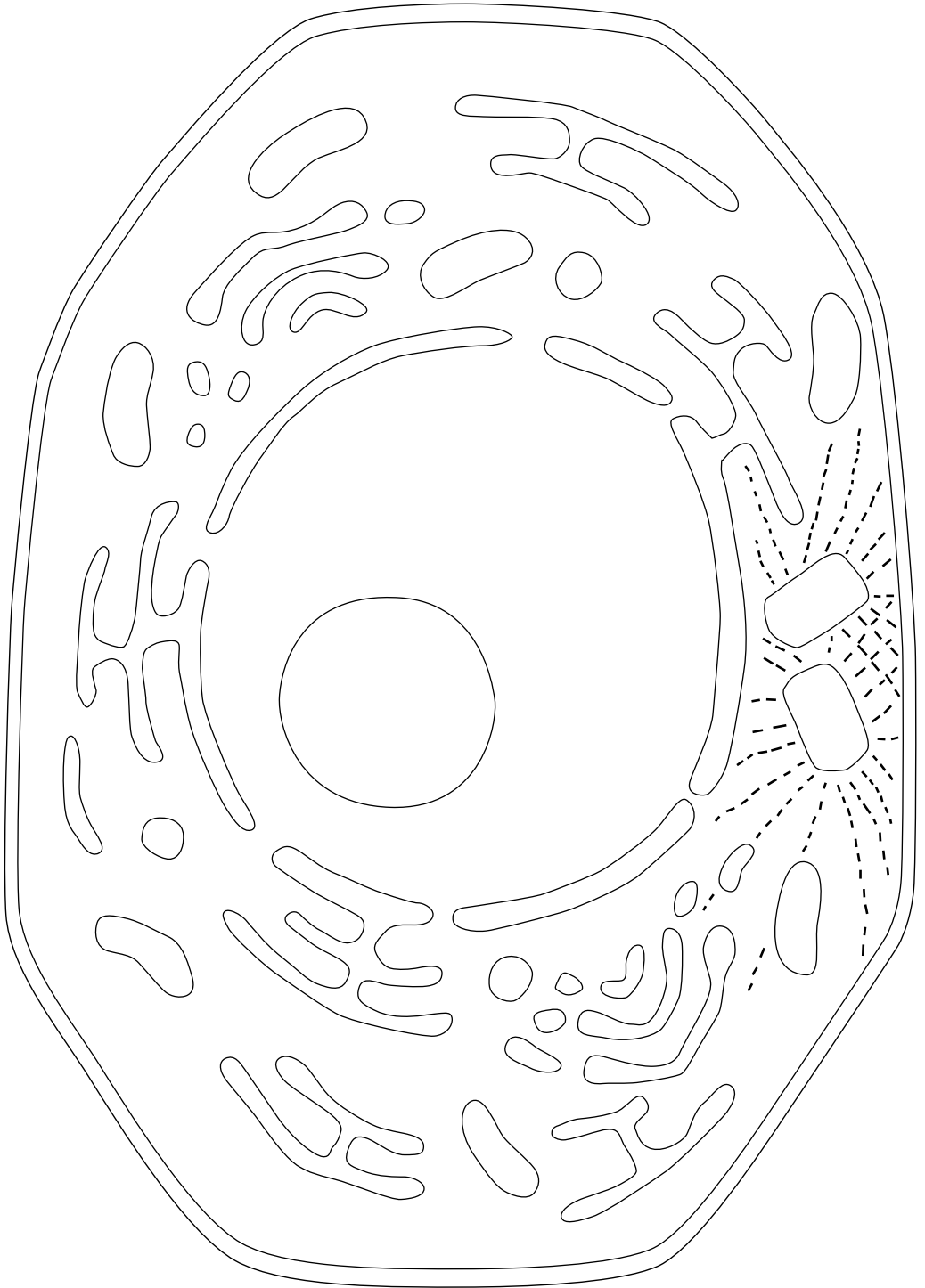


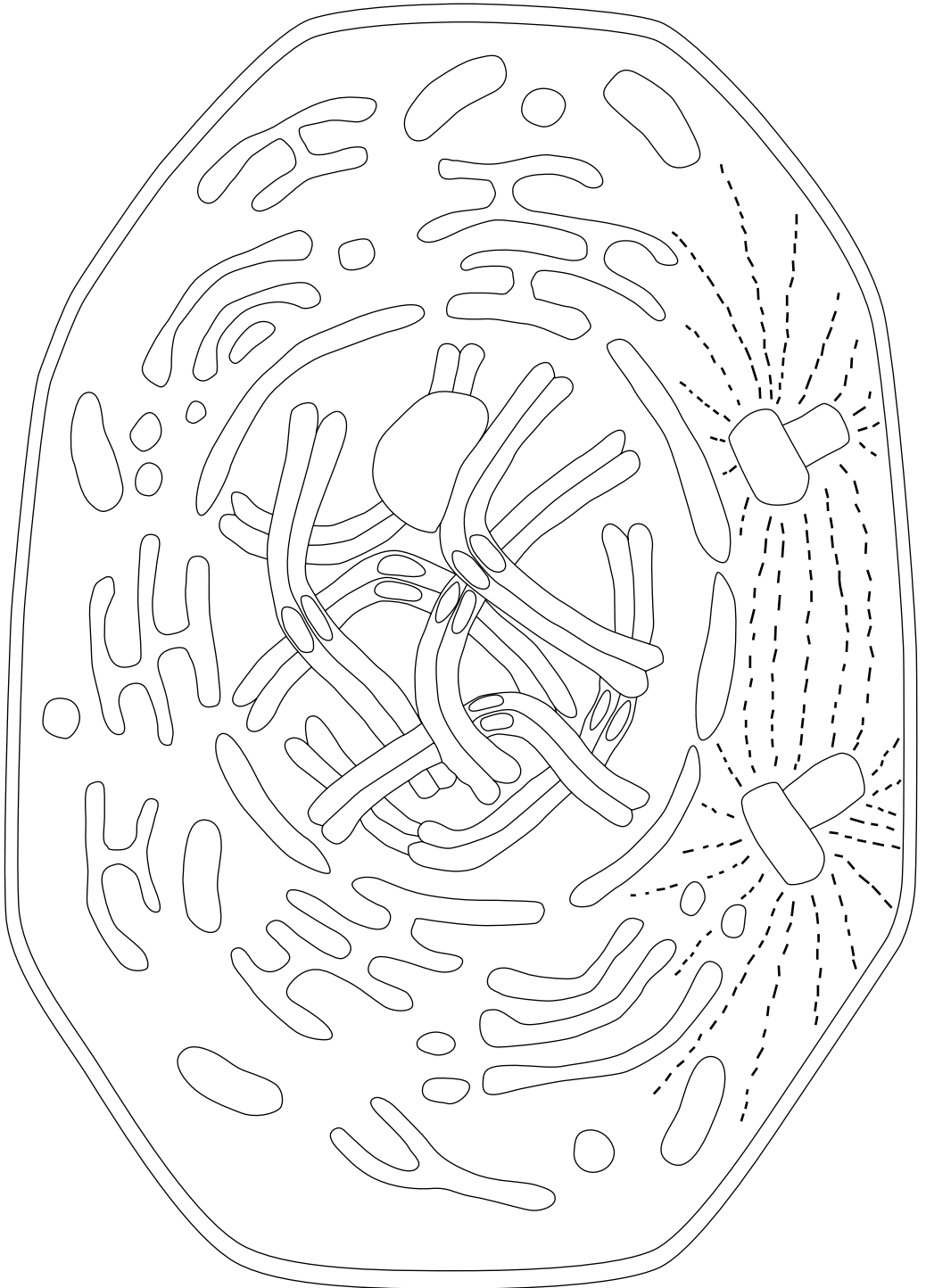
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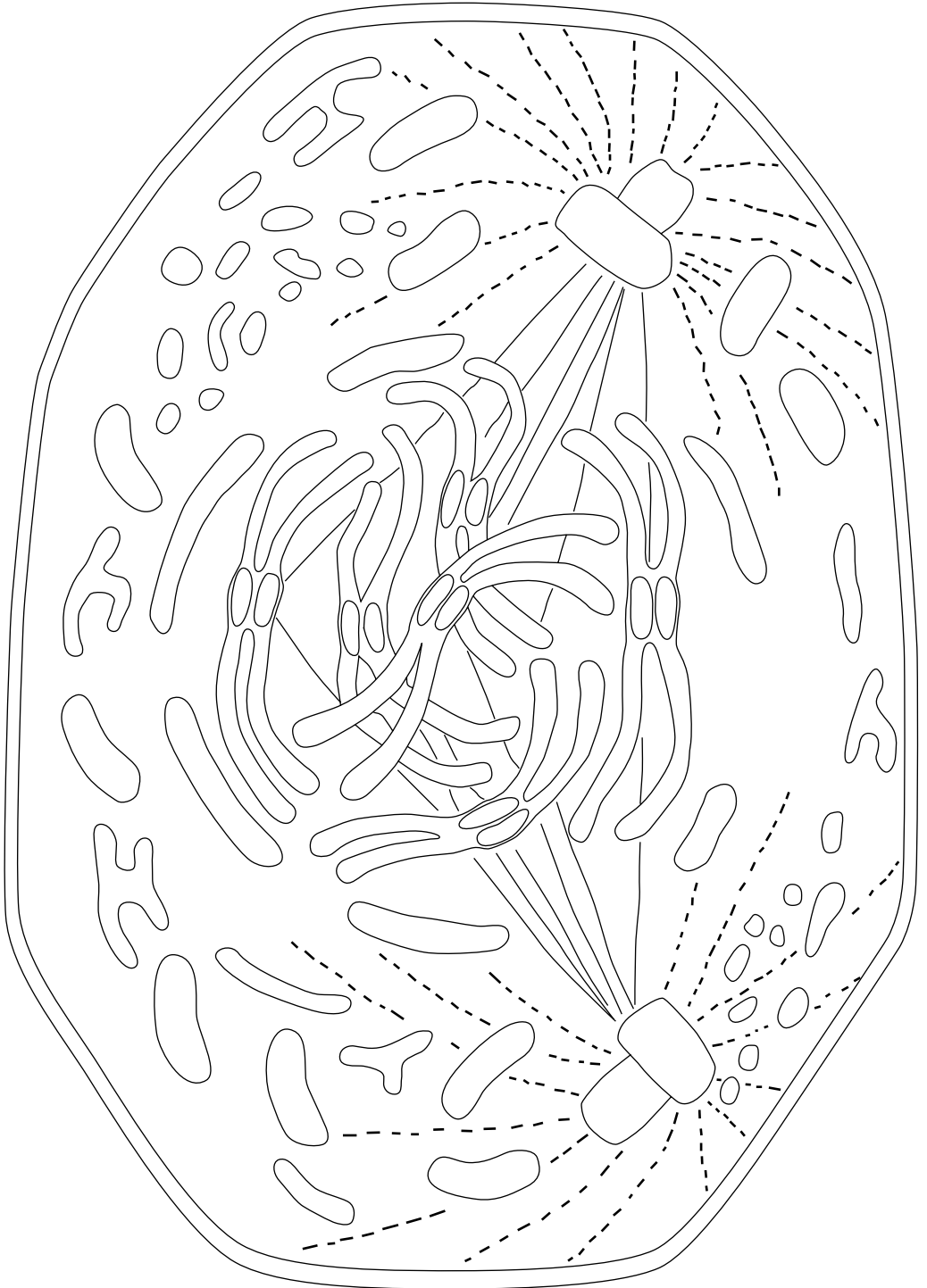


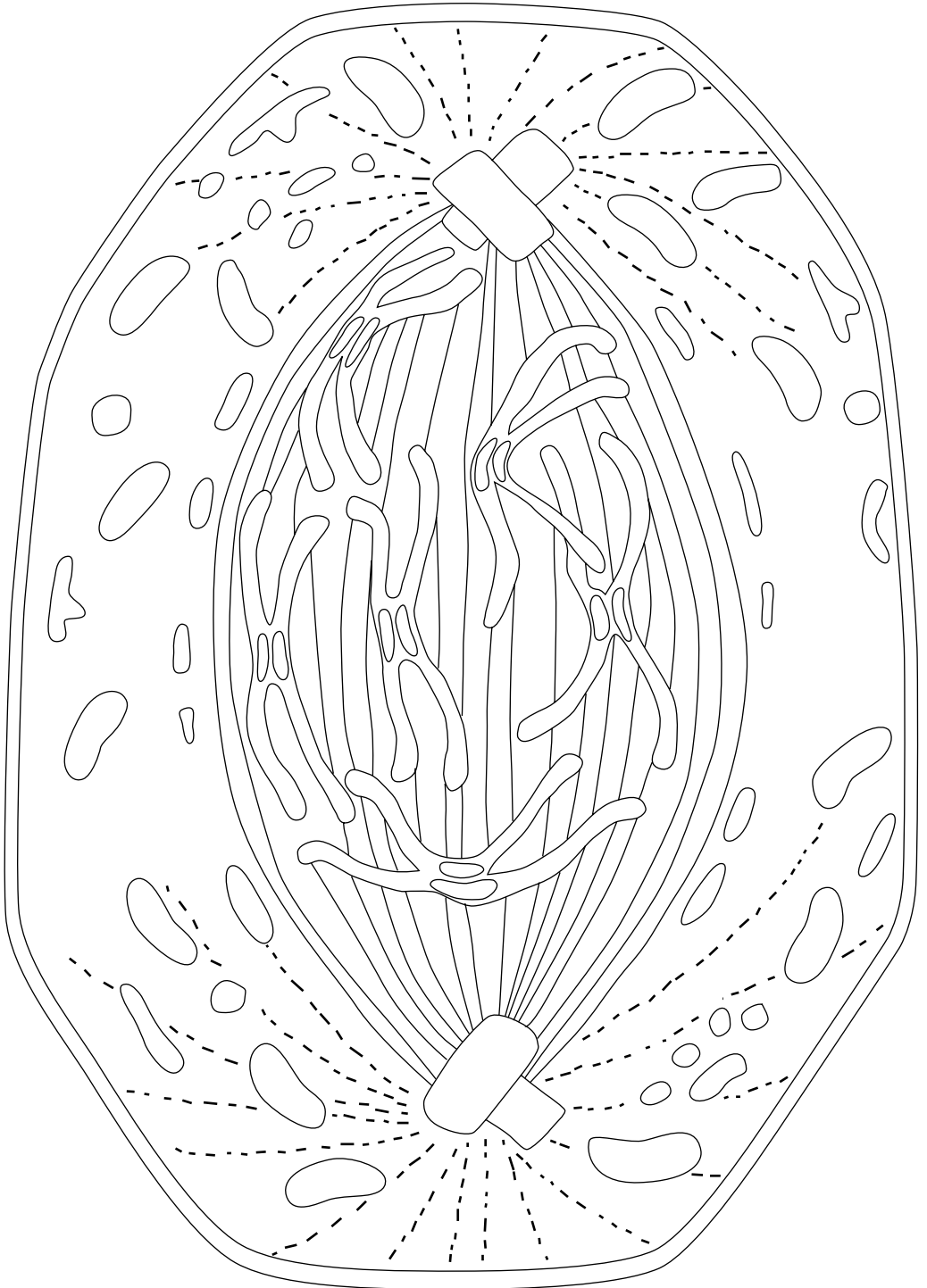
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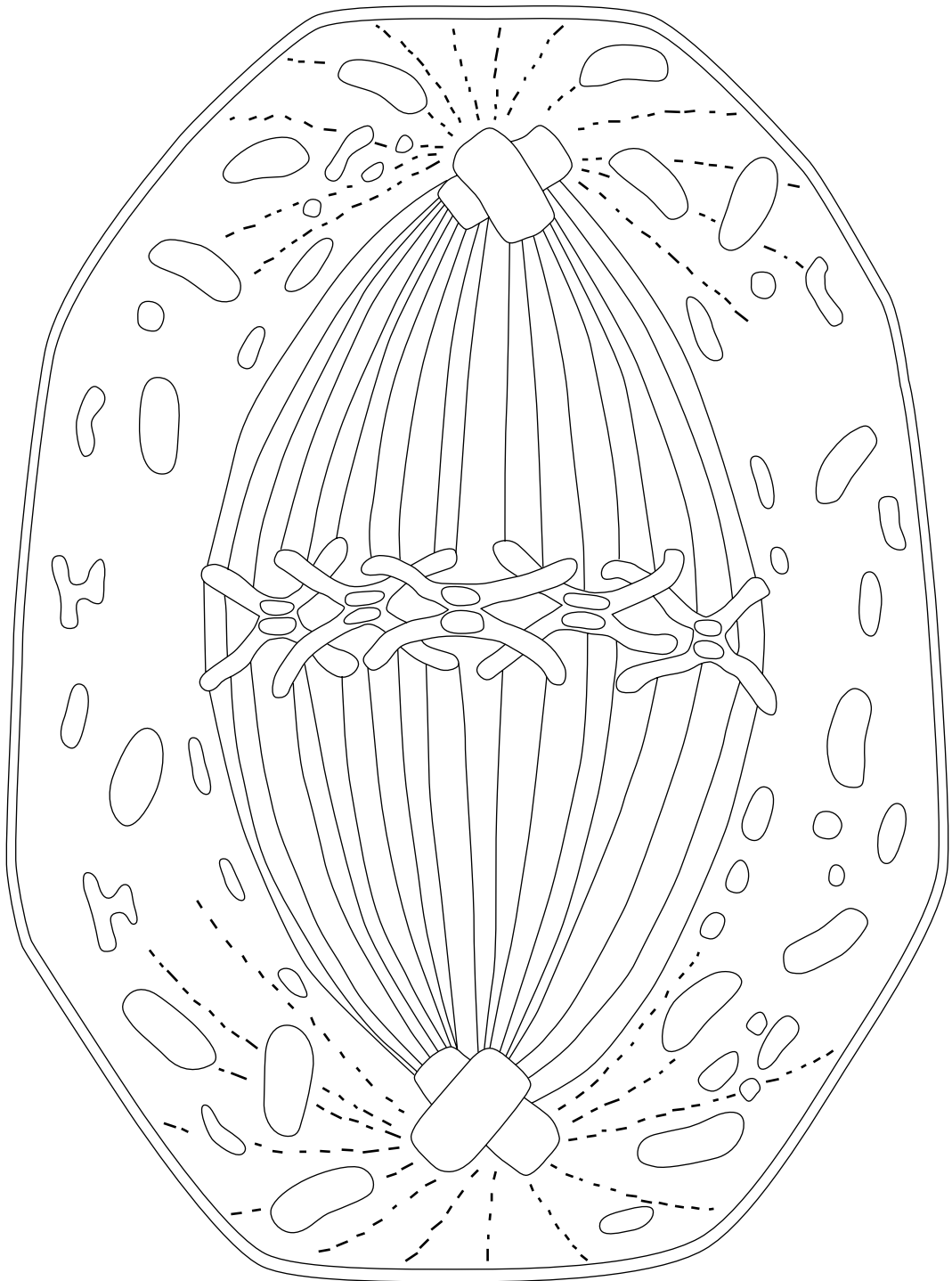


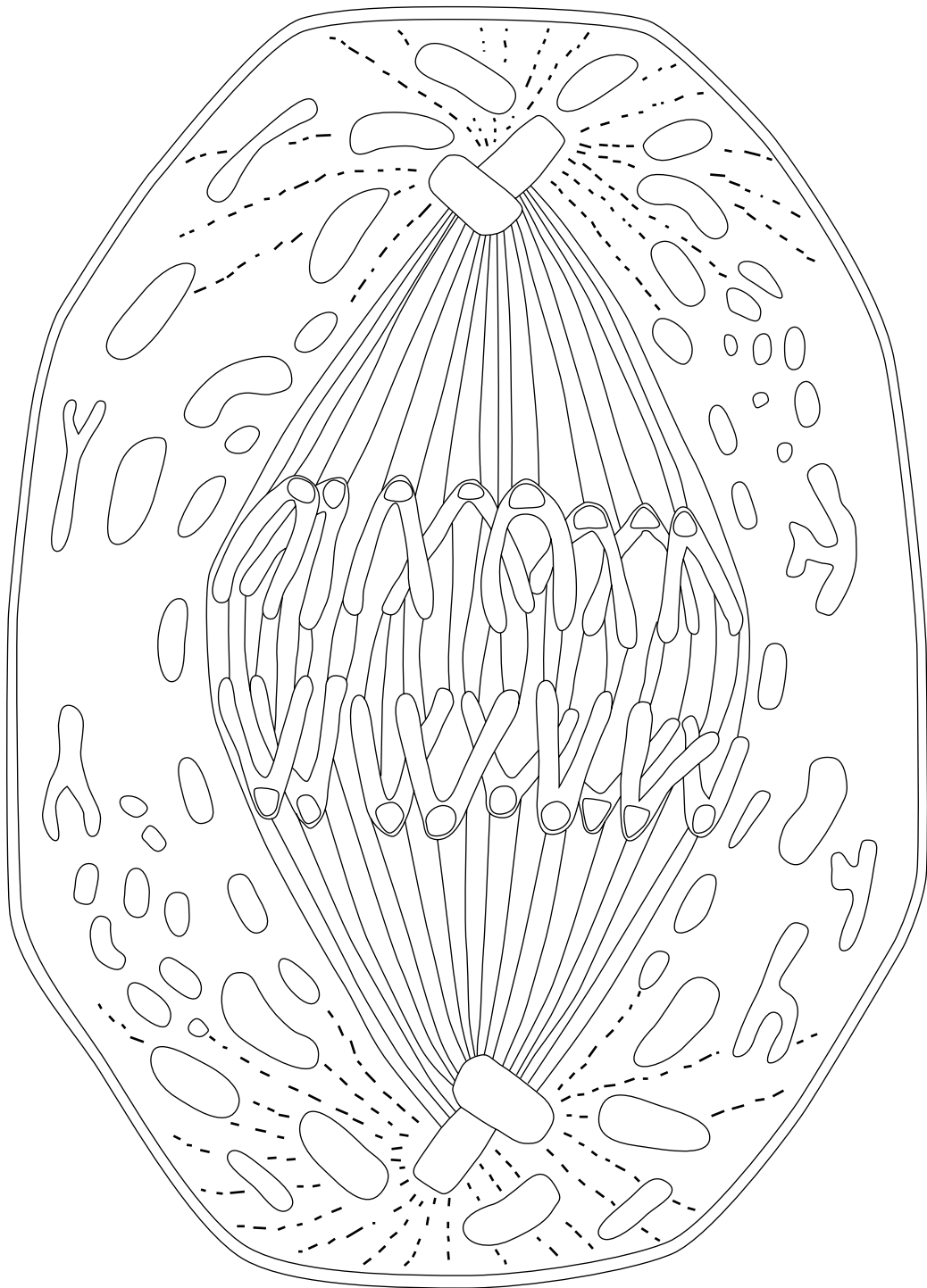


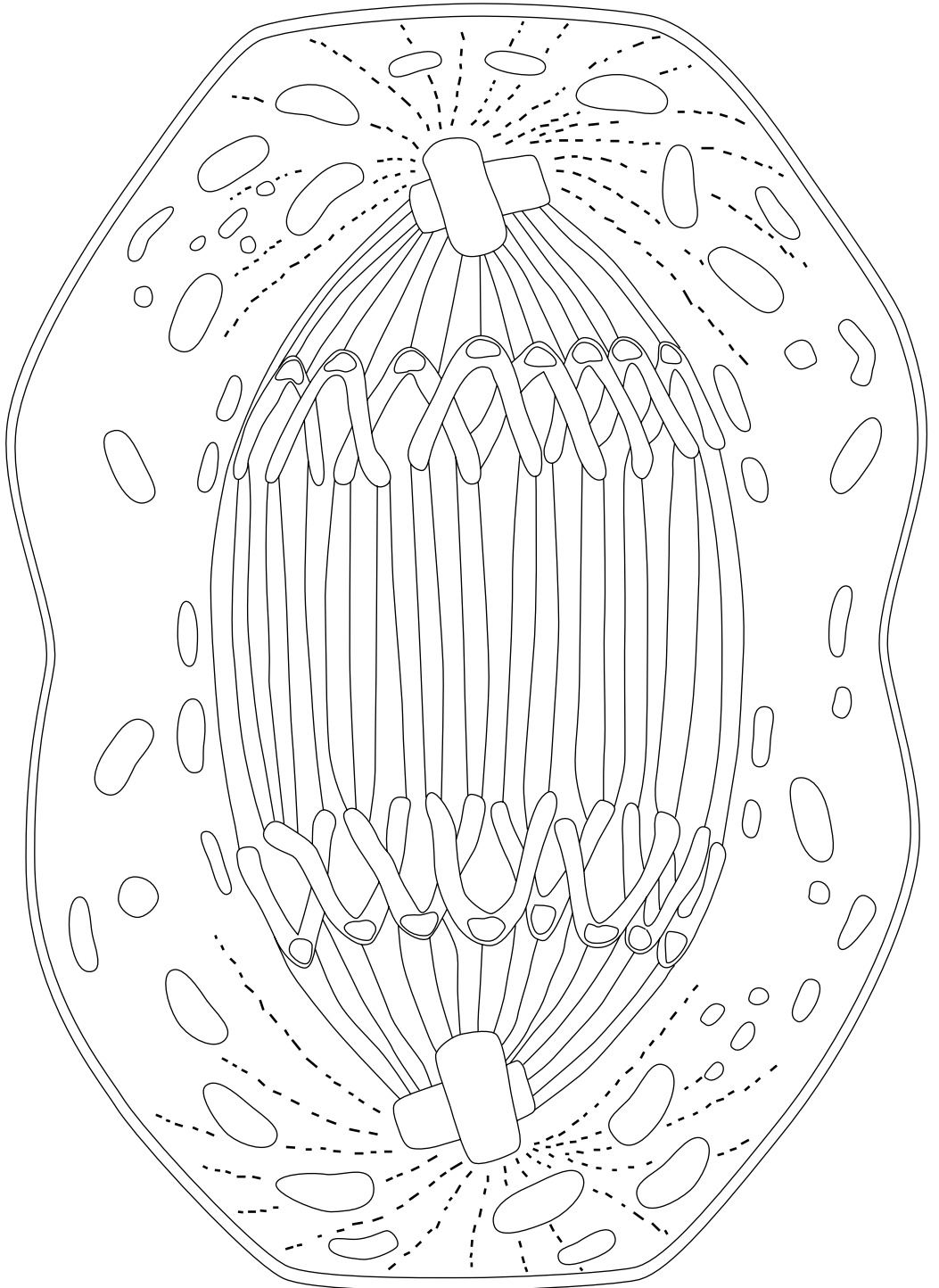


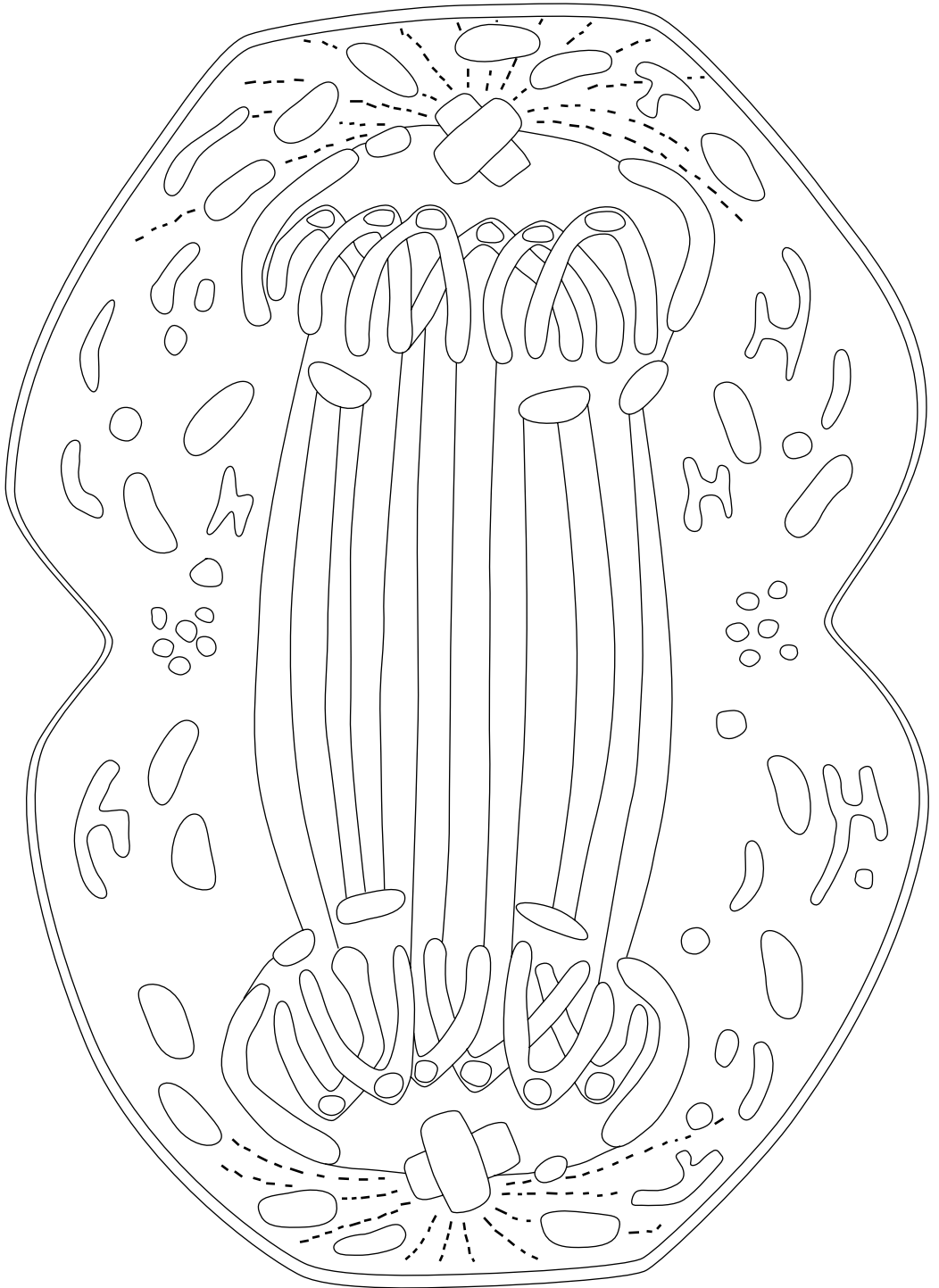














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