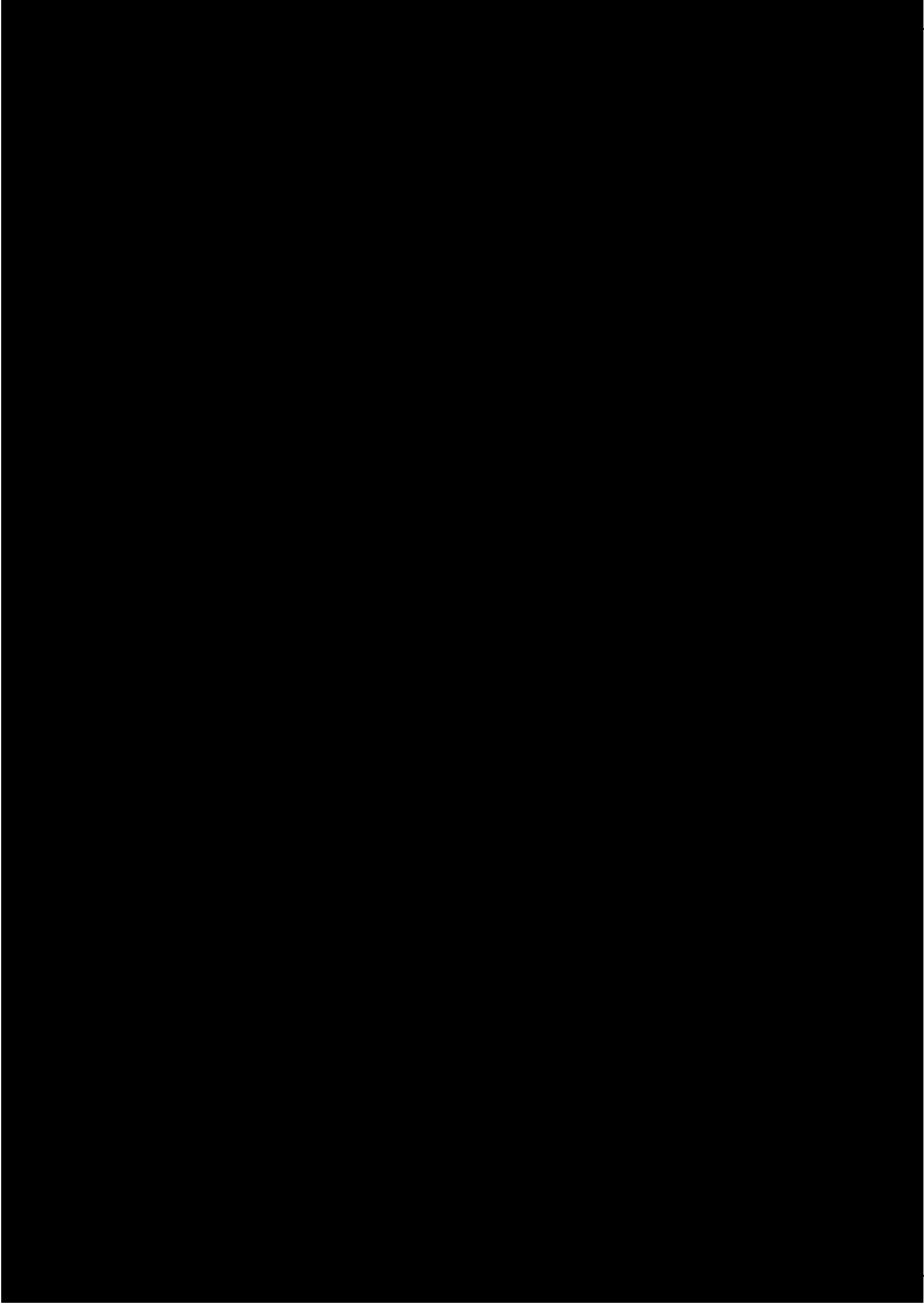
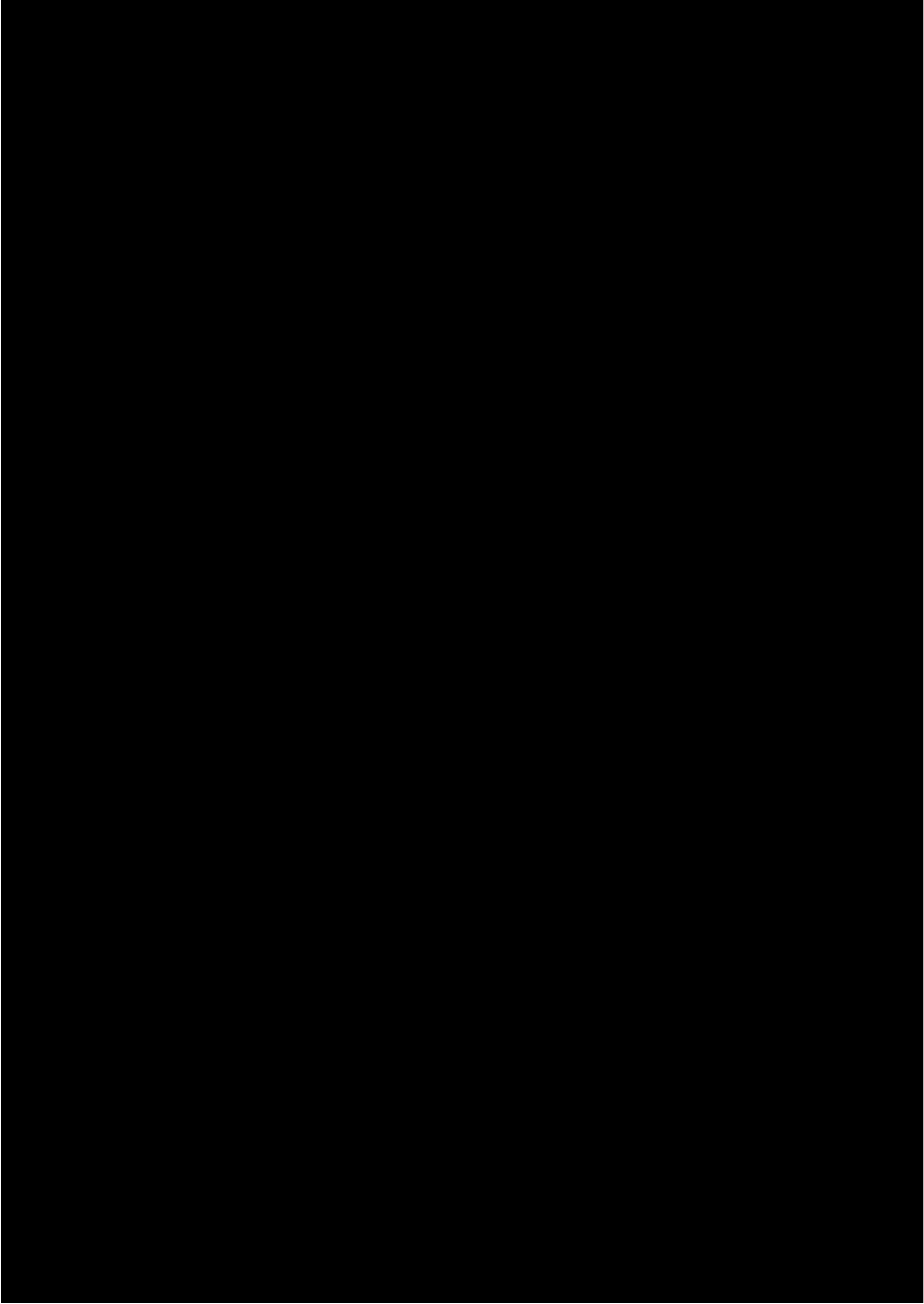
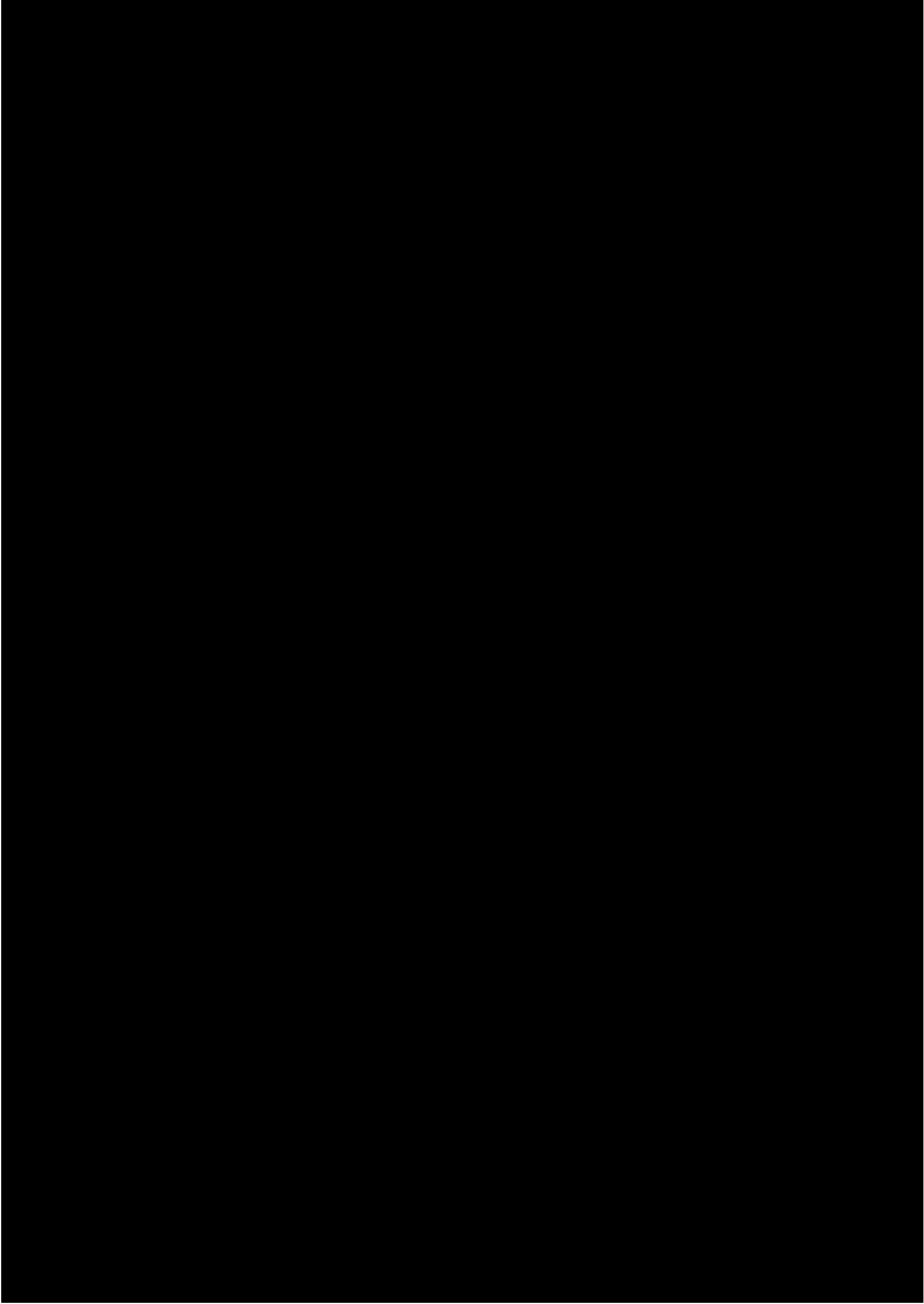
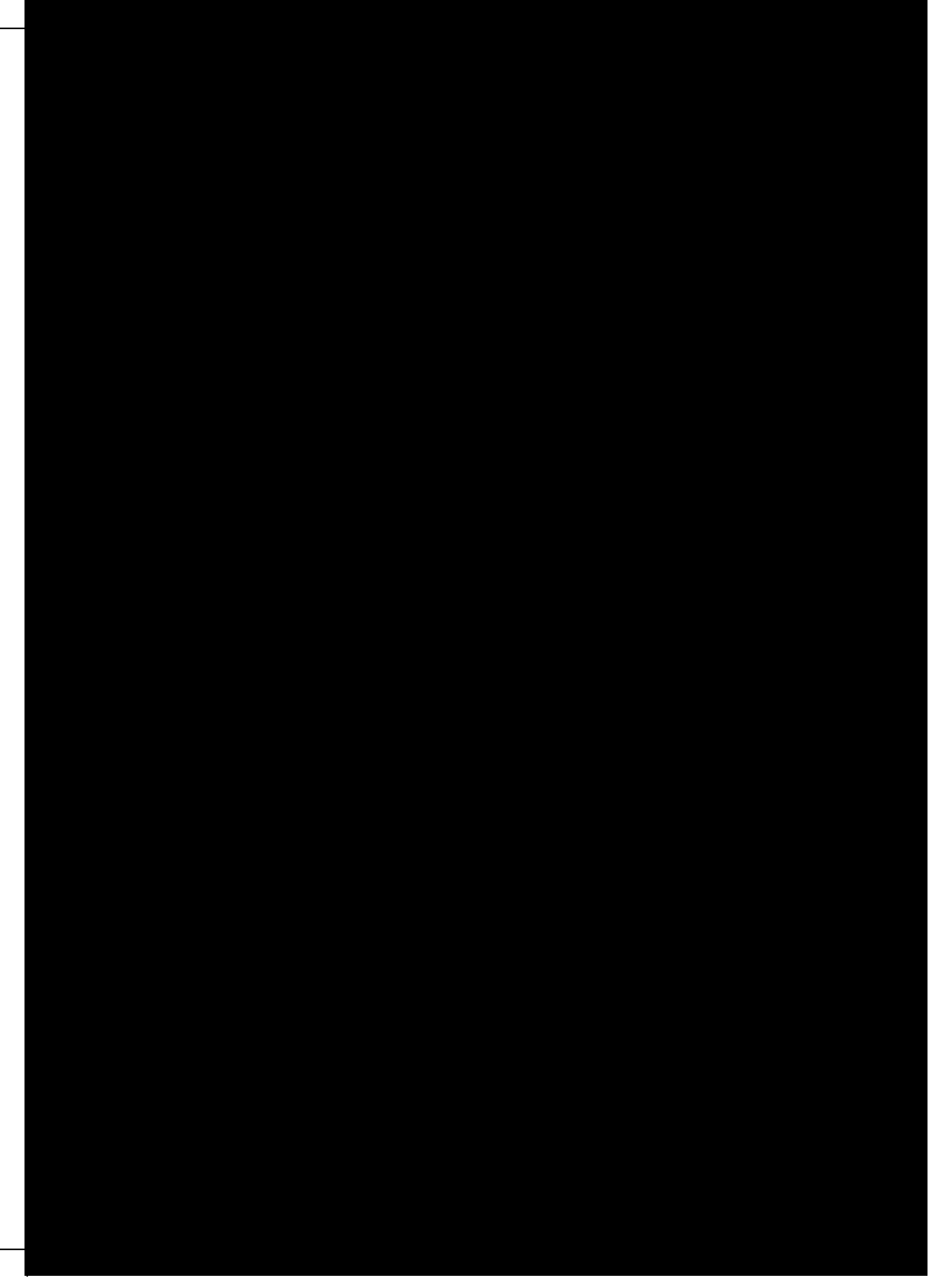
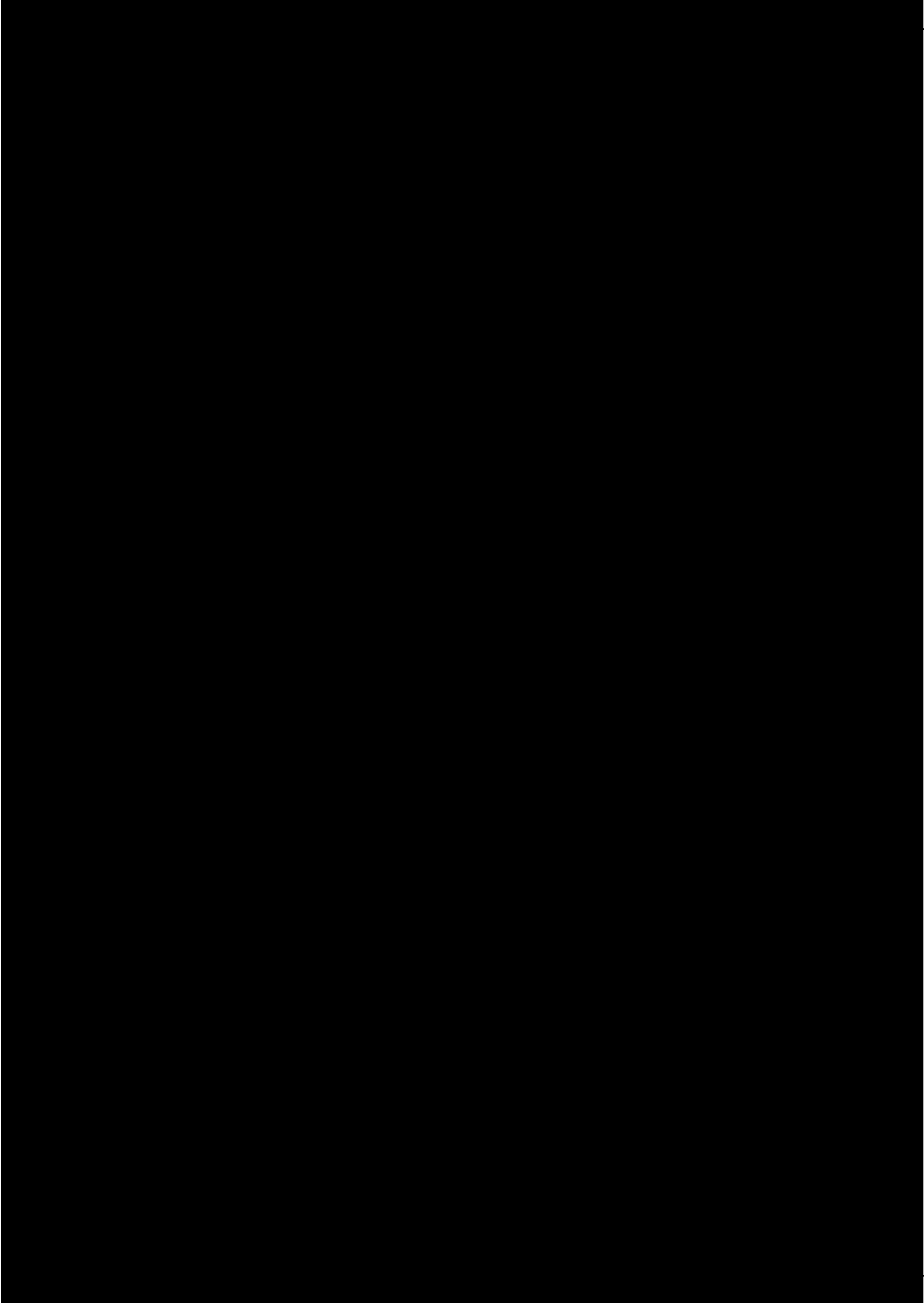


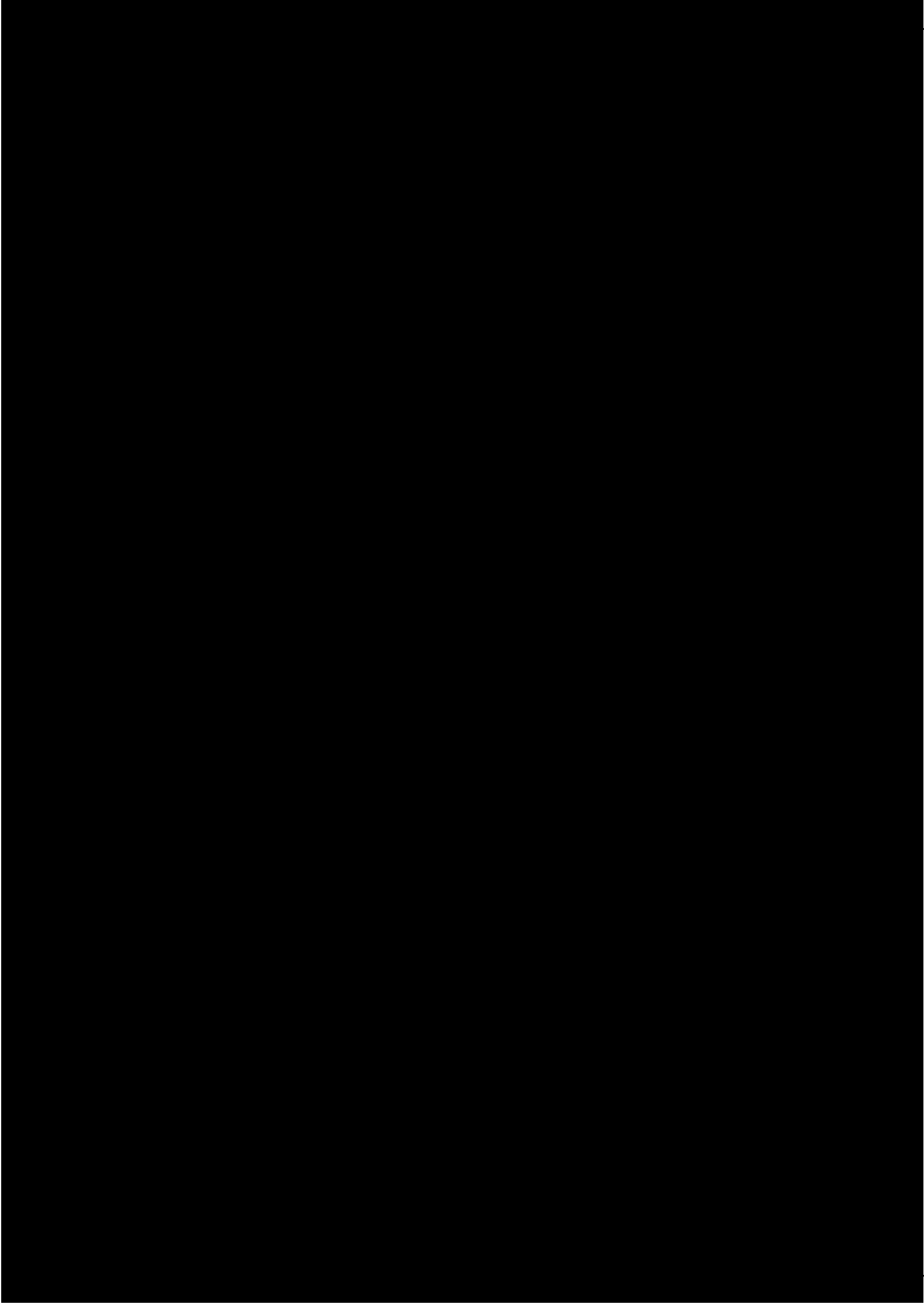












Our National Anthem

*Jana-gana-mana adhinayaka, jaya he
Bharata-bhagya-vidhata.
Punjab-Sindh-Gujarat-Maratha
Dravida-Utkala-Banga
Vindhya-Himachala-Yamuna-Ganga
Uchchhala-jaladhi-taranga.
Tava shubha name jage,
Tava shubha asisa mage,
Gahe tava jaya gatha.
Jana-gana-mangala-dayaka jaya he
Bharata-bhagya-vidhata.
Jaya he, jaya he, jaya he,
Jaya jaya jaya, jaya he!*

Our National Anthem, composed originally in Bangla by Rabindranath Tagore, was adopted in its Hindi version by the Constituent Assembly as the national anthem of India on 24 January 1950.



Quest for Truth

True education is that which helps us to know the atman, our true self, God and Truth. To acquire this knowledge, some persons may feel the need for a study of literature, some for a study of physical sciences and some others for art. But every branch of knowledge should have as its goal, knowledge of the self. That is so in the Ashram. We carry on numerous activities with that aim in view. All of them are, in my sense of the term, true education. Those activities can also be carried on without any reference to the goal of knowledge of the self. When they are so carried on, they may serve as a means of livelihood or of something else, but they are not education. In an activity carried on as education, a proper understanding of its meaning, devotion to duty and the spirit of service are necessary. The first necessarily brings about development of the intellect. In doing any piece of work, however small, we should be inspired by a holy aim and, while doing it, we should try to understand the purpose which it will serve and the scientific method of doing it. There is a science of every type of work — whether it be cooking, sanitation, carpentry or spinning. Everybody who does his work with the attitude of a student knows its science or discovers it.

— From a microfilm of the Gujarati:
M.M.U./II, 10 July 1932 (CW 50, p. 182)

...We are living in the midst of death, trying to grope our way to Truth. Perhaps it is as well that we are beset with danger at every point in our life, for, in spite of our knowledge of the danger and of our precarious existence, our indifference to the source of all life is excelled only by our amazing arrogance.

....My intellect rebels against the destruction of any life in any shape whatsoever. But my heart is not strong enough to befriend these creatures, which, experience has shown, are destructive. The language of convincing confidence, which comes from actual experience, fails me, and it will continue to do so, so long as I am cowardly enough to fear snakes, tigers and the like.

— (YI, 17 July 1927, p. 222)

THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a ¹**[SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC]** and to secure to all its citizens :

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the ²[unity and integrity of the Nation];

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949 do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.**

1. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Sovereign Democratic Republic" (w.e.f. 3.1.1977)
2. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Unity of the Nation" (w.e.f. 3.1.1977)

Chapter 1

MATTER IN OUR SURROUNDINGS

As we look at our surroundings, we see a large variety of things with different shapes, sizes and textures. Everything in this universe is made up of material which scientists have named “matter”. The air we breathe, the food we eat, stones, clouds, stars, plants and animals, even a small drop of water or a particle of sand – every thing is matter. We can also see as we look around that all the things mentioned above occupy space and have mass. In other words, they have both mass* and volume**.

Since early times, human beings have been trying to understand their surroundings. Early Indian philosophers classified matter in the form of five basic elements – the “*Panch Tatva*” – air, earth, fire, sky and water. According to them everything, living or non-living, was made up of these five basic elements. Ancient Greek philosophers had arrived at a similar classification of matter.

Modern day scientists have evolved two types of classification of matter based on their physical properties and chemical nature.

In this chapter we shall learn about matter based on its physical properties. Chemical aspects of matter will be taken up in subsequent chapters.

1.1 Physical Nature of Matter

1.1.1 MATTER IS MADE UP OF PARTICLES

For a long time, two schools of thought prevailed regarding the nature of matter. One school believed matter to be continuous like a block of wood, whereas, the other thought that matter was made up of particles like sand. Let us perform an activity to decide about the nature of matter – is it continuous or particulate?

* The SI unit of mass is kilogram (kg).

** The SI unit of volume is cubic metre (m^3). The common unit of measuring volume is litre (L) such that $1\text{ L} = 1\text{ dm}^3$, $1\text{ L} = 1000\text{ mL}$, $1\text{ mL} = 1\text{ cm}^3$.

Activity 1.1

- Take a 100 mL beaker.
- Fill half the beaker with water and mark the level of water.
- Dissolve some salt/ sugar with the help of a glass rod.
- Observe any change in water level.
- What do you think has happened to the salt?
- Where does it disappear?
- Does the level of water change?

In order to answer these questions we need to use the idea that matter is made up of particles. What was there in the spoon, salt or sugar, has now spread throughout water. This is illustrated in Fig. 1.1.

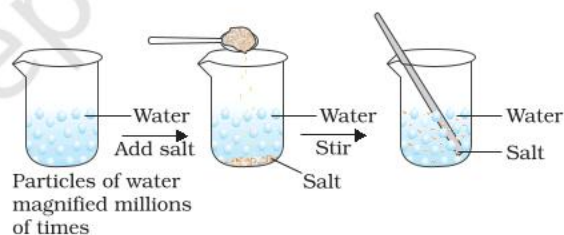
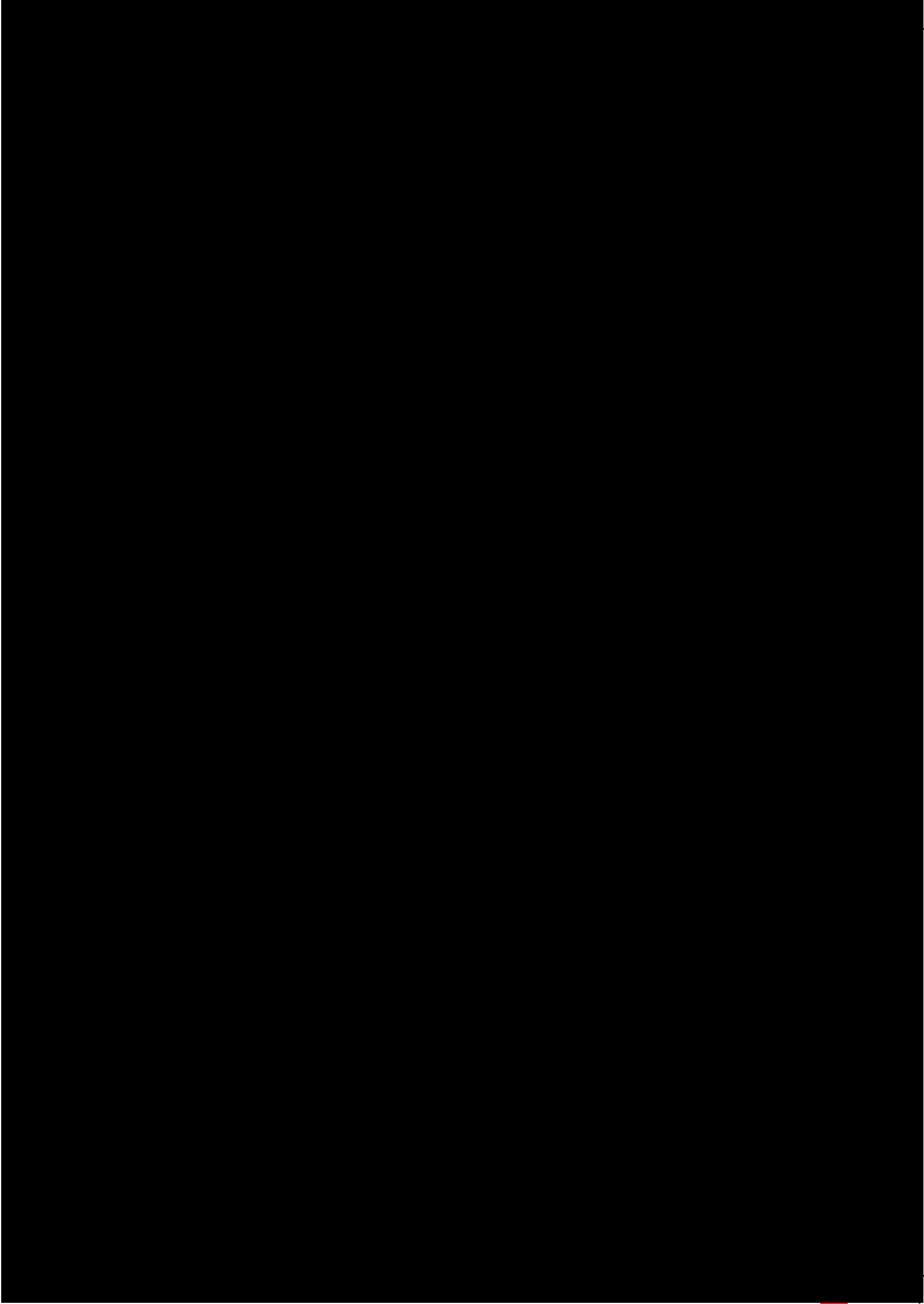


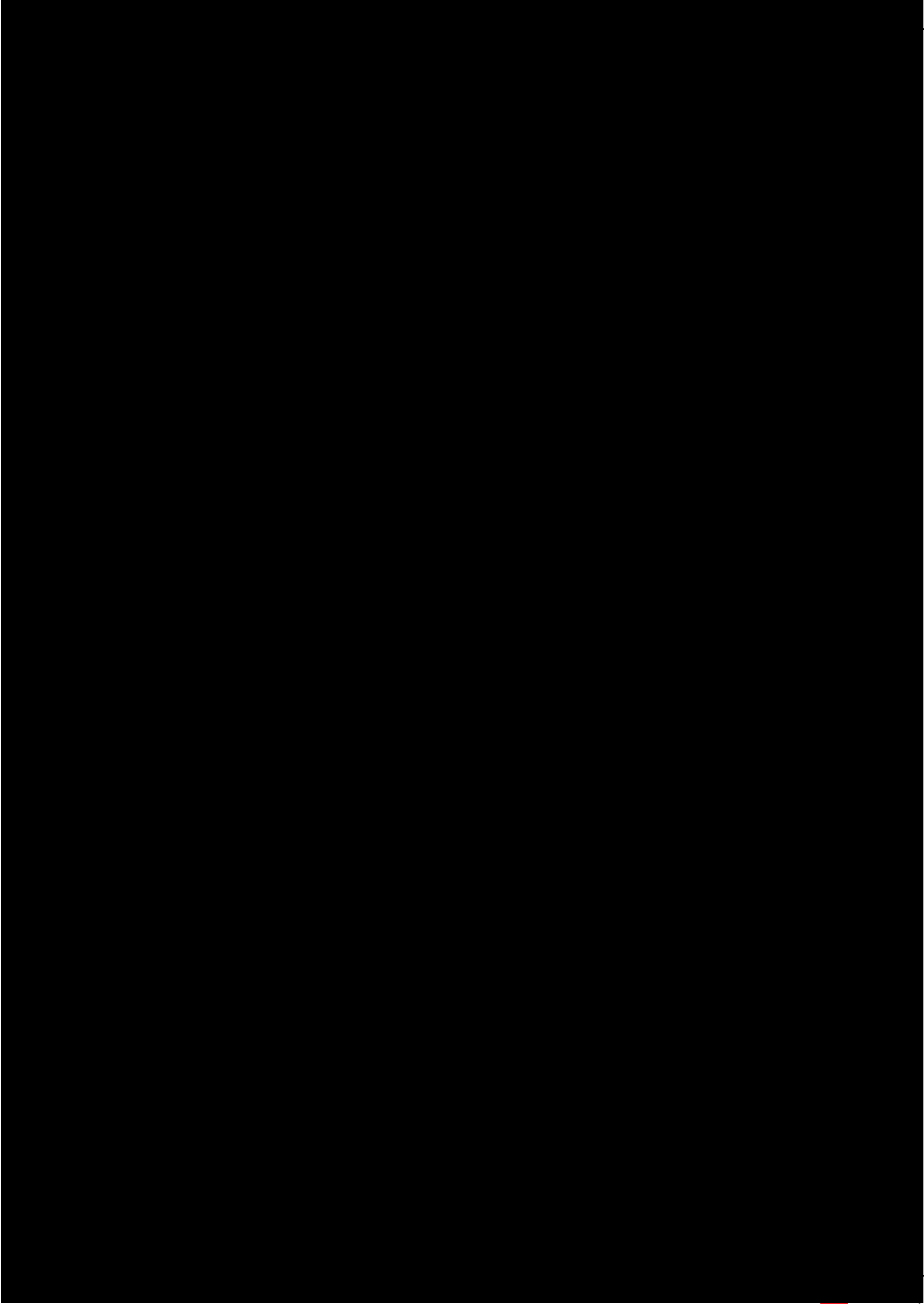
Fig. 1.1: When we dissolve salt in water, the particles of salt get into the spaces between particles of water.

1.1.2 HOW SMALL ARE THESE PARTICLES OF MATTER?

Activity 1.2

- Take 2-3 crystals of potassium permanganate and dissolve them in 100 mL of water.





Questions

- The mass per unit volume of a substance is called density. (density = mass/volume). Arrange the following in order of increasing density – air, exhaust from chimneys, honey, water, chalk, cotton and iron.
- Tabulate the differences in the characteristics of states of matter.
 - Comment upon the following: rigidity, compressibility, fluidity, filling a gas container, shape, kinetic energy and density.
- Give reasons
 - A gas fills completely the vessel in which it is kept.
 - A gas exerts pressure on the walls of the container.
 - A wooden table should be called a solid.
 - We can easily move our hand in air but to do the same through a solid block of wood we need a karate expert.
- Liquids generally have lower density as compared to solids. But you must have observed that ice floats on water. Find out why.

1.4 Can Matter Change its State?

We all know from our observation that water can exist in three states of matter–

- solid, as ice,
- liquid, as the familiar water, and
- gas, as water vapour.

What happens inside the matter during this change of state? What happens to the particles of matter during the change of states? How does this change of state take place? We need answers to these questions, isn't it?

1.4.1 EFFECT OF CHANGE OF TEMPERATURE

Activity 1.12

- Take about 150 g of ice in a beaker and suspend a laboratory thermometer so that its bulb is in contact with the ice, as in Fig. 1.6.

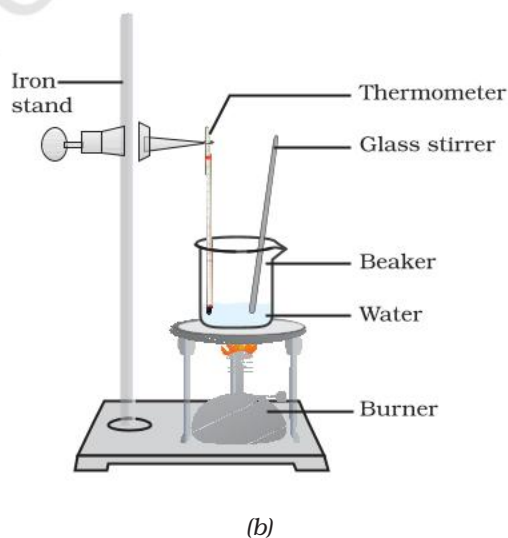
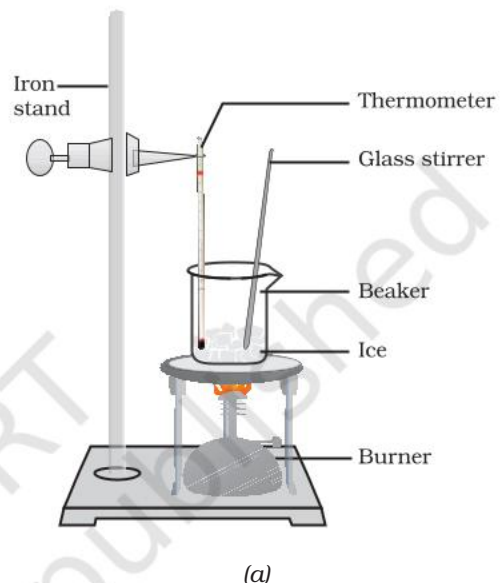
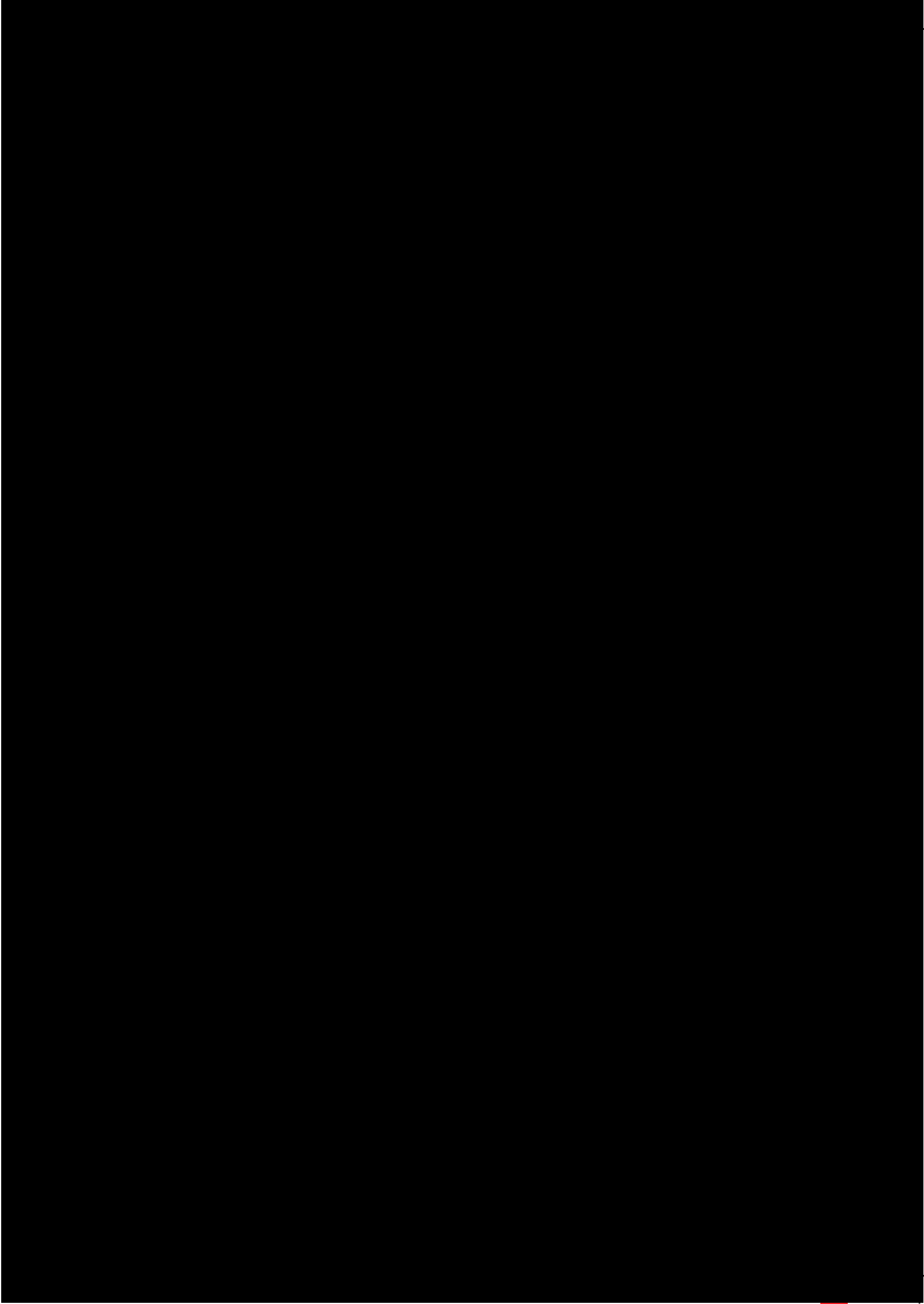


Fig. 1.6: (a) Conversion of ice to water, (b) conversion of water to water vapour



are some that change directly from solid state to gaseous state and vice versa without changing into the liquid state.

Activity _____ 1.13

- Take some camphor or ammonium chloride. Crush it and put it in a china dish.
- Put an inverted funnel over the china dish.
- Put a cotton plug on the stem of the funnel, as shown in Fig. 1.7.

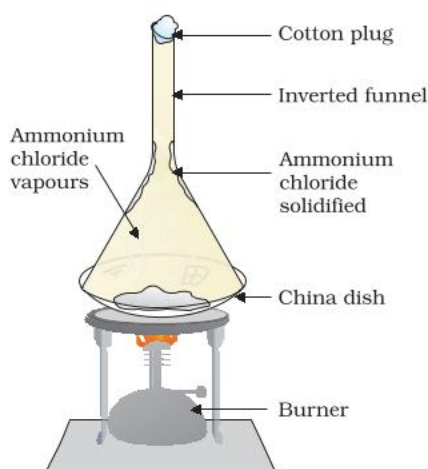


Fig. 1.7: Sublimation of ammonium chloride

- Now, heat slowly and observe.
- What do you infer from the above activity?

A change of state directly from solid to gas without changing into liquid state is called sublimation and the direct change of gas to solid without changing into liquid is called deposition.

1.4.2 EFFECT OF CHANGE OF PRESSURE

We have already learnt that the difference in various states of matter is due to the difference in the distances between the constituent particles. What will happen when we start putting pressure and compress a gas

enclosed in a cylinder? Will the particles come closer? Do you think that increasing or decreasing the pressure can change the state of matter?

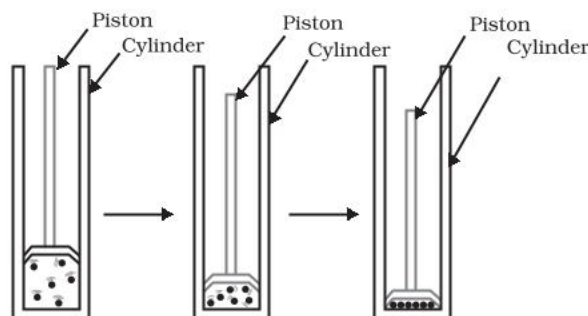


Fig. 1.8: By applying pressure, particles of matter can be brought close together.

Applying pressure and reducing temperature can liquefy gases.

Have you heard of solid carbon dioxide (CO_2)? It is stored under high pressure. Solid CO_2 gets converted directly to gaseous state on decrease of pressure to 1 atmosphere* without coming into liquid state. This is the reason that solid carbon dioxide is also known as dry ice.

Thus, we can say that pressure and temperature determine the state of a substance, whether it will be solid, liquid or gas.

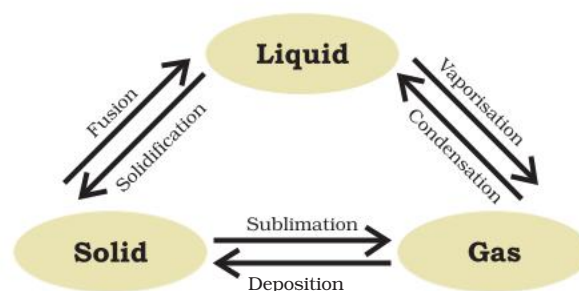
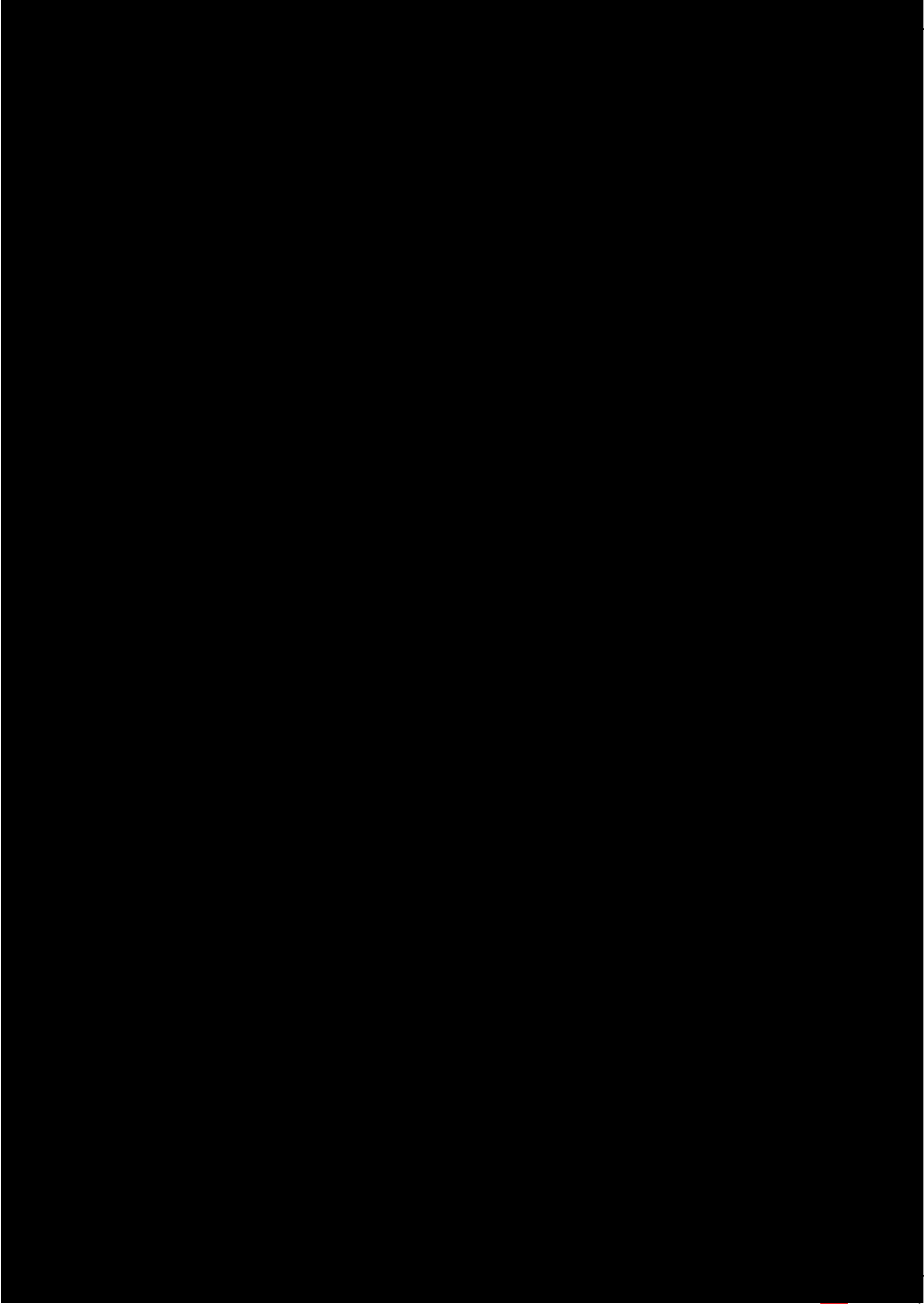
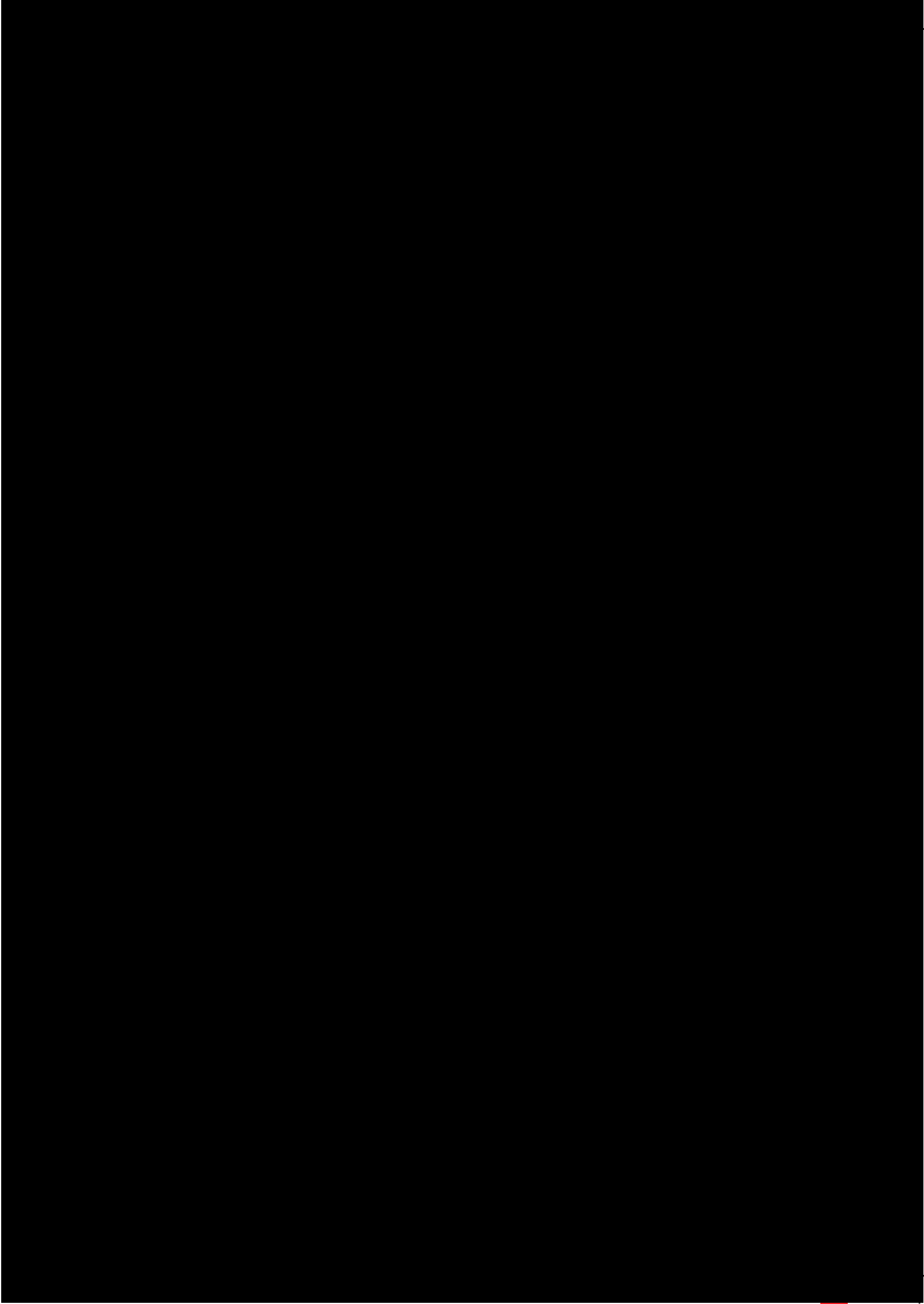
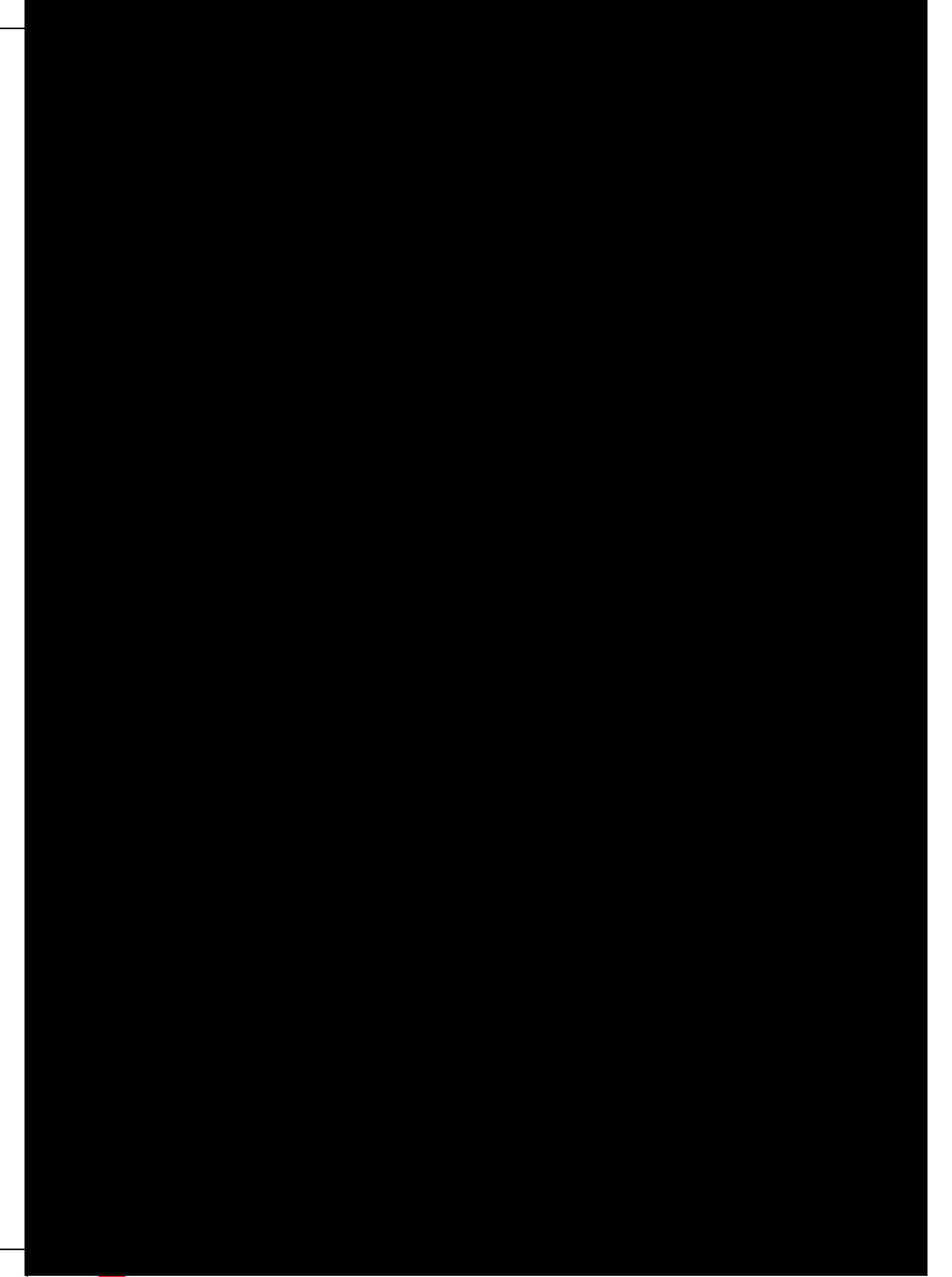


Fig. 1.9: Interconversion of the three states of matter

* atmosphere (atm) is a unit of measuring pressure exerted by a gas. The unit of pressure is Pascal (Pa): 1 atmosphere = 1.01×10^5 Pa. The pressure of air in atmosphere is called atmospheric pressure. The atmospheric pressure at sea level is 1 atmosphere, and is taken as the normal atmospheric pressure.









Group Activity



Prepare a model to demonstrate movement of particles in solids, liquids and gases.

For making this model you will need

- A transparent jar
- A big rubber balloon or piece of stretchable rubber sheet
- A string
- Few chick-peas or black gram or dry green peas.

How to make?

- Put the seeds in the jar.
- Sew the string to the centre of the rubber sheet and put some tape to keep it tied securely.
- Stretch and tie the rubber sheet on the mouth of the jar.
- Your model is ready. Now run your fingers up and down the string by first tugging at it slowly and then rapidly.

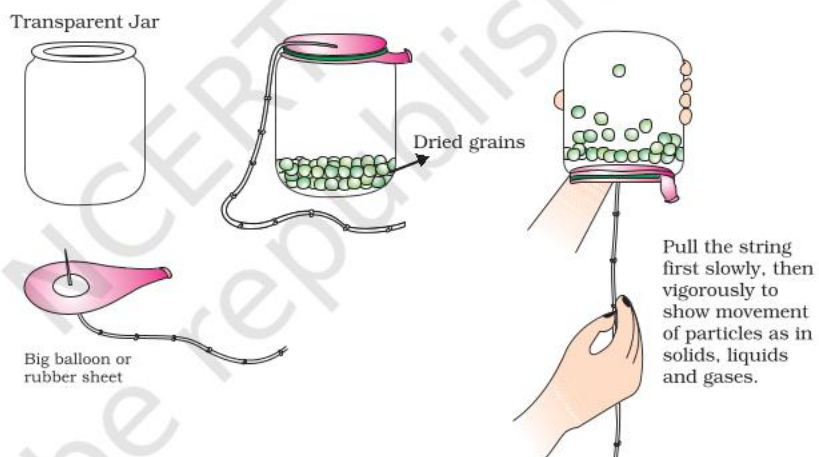


Fig. 1.10: A model for converting of solid to liquid and liquid to gas.

Chapter 2

Is Matter Around Us Pure?

How do we judge whether milk, ghee, butter, salt, spices, mineral water or juice that we buy from the market are pure?



Fig. 2.1: Some consumable items

Have you ever noticed the word 'pure' written on the packs of these consumables? For a common person pure means having no adulteration. But, for a scientist all these things are actually mixtures of different substances and hence not pure. For example, milk is actually a mixture of water, fat, proteins etc. When a scientist says that something is pure, it means that all the constituent particles of that substance are the same in their chemical nature. A pure substance consists of a single type of particles. In other words, a substance is a pure single form of matter.

As we look around, we can see that most of the matter around us exist as mixtures of two or more pure components, for example, sea water, minerals, soil etc. are all mixtures.

2.1 What is a Mixture?

Mixtures are constituted by more than one kind of pure form of matter. We know that dissolved sodium chloride can be separated from water by the physical process of

evaporation. However, sodium chloride is itself a pure substance and cannot be separated by physical process into its chemical constituents. Similarly, sugar is a substance which contains only one kind of pure matter and its composition is the same throughout.

Soft drink and soil are not single pure substances. Whatever the source of a substance may be, it will always have the same characteristic properties.

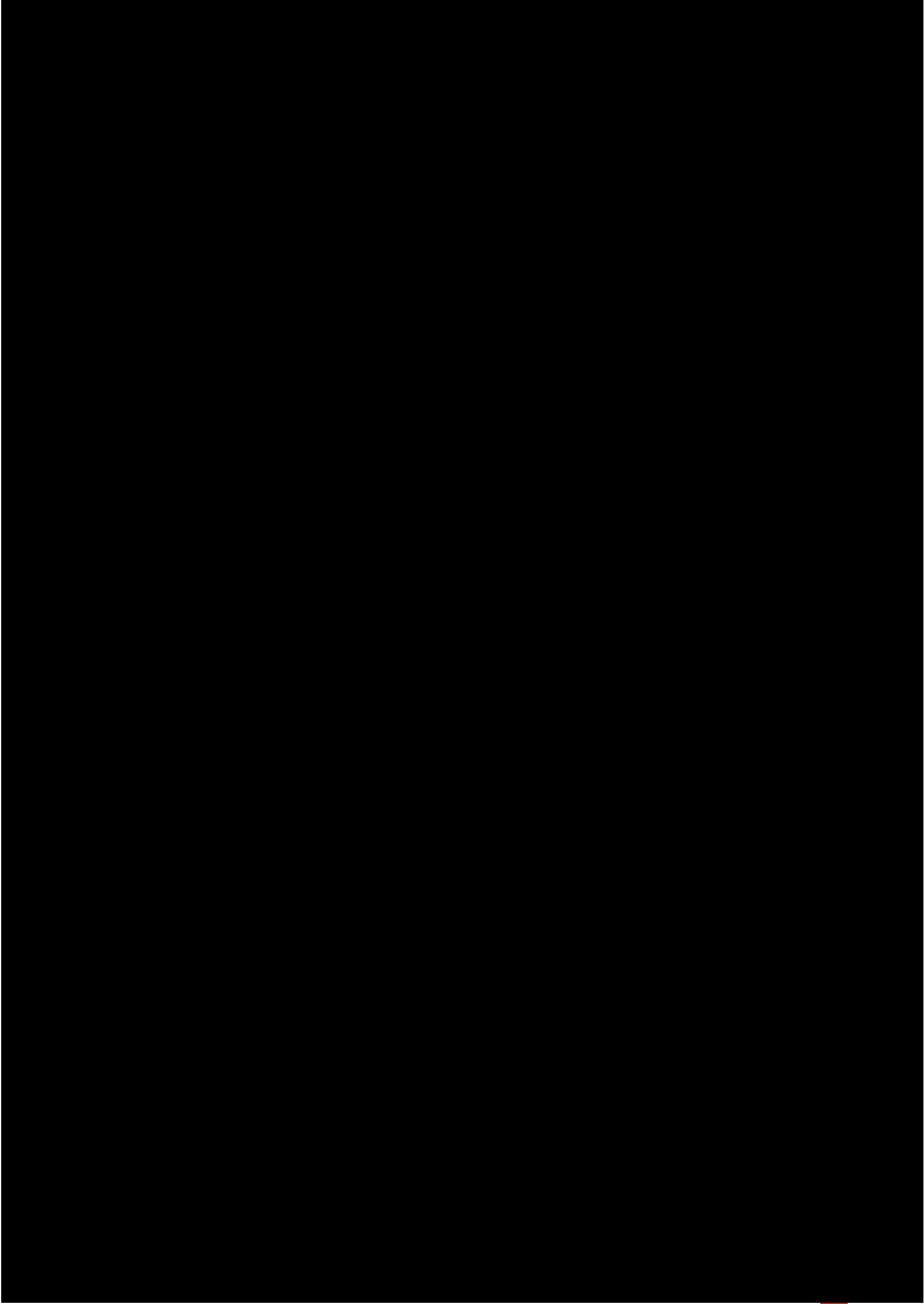
Therefore, we can say that a mixture contains more than one pure substance.

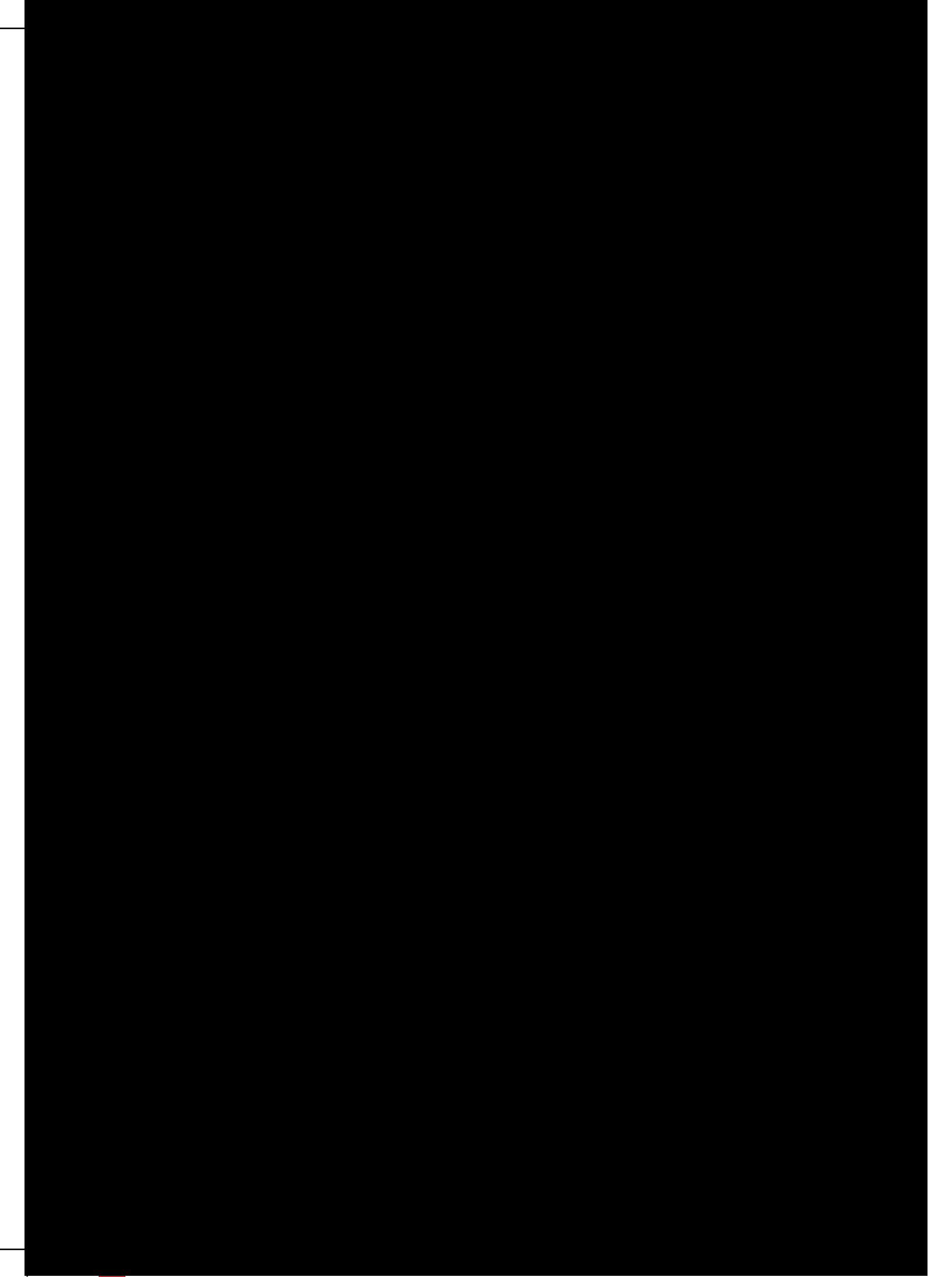
2.1.1 TYPES OF MIXTURES

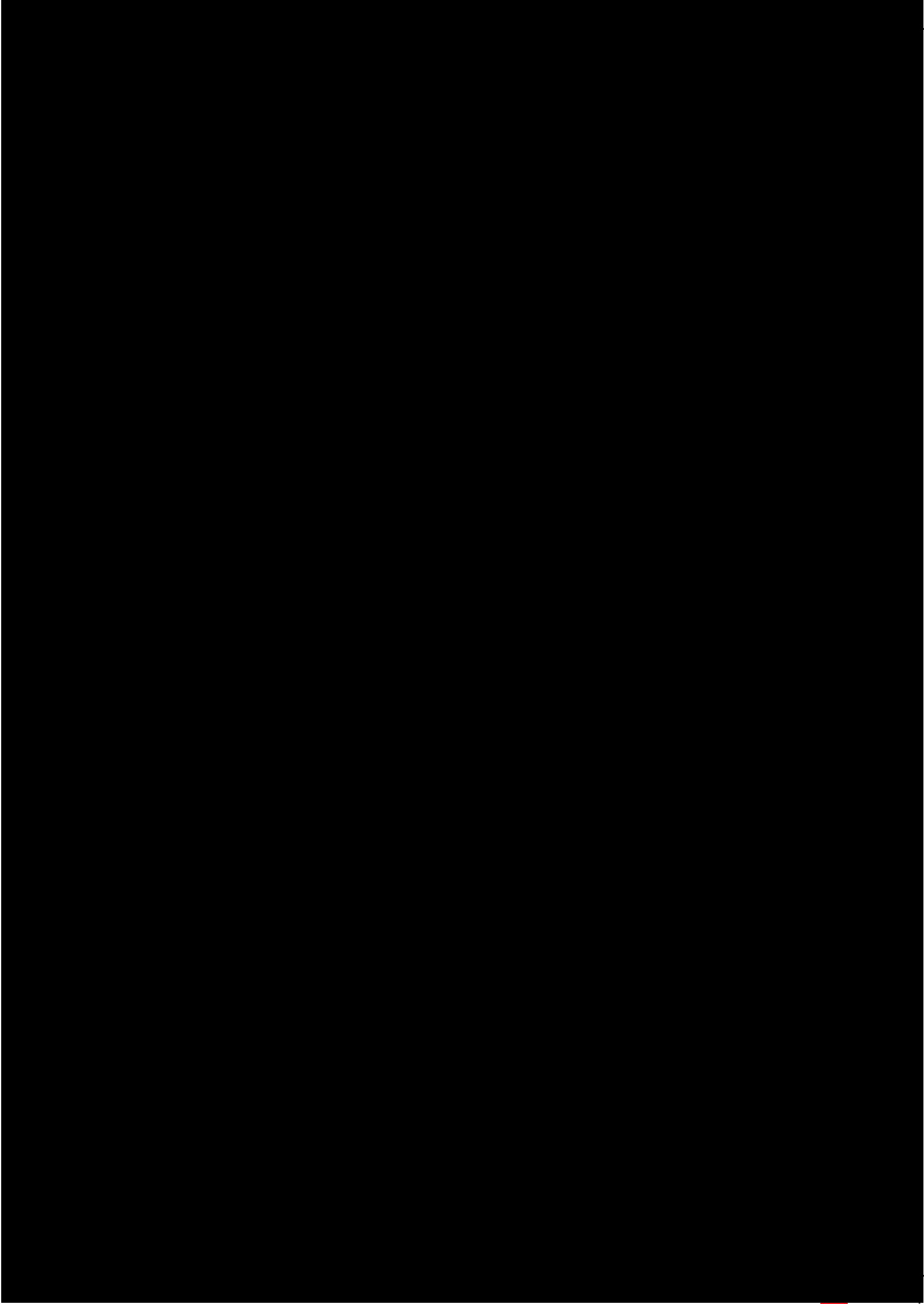
Depending upon the nature of the components that form a mixture, we can have different types of mixtures.

Activity 2.1

- Let us divide the class into groups A, B, C and D.
- Group A takes a beaker containing 50 mL of water and one spatula full of copper sulphate powder. Group B takes 50 mL of water and two spatula full of copper sulphate powder in a beaker.
- Groups C and D can take different amounts of copper sulphate and potassium permanganate or common salt (sodium chloride) and mix the given components to form a mixture.
- Report the observations on the uniformity in colour and texture.
- Groups A and B have obtained a mixture which has a uniform composition throughout. Such mixtures are called homogeneous mixtures or solutions. Some other examples of such mixtures are: (i) salt dissolved in water and (ii) sugar







2.3 Separating the Components of a Mixture

We have learnt that most of the natural substances are not chemically pure. Different methods of separation are used to get individual components from a mixture. Separation makes it possible to study and use the individual components of a mixture.

Heterogeneous mixtures can be separated into their respective constituents by simple physical methods like handpicking, sieving, filtration that we use in our day-to-day life. Sometimes special techniques have to be used for the separation of the components of a mixture.

2.3.1 HOW CAN WE OBTAIN COLOURED COMPONENT (DYE) FROM BLUE/BLACK INK?

Activity _____ 2.4

- Fill half a beaker with water.
- Put a watch glass on the mouth of the beaker (Fig. 2.5).
- Put few drops of ink on the watch glass.
- Now start heating the beaker. We do not want to heat the ink directly. You will see that evaporation is taking place from the watch glass.
- Continue heating as the evaporation goes on and stop heating when you do not see any further change on the watch glass.
- Observe carefully and record your observations.



Fig. 2.5: Evaporation

Now answer

- What do you think has got evaporated from the watch glass?
- Is there a residue on the watch glass?
- What is your interpretation? Is ink a single substance (pure) or is it a mixture?

We find that ink is a mixture of a dye in water. Thus, we can separate the volatile component (solvent) from its non-volatile solute by the method of evaporation.

2.3.2 HOW CAN WE SEPARATE CREAM FROM MILK?

Now-a-days, we get full-cream, toned and double-toned varieties of milk packed in poly-packs or tetra packs in the market. These varieties of milk contain different amounts of fat.

Activity _____ 2.5

- Take some full-cream milk in a test tube.
- Centrifuge it by using a centrifuging machine for two minutes. If a centrifuging machine is not available in the school, you can do this activity at home by using a milk churner, used in the kitchen.
- If you have a milk dairy nearby, visit it and ask (i) how they separate cream from milk and (ii) how they make cheese (*paneer*) from milk.

Now answer

- What do you observe on churning the milk?
- Explain how the separation of cream from milk takes place.

Sometimes the solid particles in a liquid are very small and pass through a filter paper. For such particles the filtration technique cannot be used for separation. Such mixtures

are separated by centrifugation. The principle is that the denser particles are forced to the bottom and the lighter particles stay at the top when spun rapidly.

Applications

- Used in diagnostic laboratories for blood and urine tests.
- Used in dairies and home to separate butter from cream.
- Used in washing machines to squeeze out water from wet clothes.

2.3.3 HOW CAN WE SEPARATE A MIXTURE OF TWO IMMISCIBLE LIQUIDS?

Activity 2.6

- Let us try to separate kerosene oil from water using a separating funnel.
- Pour the mixture of kerosene oil and water in a separating funnel (Fig. 2.6).
- Let it stand undisturbed for sometime so that separate layers of oil and water are formed.
- Open the stopcock of the separating funnel and pour out the lower layer of water carefully.
- Close the stopcock of the separating funnel as the oil reaches the stop-cock.

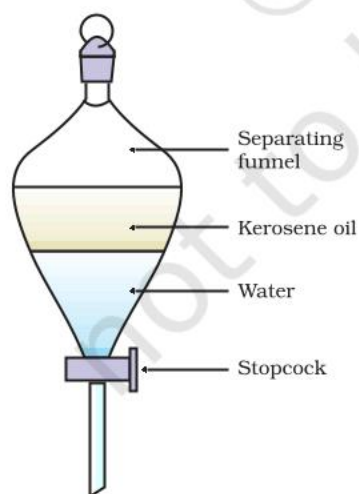


Fig. 2.6: Separation of immiscible liquids

Applications

- To separate mixture of oil and water.
- In the extraction of iron from its ore, the lighter slag is removed from the top by this method to leave the molten iron at the bottom in the furnace.

The principle is that immiscible liquids separate out in layers depending on their densities.

2.3.4 HOW CAN WE SEPARATE A MIXTURE OF SALT AND CAMPHOR?

We have learnt in chapter 1 that camphor changes directly from solid to gaseous state on heating. So, to separate such mixtures that contain a sublimable volatile component from a non-sublimable impurity, the sublimation process is used (Fig. 2.7). Some examples of solids which sublime are ammonium chloride, naphthalene and anthracene.

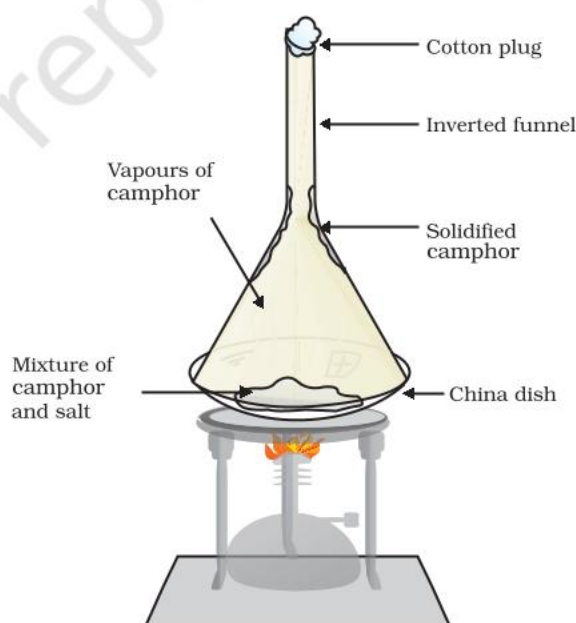


Fig. 2.7: Separation of camphor and salt by sublimation

2.3.5 IS THE DYE IN BLACK INK A SINGLE COLOUR?

Activity 2.7

- Take a thin strip of filter paper.
- Draw a line on it using a pencil, approximately 3 cm above the lower edge [Fig. 2.8 (a)].
- Put a small drop of ink (water soluble, that is, from a sketch pen or fountain pen) at the centre of the line. Let it dry.
- Lower the filter paper into a jar/glass/ beaker/test tube containing water so that the drop of ink on the paper is just above the water level, as shown in Fig. 2.8(b) and leave it undisturbed.
- Watch carefully, as the water rises up on the filter paper. Record your observations.

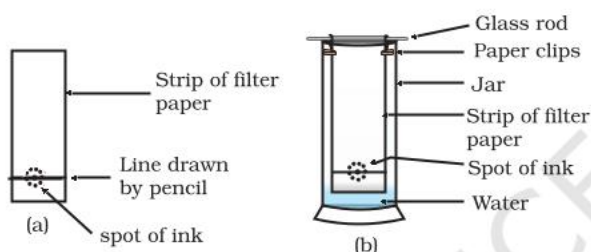


Fig. 2.8: Separation of dyes in black ink using chromatography

Now answer

- What do you observe on the filter paper as the water rises on it?
- Do you obtain different colours on the filter paper strip?
- What according to you, can be the reason for the rise of the coloured spot on the paper strip?

The ink that we use has water as the solvent and the dye is soluble in it. As the water rises on the filter paper it takes along with it the dye particles. Usually, a dye is a mixture of two or more colours. The coloured component that is more soluble in water, rises faster and in this way the colours get separated.

This process of separation of components of a mixture is known as chromatography. *Kroma* in Greek means colour. This technique was first used for separation of colours, so this name was given. Chromatography is the technique used for separation of those solutes that dissolve in the same solvent.

With the advancement in technology, newer techniques of chromatography have been developed. You will study about chromatography in higher classes.

Applications

To separate

- colours in a dye
- pigments from natural colours
- drugs from blood.

2.3.6 HOW CAN WE SEPARATE A MIXTURE OF TWO MISCIBLE LIQUIDS?

Activity 2.8

- Let us try to separate acetone and water from their mixture.
- Take the mixture in a distillation flask. Fit it with a thermometer.
- Arrange the apparatus as shown in Fig. 2.9.
- Heat the mixture slowly keeping a close watch at the thermometer.
- The acetone vaporises, condenses in the condenser and can be collected from the condenser outlet.
- Water is left behind in the distillation flask.

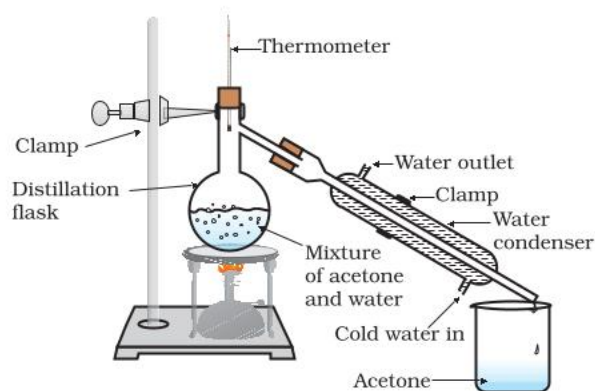


Fig.2.9: Separation of two miscible liquids by distillation

Now answer

- What do you observe as you start heating the mixture?
- At what temperature does the thermometer reading become constant for some time?
- What is the boiling point of acetone?
- Why do the two components separate?

This method is called distillation. It is used for the separation of components of a mixture containing two miscible liquids that boil without decomposition and have sufficient difference in their boiling points.

To separate a mixture of two or more miscible liquids for which the difference in boiling points is less than 25 K, fractional distillation process is used, for example, for the separation of different gases from air, different fractions from petroleum products etc. The apparatus is similar to that for simple distillation, except that a fractionating column is fitted in between the distillation flask and the condenser.

A simple fractionating column is a tube packed with glass beads. The beads provide surface for the vapours to cool and condense repeatedly, as shown in Fig. 2.10.

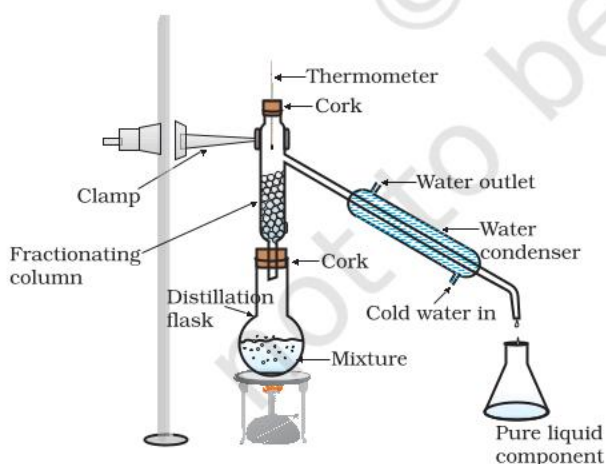


Fig. 2.10: Fractional distillation

2.3.7 HOW CAN WE OBTAIN DIFFERENT GASES FROM AIR?

Air is a homogeneous mixture and can be separated into its components by fractional distillation. The flow diagram (Fig. 2.11) shows the steps of the process.

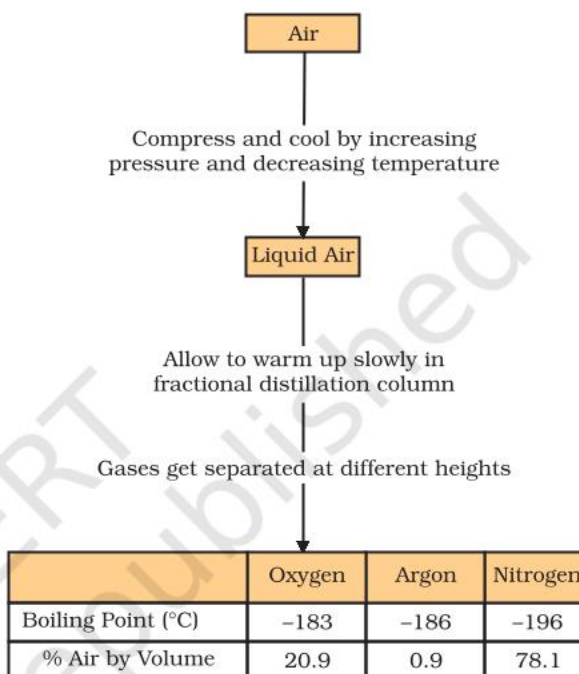


Fig. 2.11: Flow diagram shows the process of obtaining gases from air

If we want oxygen gas from air (Fig. 2.12), we have to separate out all the other gases present in the air. The air is compressed by increasing the pressure and is then cooled by decreasing the temperature to get liquid air. This liquid air is allowed to warm-up slowly in a fractional distillation column, where gases get separated at different heights depending upon their boiling points.

Answer the following:

- Arrange the gases present in air in increasing order of their boiling points.
- Which gas forms the liquid first as the air is cooled?

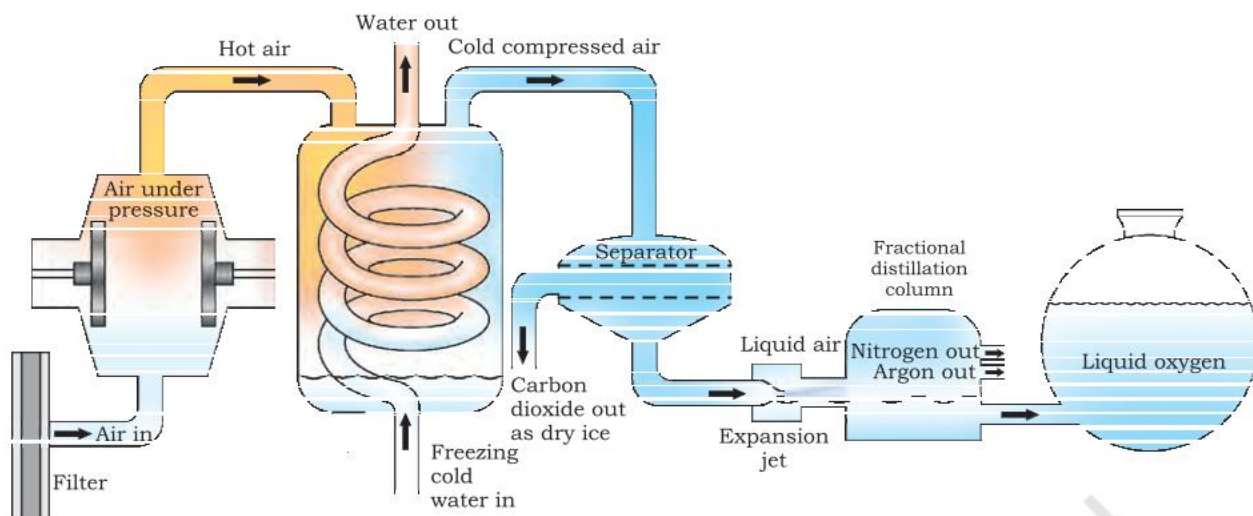


Fig. 2.12: Separation of components of air

2.3.8 HOW CAN WE OBTAIN PURE COPPER SULPHATE FROM AN IMPURE SAMPLE?

Activity _____ 2.9

- Take some (approximately 5 g) impure sample of copper sulphate in a china dish.
- Dissolve it in minimum amount of water.
- Filter the impurities out.
- Evaporate water from the copper sulphate solution so as to get a saturated solution.
- Cover the solution with a filter paper and leave it undisturbed at room temperature to cool slowly for a day.
- You will obtain the crystals of copper sulphate in the china dish.
- This process is called crystallisation.

Now answer

- What do you observe in the china dish?
- Do the crystals look alike?
- How will you separate the crystals from the liquid in the china dish?

The crystallisation method is used to purify solids. For example, the salt we get from sea water can have many impurities in

it. To remove these impurities, the process of crystallisation is used. Crystallisation is a process that separates a pure solid in the form of its crystals from a solution. Crystallisation technique is better than simple evaporation technique as –

- some solids decompose or some, like sugar, may get charred on heating to dryness.
- some impurities may remain dissolved in the solution even after filtration. On evaporation these contaminate the solid.

Applications

- Purification of salt that we get from sea water.
- Separation of crystals of alum (*phitkari*) from impure samples.

Thus, by choosing one of the above methods according to the nature of the components of a mixture, we get a pure substance. With advancements in technology many more methods of separation techniques have been devised.

In cities, drinking water is supplied from water works. A flow diagram of a typical water works is shown in Fig. 2.13. From this figure write down the processes involved to get the supply of drinking water to your home from the water works and discuss it in your class.

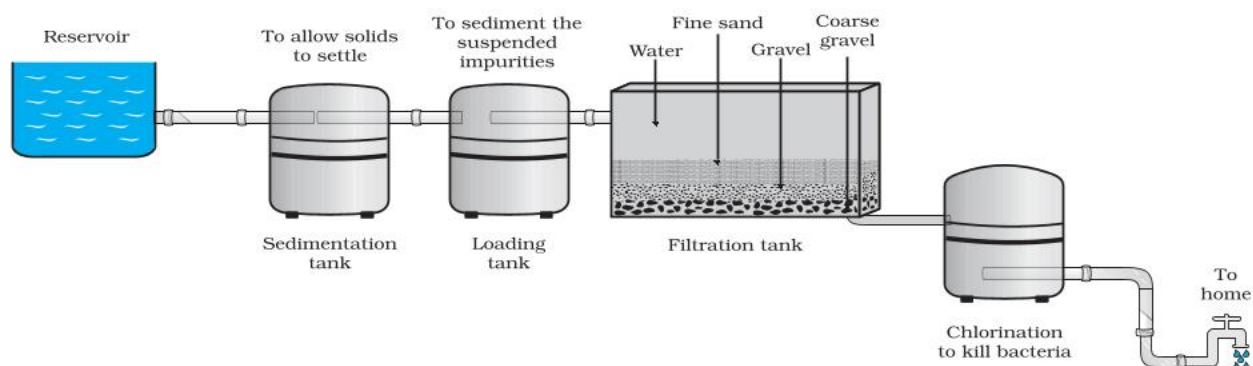


Fig. 2.13: Water purification system in water works

Questions

1. How will you separate a mixture containing kerosene and petrol (difference in their boiling points is more than 25°C), which are miscible with each other?
2. Name the technique to separate
 - (i) butter from curd,
 - (ii) salt from sea-water,
 - (iii) camphor from salt.
3. What type of mixtures are separated by the technique of crystallisation?

2.4 Physical and Chemical Changes

In the previous chapter, we have learnt about a few physical properties of matter. The properties that can be observed and specified like colour, hardness, rigidity, fluidity, density, melting point, boiling point etc. are the physical properties.

The interconversion of states is a physical change because these changes occur without a change in composition and no change in the chemical nature of the substance. Although ice, water and water vapour all look different and display different physical properties, they are chemically the same.

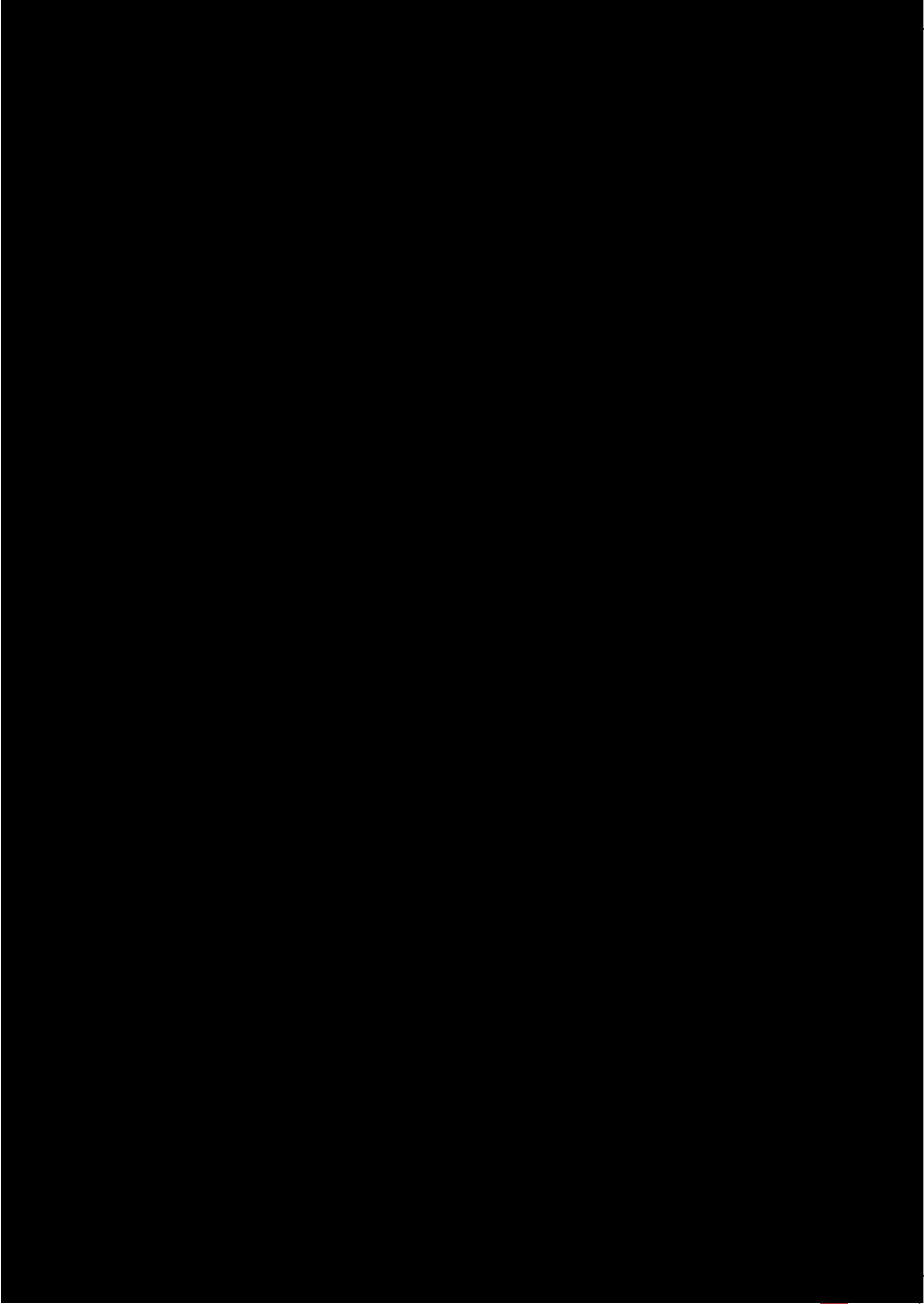
Both water and cooking oil are liquid but their chemical characteristics are different.

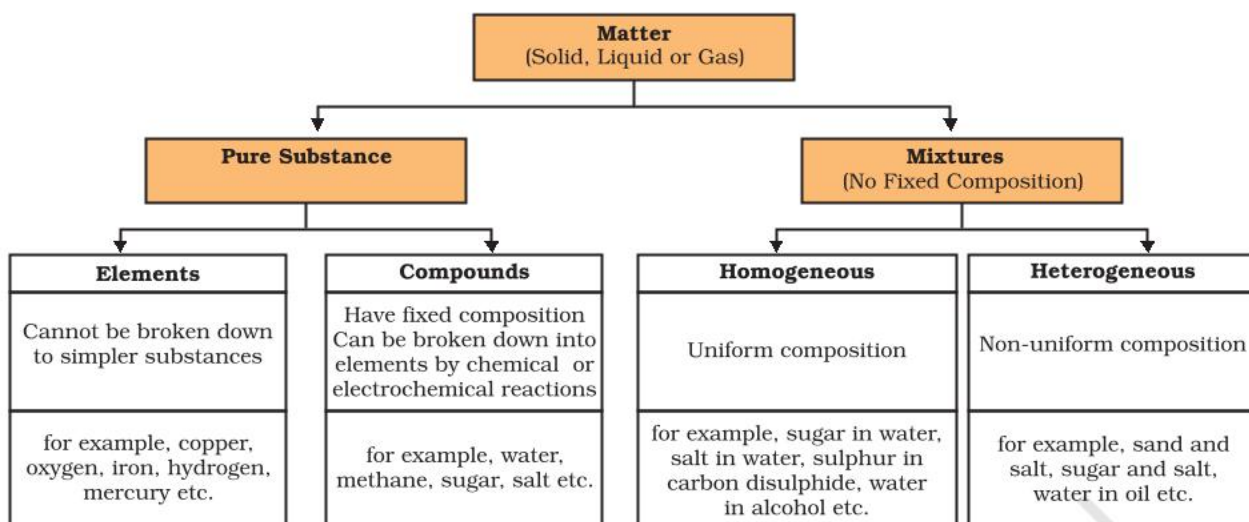
They differ in odour and inflammability. We know that oil burns in air whereas water extinguishes fire. It is this chemical property of oil that makes it different from water. Burning is a chemical change. During this process one substance reacts with another to undergo a change in chemical composition. Chemical change brings change in the chemical properties of matter and we get new substances. A chemical change is also called a chemical reaction.

During burning of a candle, both physical and chemical changes take place. Can you distinguish these?

Questions

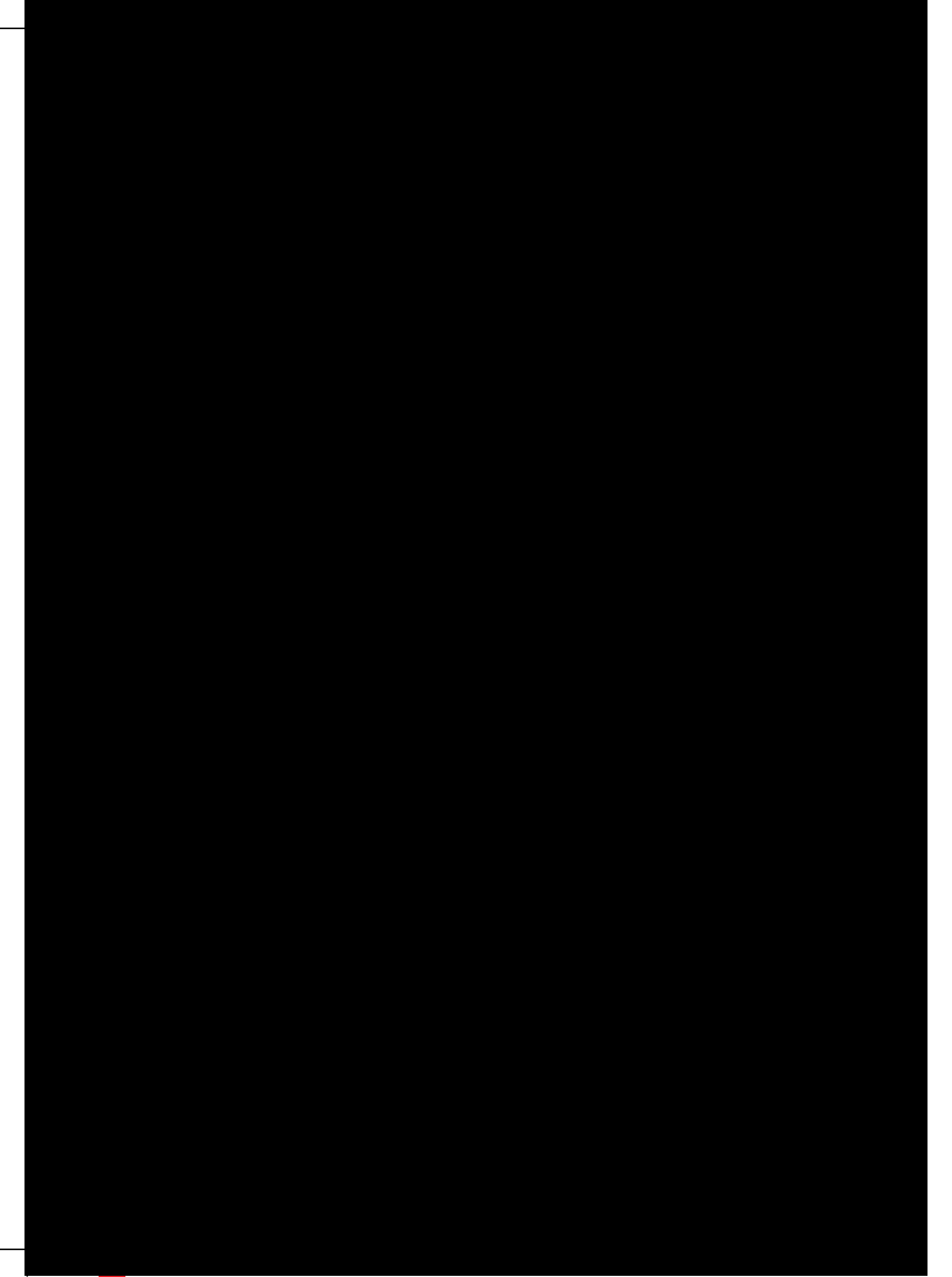
1. Classify the following as chemical or physical changes:
 - cutting of trees,
 - melting of butter in a pan,
 - rusting of almirah,
 - boiling of water to form steam,
 - passing of electric current, through water and the water breaking down into hydrogen and oxygen gases,
 - dissolving common salt in water,
 - making a fruit salad with raw fruits, and
 - burning of paper and wood.
2. Try segregating the things around you as pure substances or mixtures.

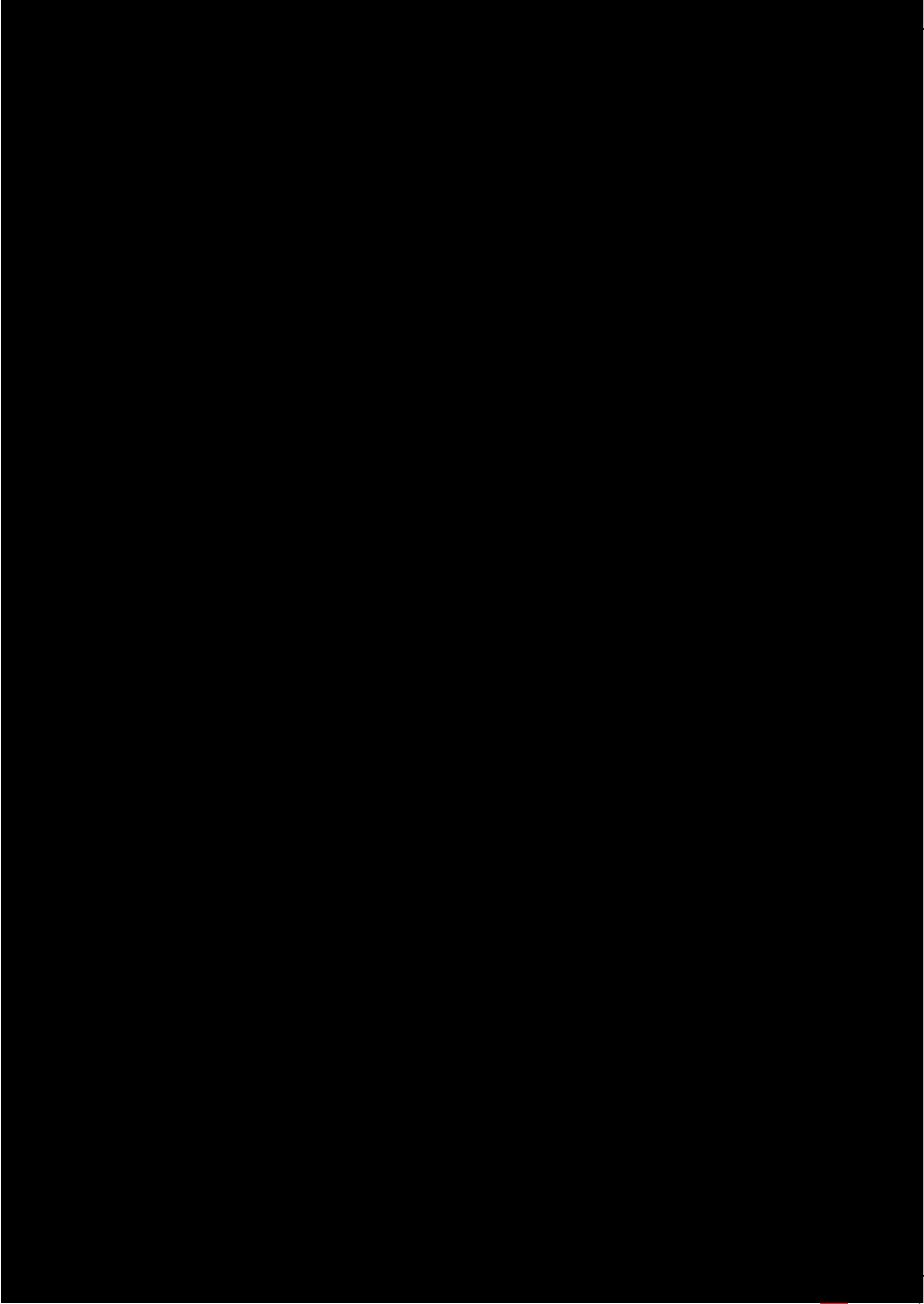


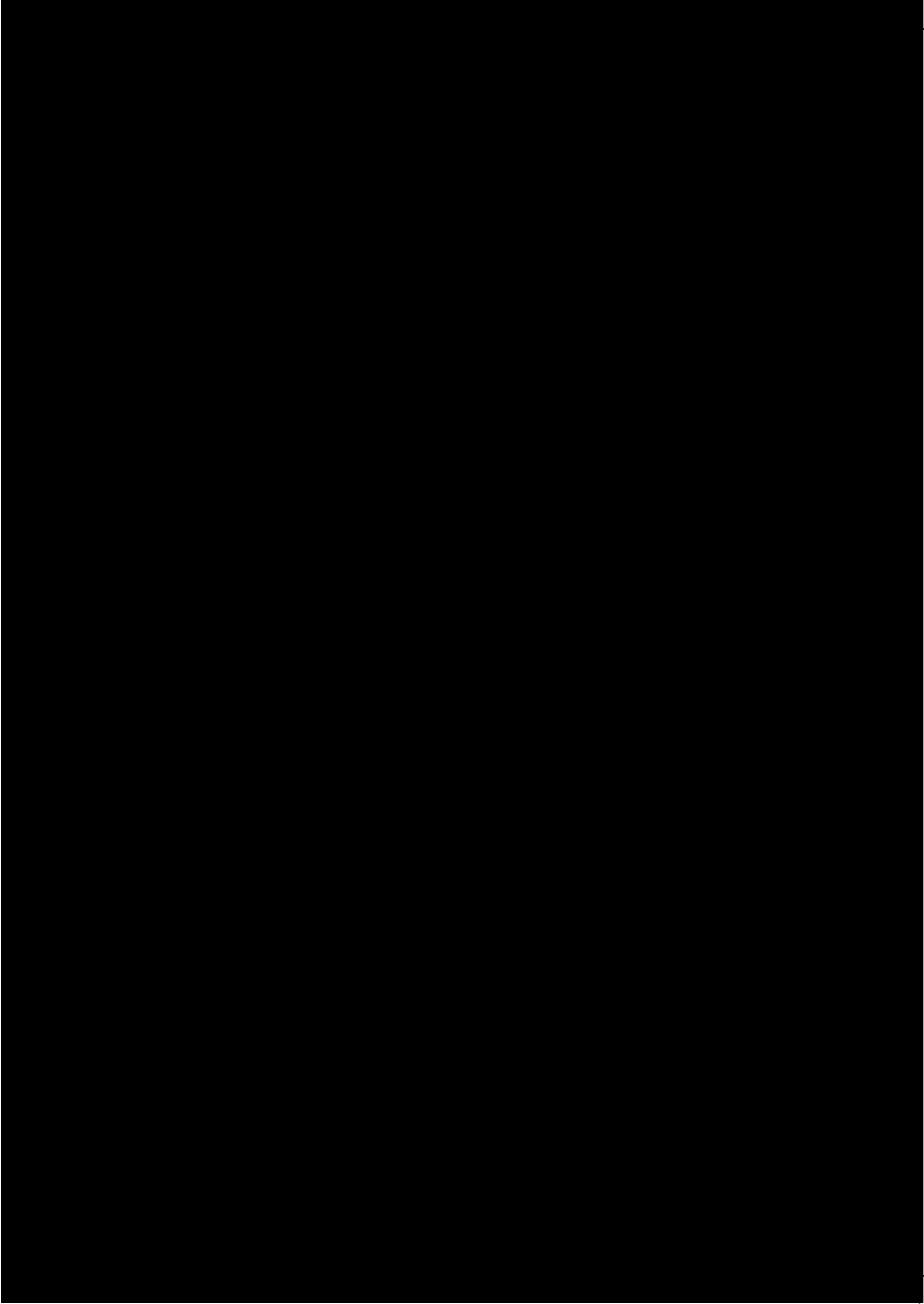


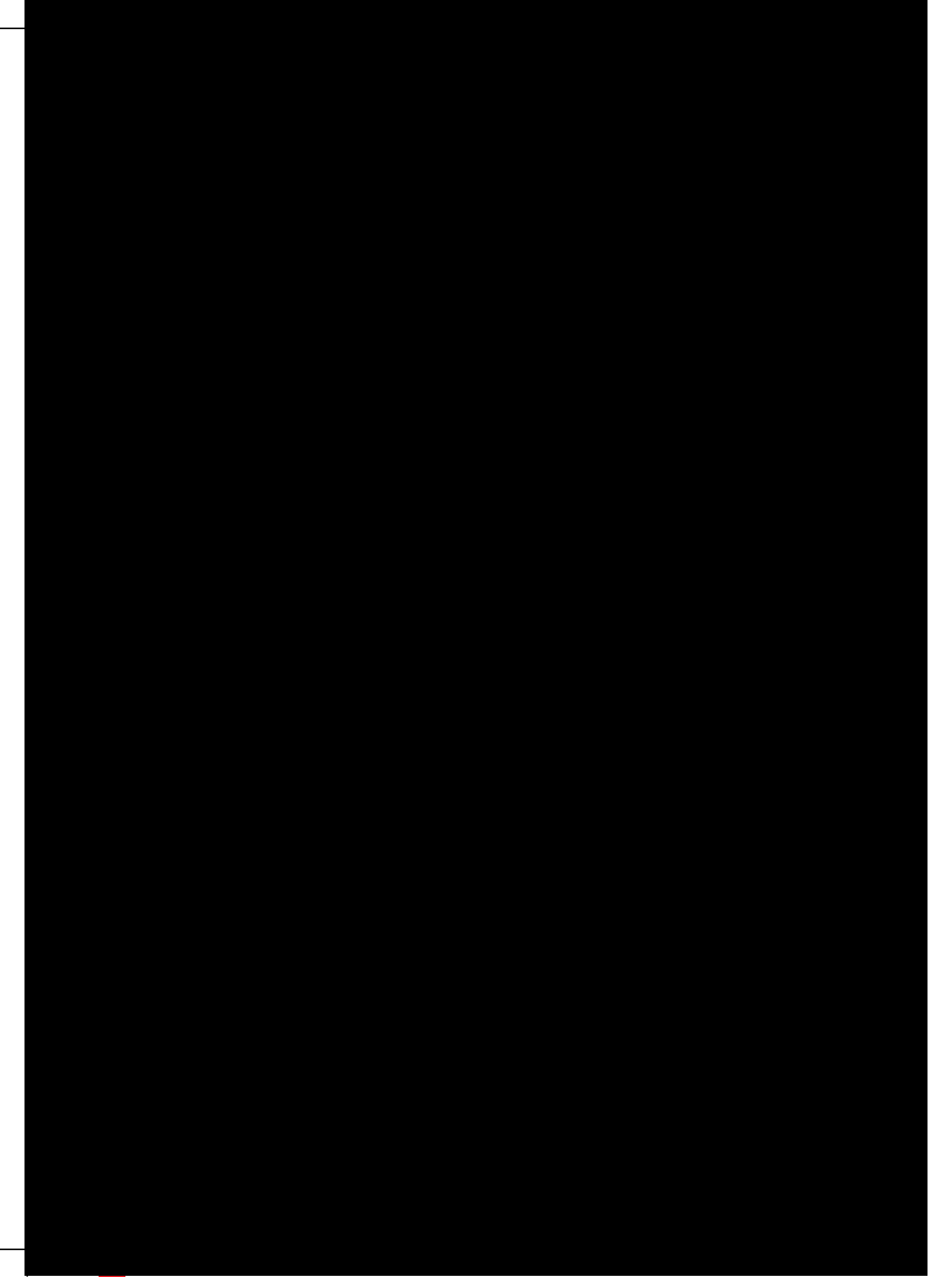
What you have learnt

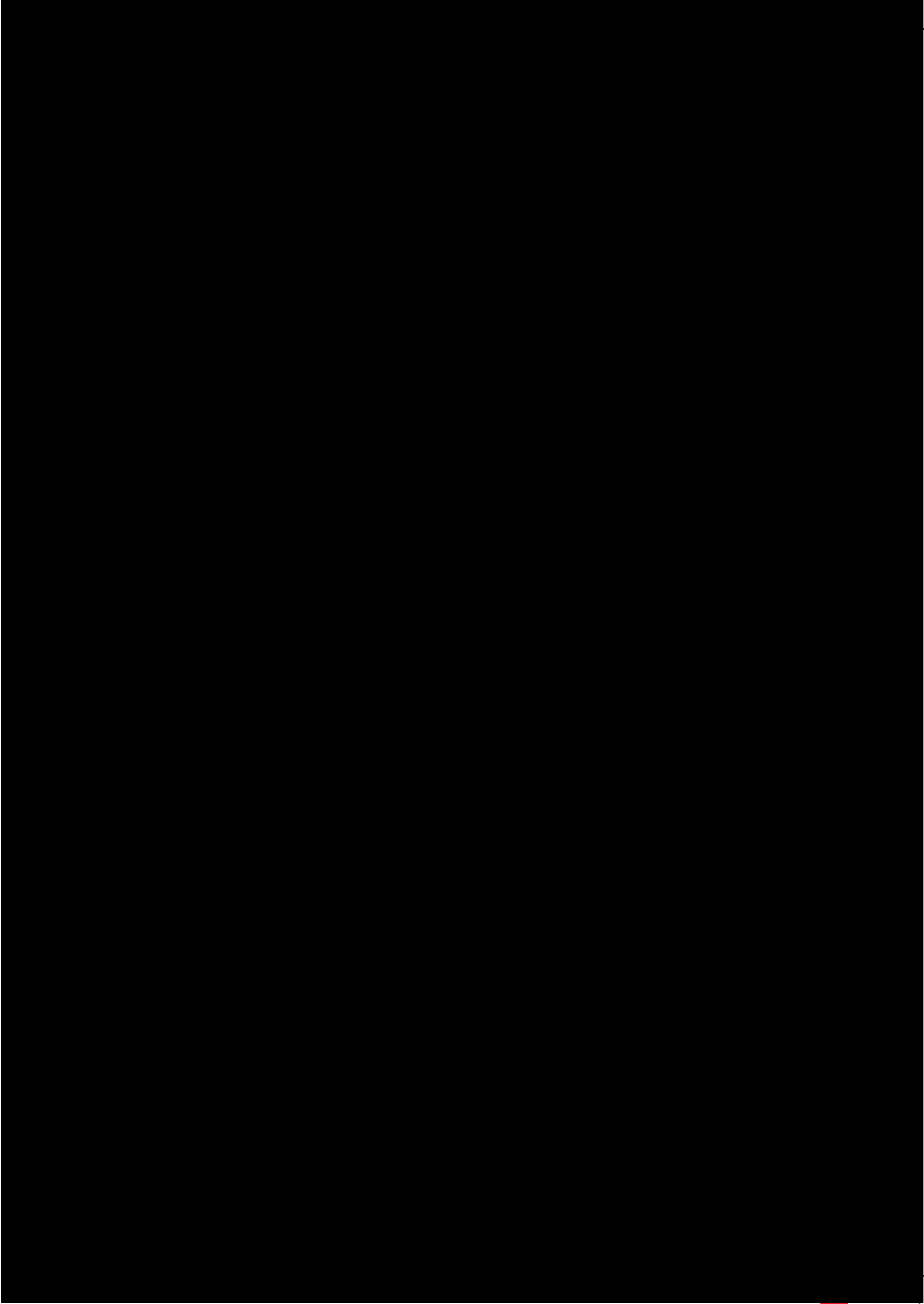
- A mixture contains more than one substance (element and/or compound) mixed in any proportion.
- Mixtures can be separated into pure substances using appropriate separation techniques.
- A solution is a homogeneous mixture of two or more substances. The major component of a solution is called the solvent, and the minor, the solute.
- The concentration of a solution is the amount of solute present per unit volume or per unit mass of the solution.
- Materials that are insoluble in a solvent and have particles that are visible to naked eyes, form a suspension. A suspension is a heterogeneous mixture.
- Colloids are heterogeneous mixtures in which the particle size is too small to be seen with the naked eye, but is big enough to scatter light. Colloids are useful in industry and daily life. The particles are called the dispersed phase and the medium in which they are distributed is called the dispersion medium.
- Pure substances can be elements or compounds. An element is a form of matter that cannot be broken down by chemical reactions into simpler substances. A compound is a substance composed of two or more different types of elements, chemically combined in a fixed proportion.
- Properties of a compound are different from its constituent elements, whereas a mixture shows the properties of its constituting elements or compounds.

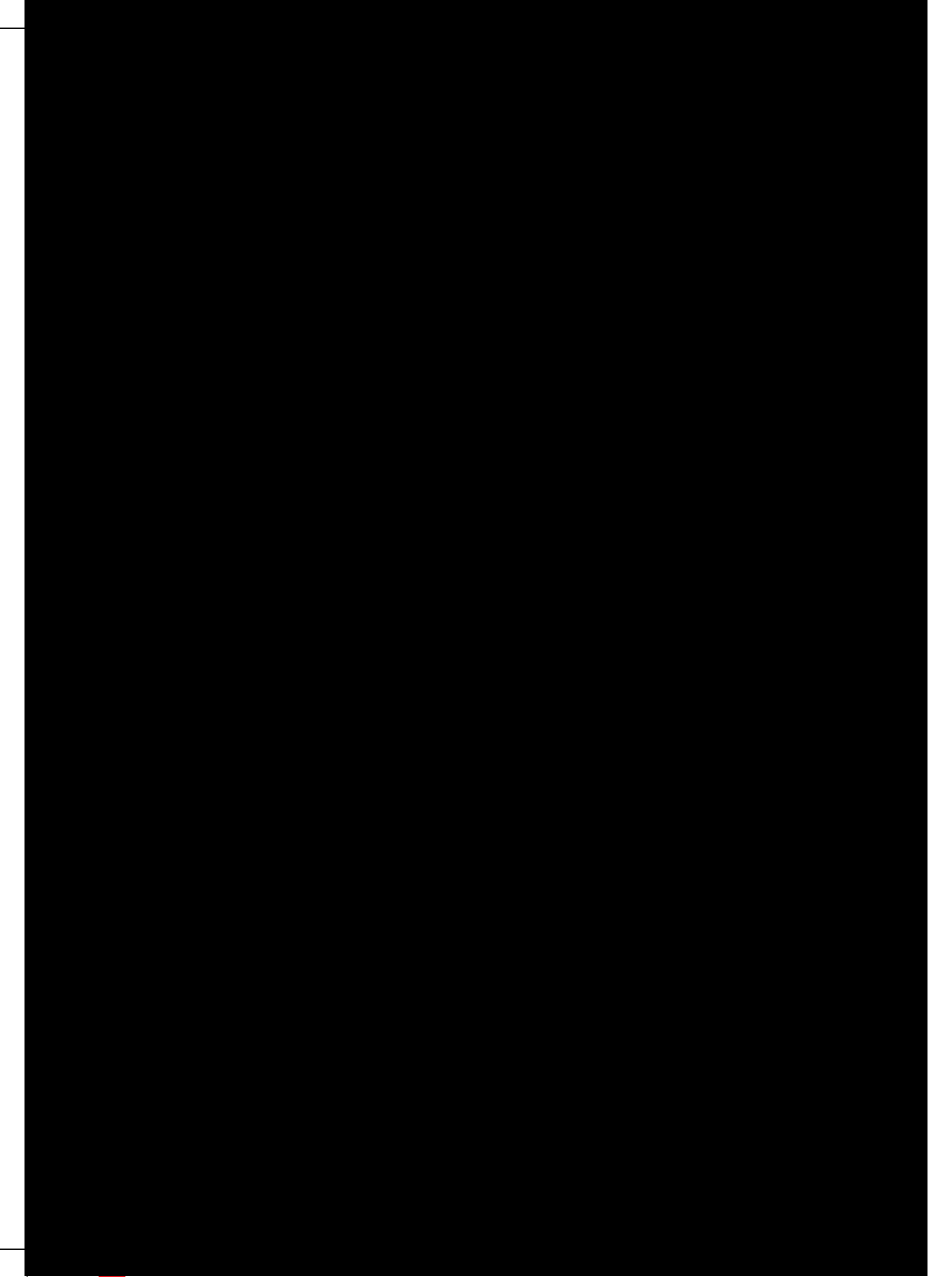












whole numbers or as near to a whole numbers as possible. While searching for various atomic mass units, scientists initially took $1/16$ of the mass of an atom of naturally occurring oxygen as the unit. This was considered relevant due to two reasons:

- oxygen reacted with a large number of elements and formed compounds.
- this atomic mass unit gave masses of most of the elements as whole numbers.

However, in 1961 for a universally accepted atomic mass unit, carbon-12 isotope was chosen as the standard reference for measuring atomic masses. One atomic mass unit is a mass unit equal to exactly one-twelfth ($1/12^{\text{th}}$) the mass of one atom of carbon-12. The relative atomic masses of all elements have been found with respect to an atom of carbon-12.

Imagine a fruit seller selling fruits without any standard weight with him. He takes a watermelon and says, “this has a mass equal to 12 units” (12 watermelon units or 12 fruit mass units). He makes twelve equal pieces of the watermelon and finds the mass of each fruit he is selling, relative to the mass of one piece of the watermelon. Now he sells his fruits by relative fruit mass unit (fmu), as in Fig. 3.4.

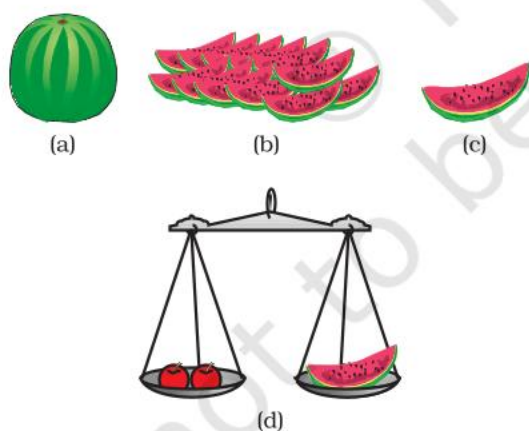


Fig. 3.4 : (a) Watermelon, (b) 12 pieces, (c) $1/12$ of watermelon, (d) how the fruit seller can weigh the fruits using pieces of watermelon

Similarly, the relative atomic mass of the atom of an element is defined as the average

mass of the atom, as compared to $1/12^{\text{th}}$ the mass of one carbon-12 atom.

Table 3.2: Atomic masses of a few elements

Element	Atomic Mass (u)
Hydrogen	1
Carbon	12
Nitrogen	14
Oxygen	16
Sodium	23
Magnesium	24
Sulphur	32
Chlorine	35.5
Calcium	40

3.2.3 HOW DO ATOMS EXIST?

Atoms of most elements are not able to exist independently. Atoms form molecules and ions. These molecules or ions aggregate in large numbers to form the matter that we can see, feel or touch.

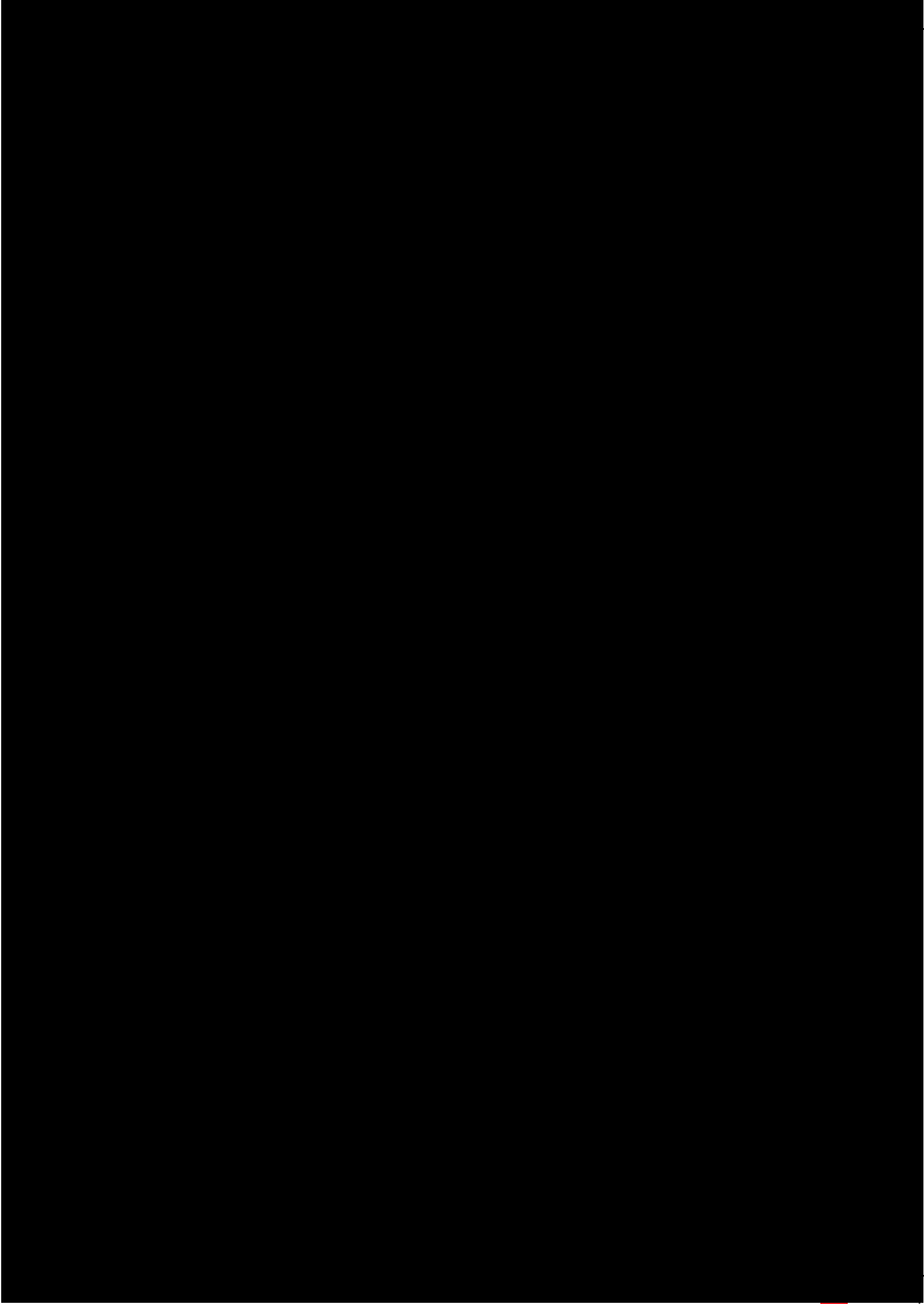


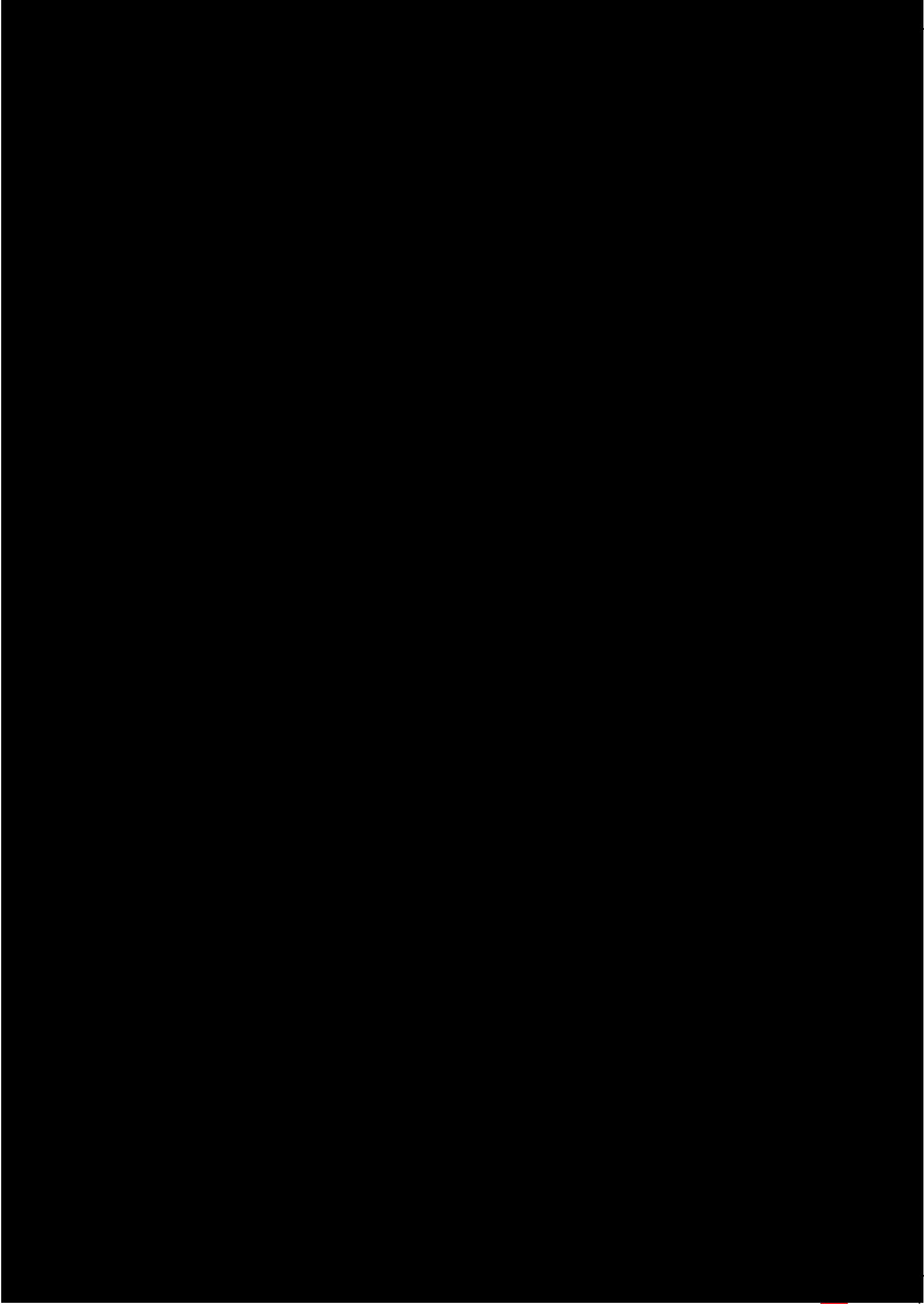
Questions

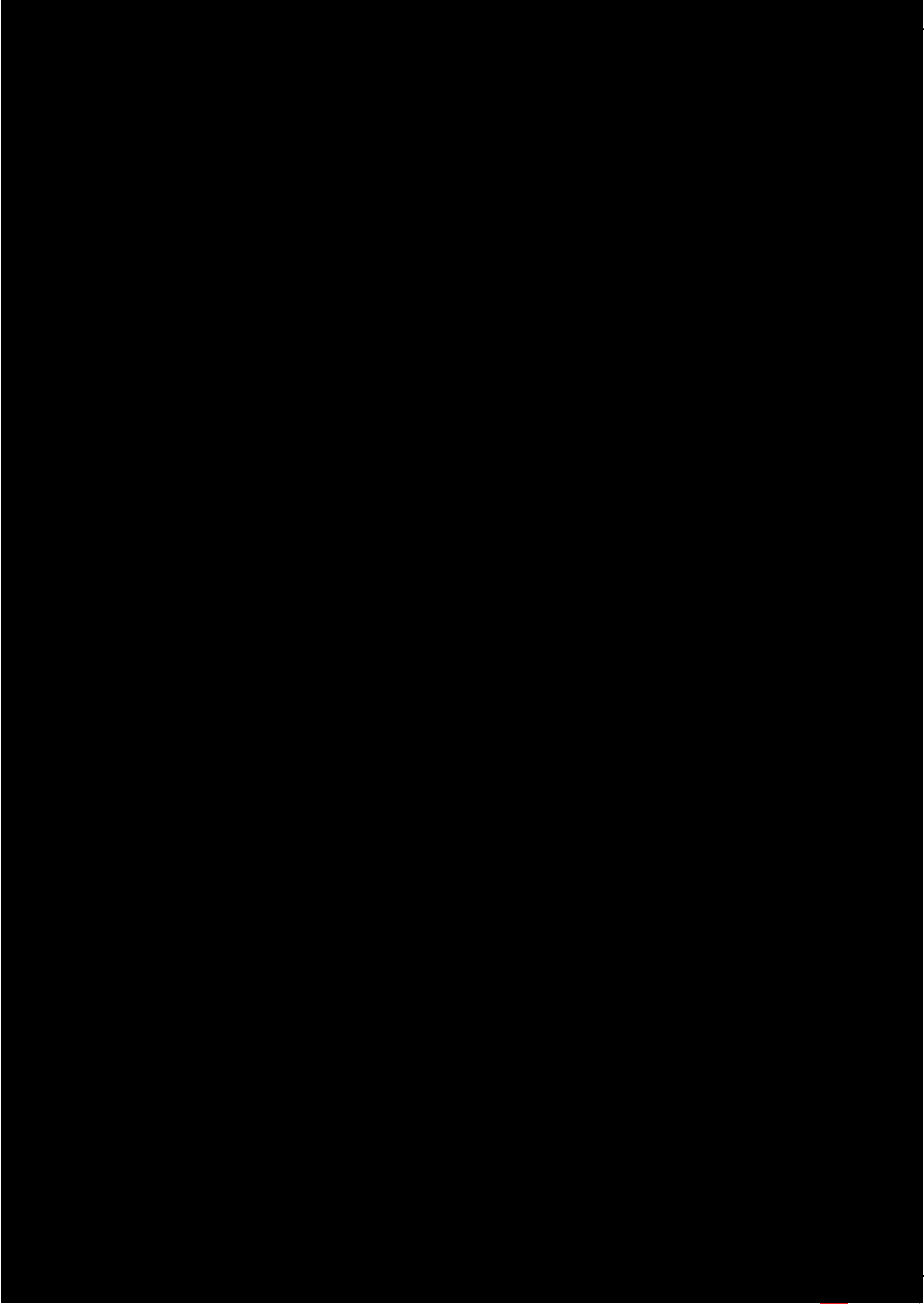
1. Define the atomic mass unit.
2. Why is it not possible to see an atom with naked eyes?

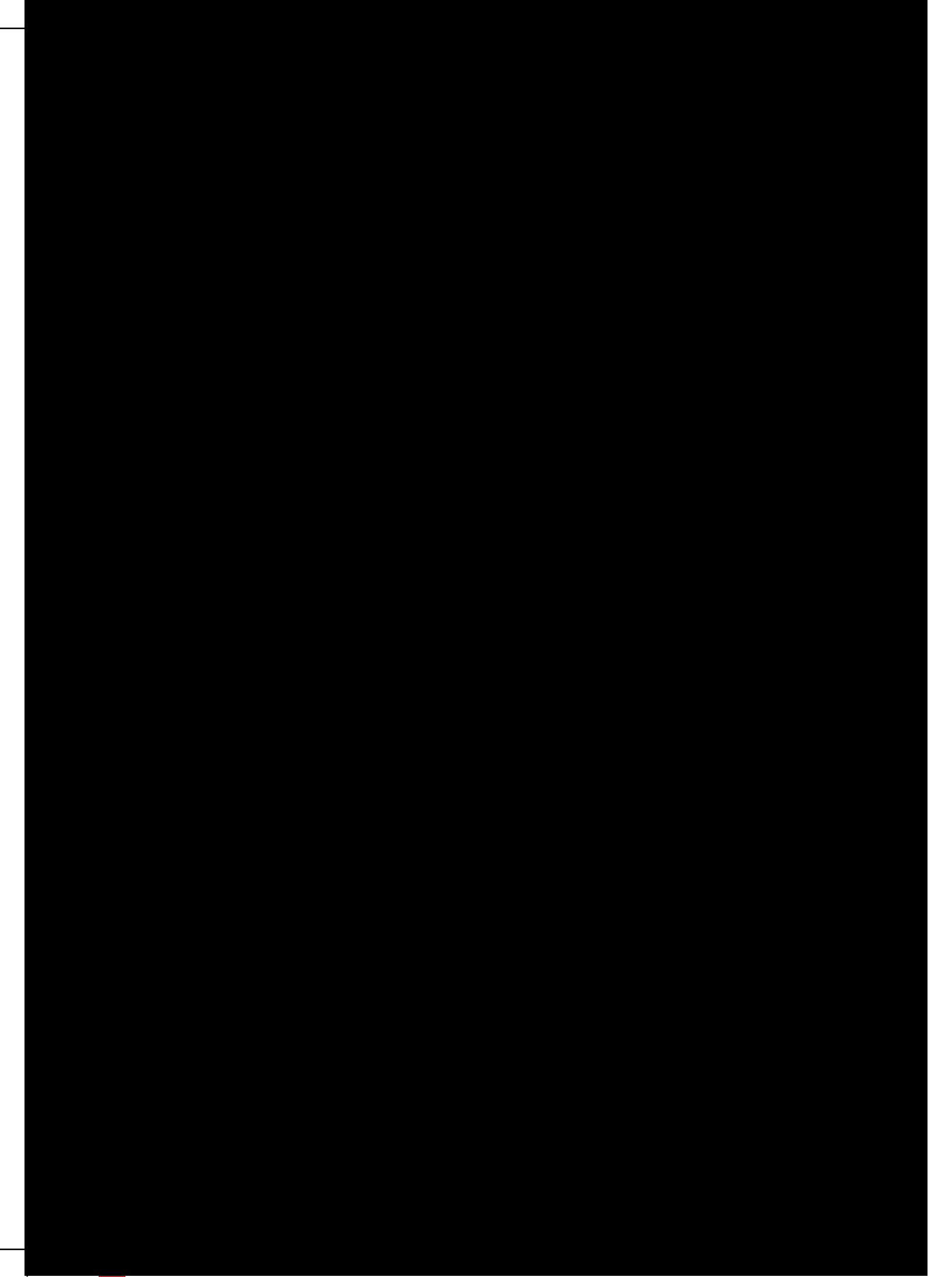
3.3 What is a Molecule?

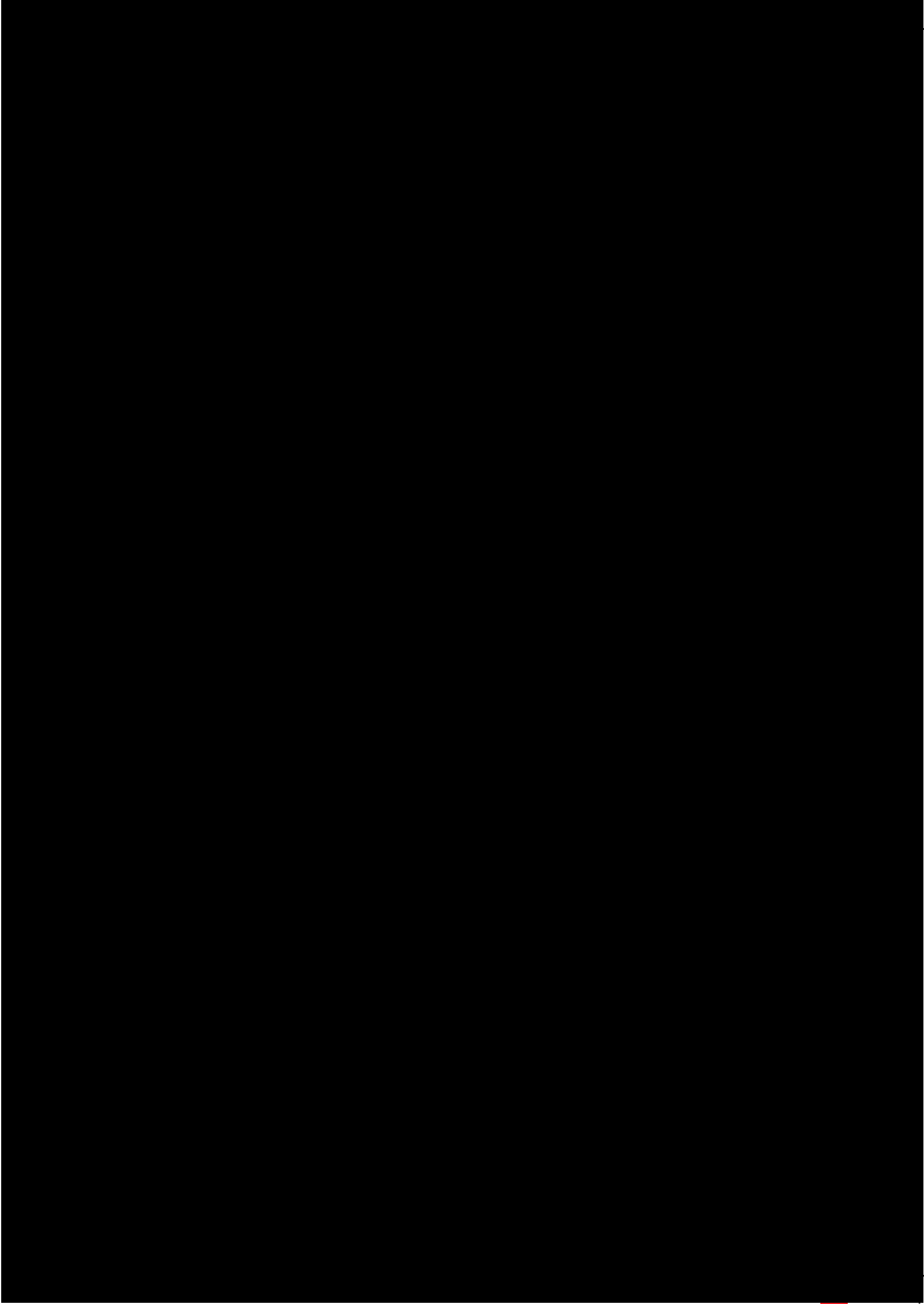
A molecule is in general a group of two or more atoms that are chemically bonded together, that is, tightly held together by attractive forces. A molecule can be defined as the smallest particle of an element or a compound that is capable of an independent existence and shows all the properties of that substance. Atoms of the same element or of different elements can join together to form molecules.

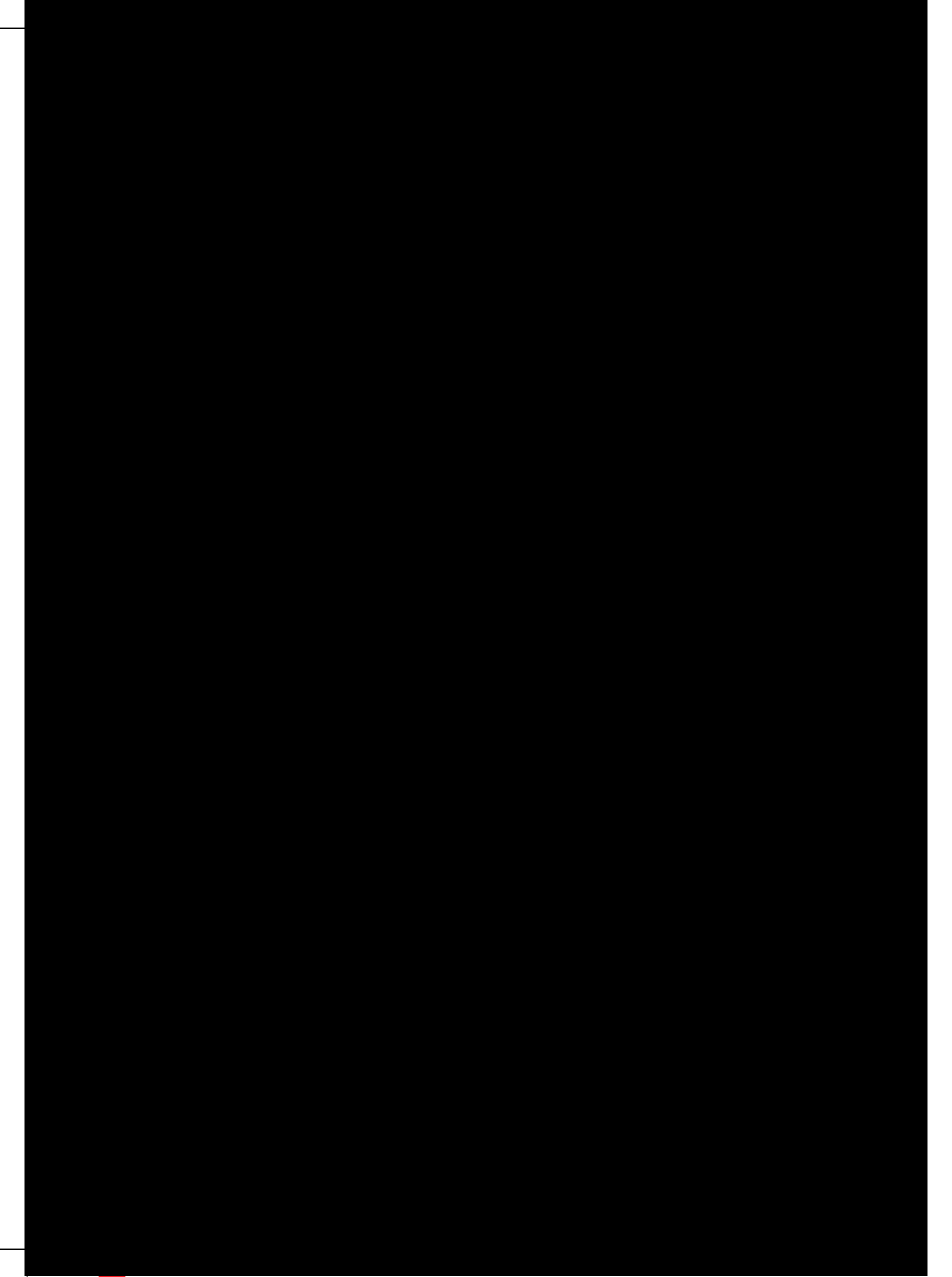


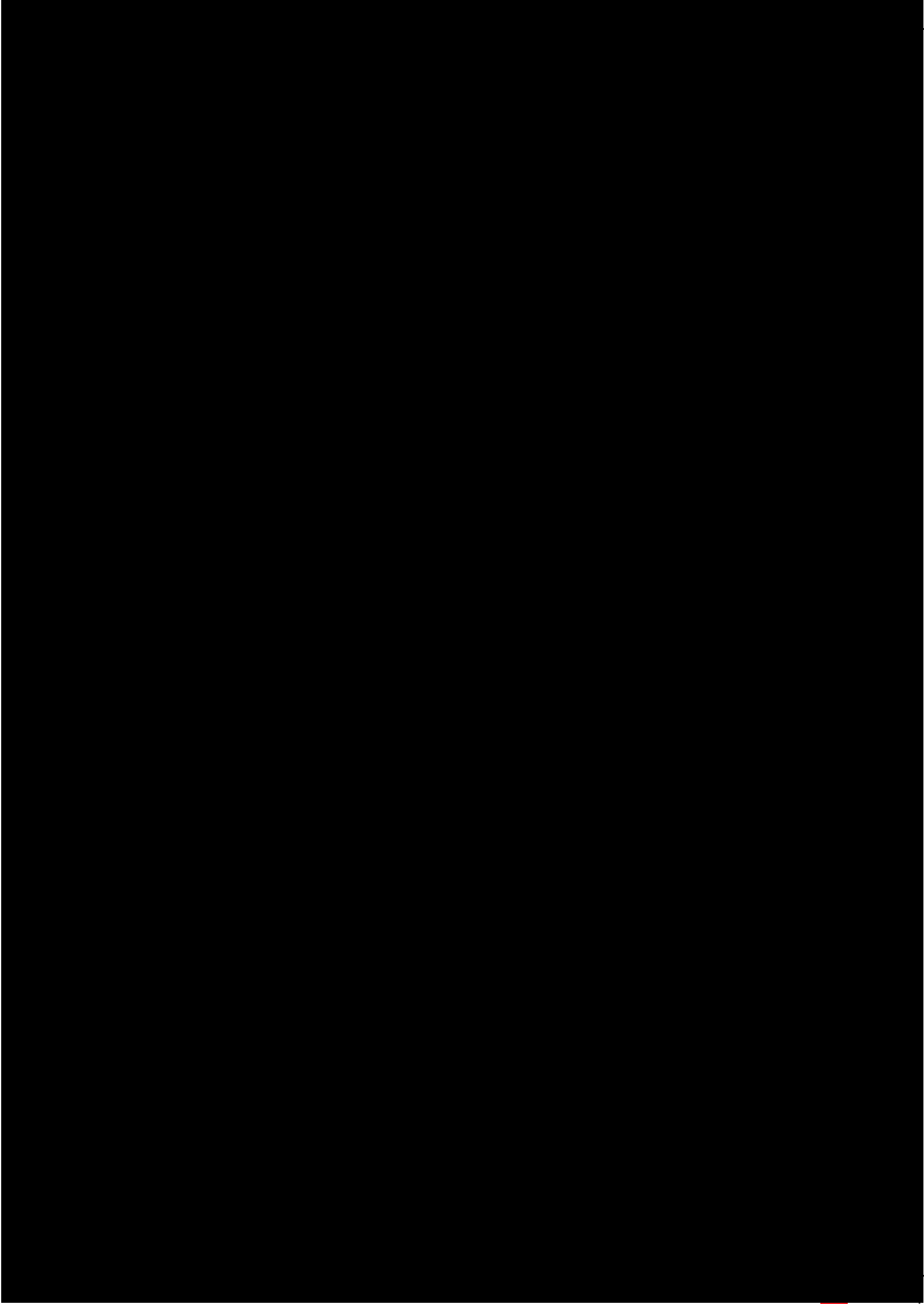


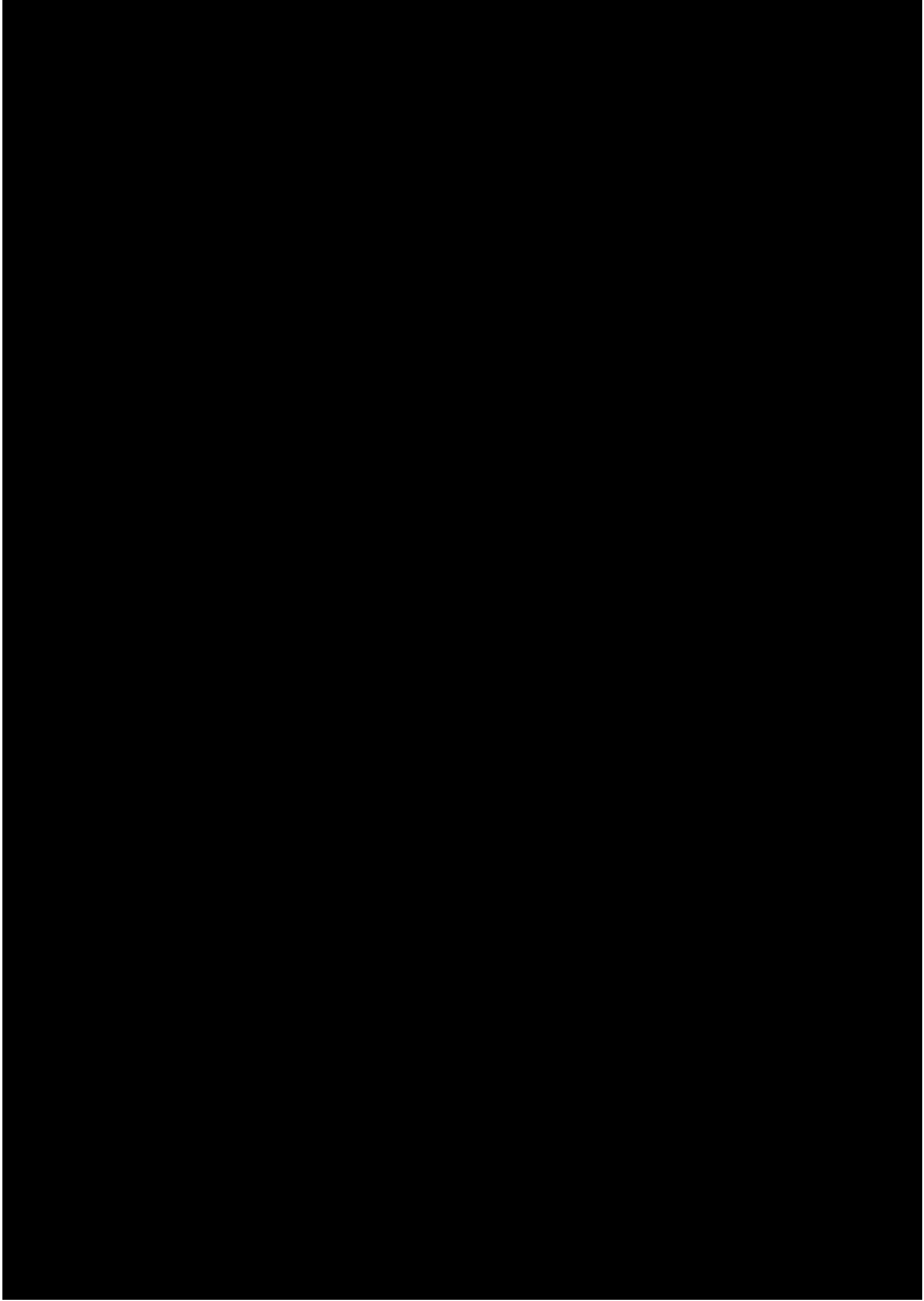


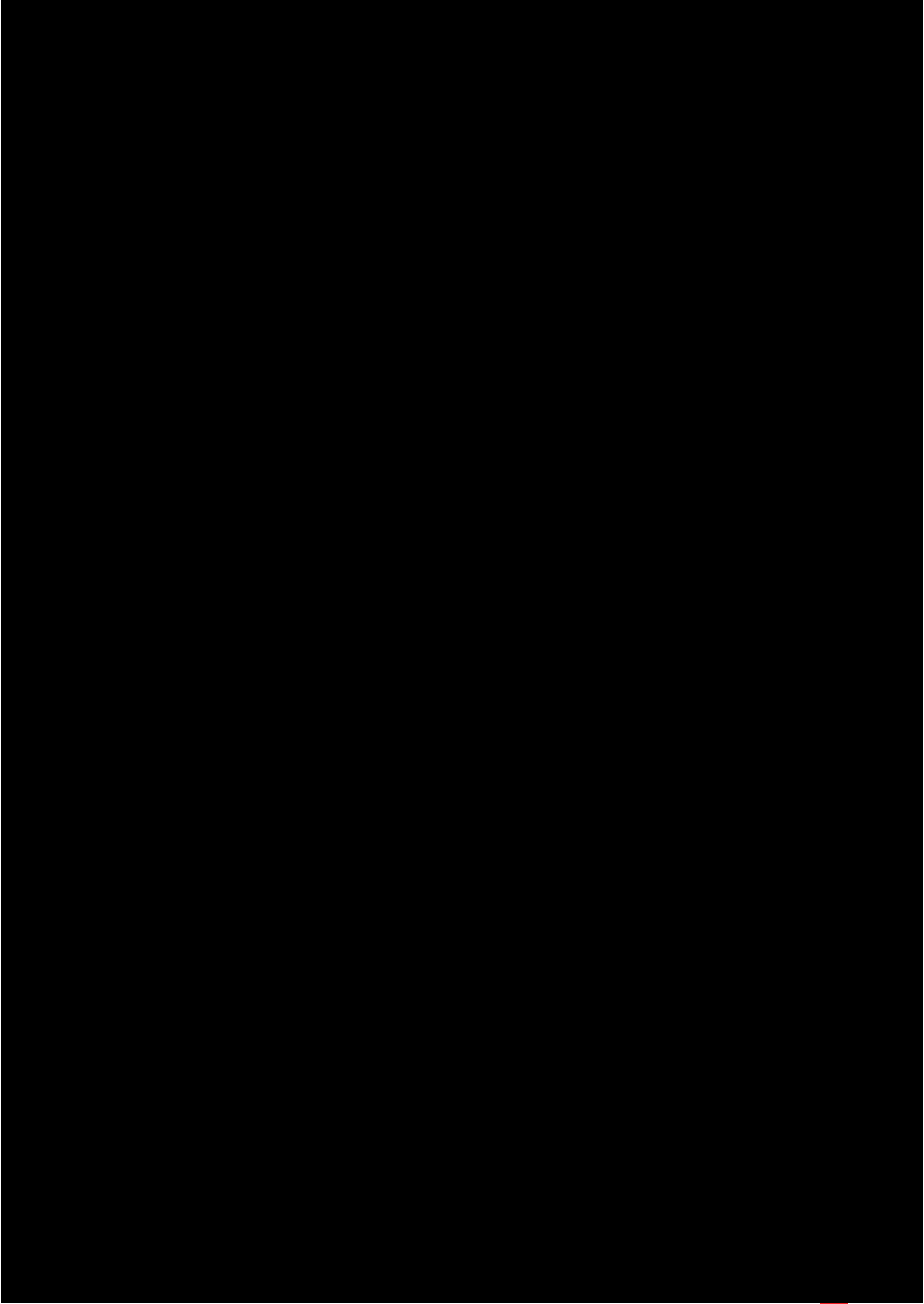


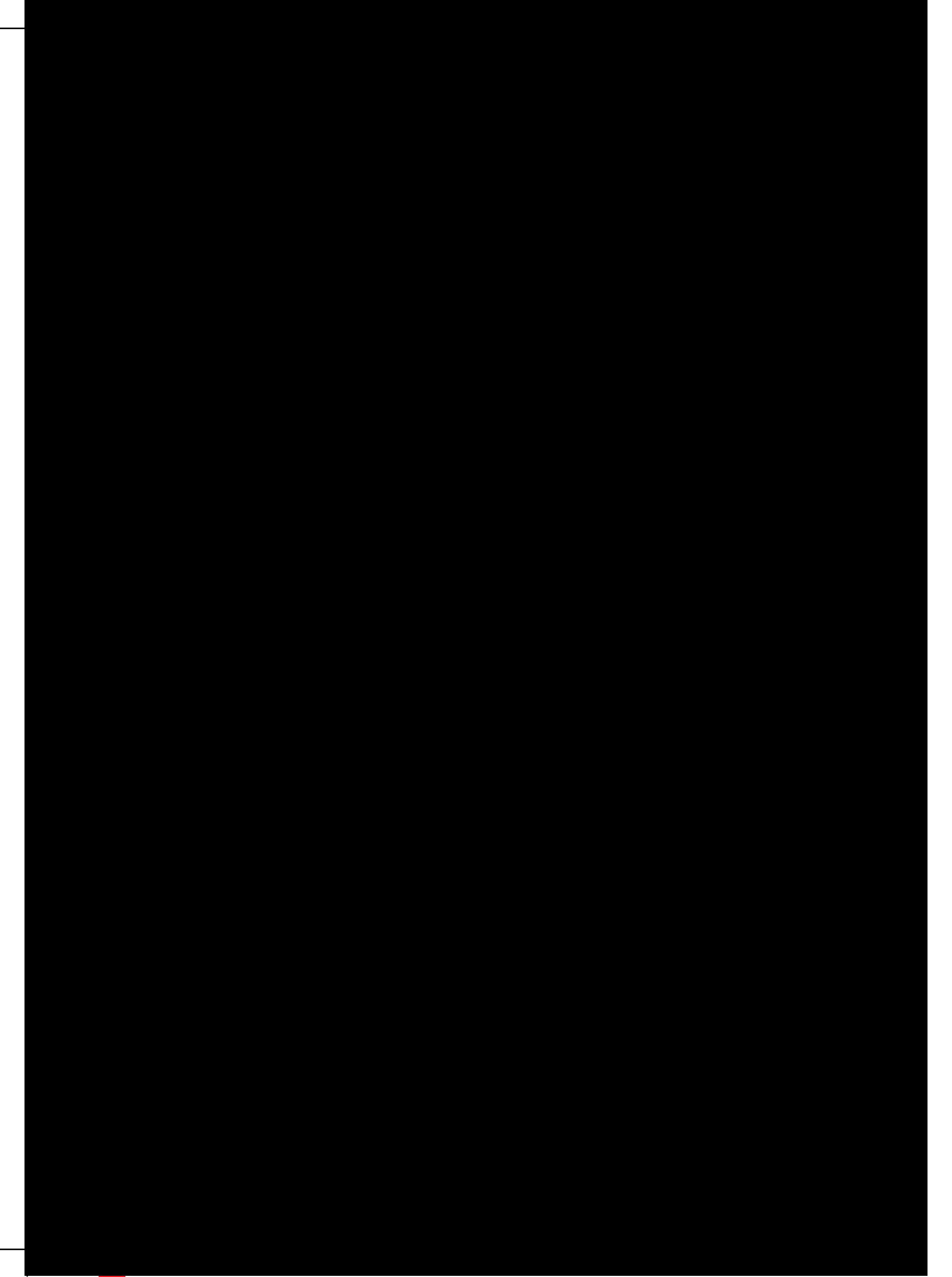


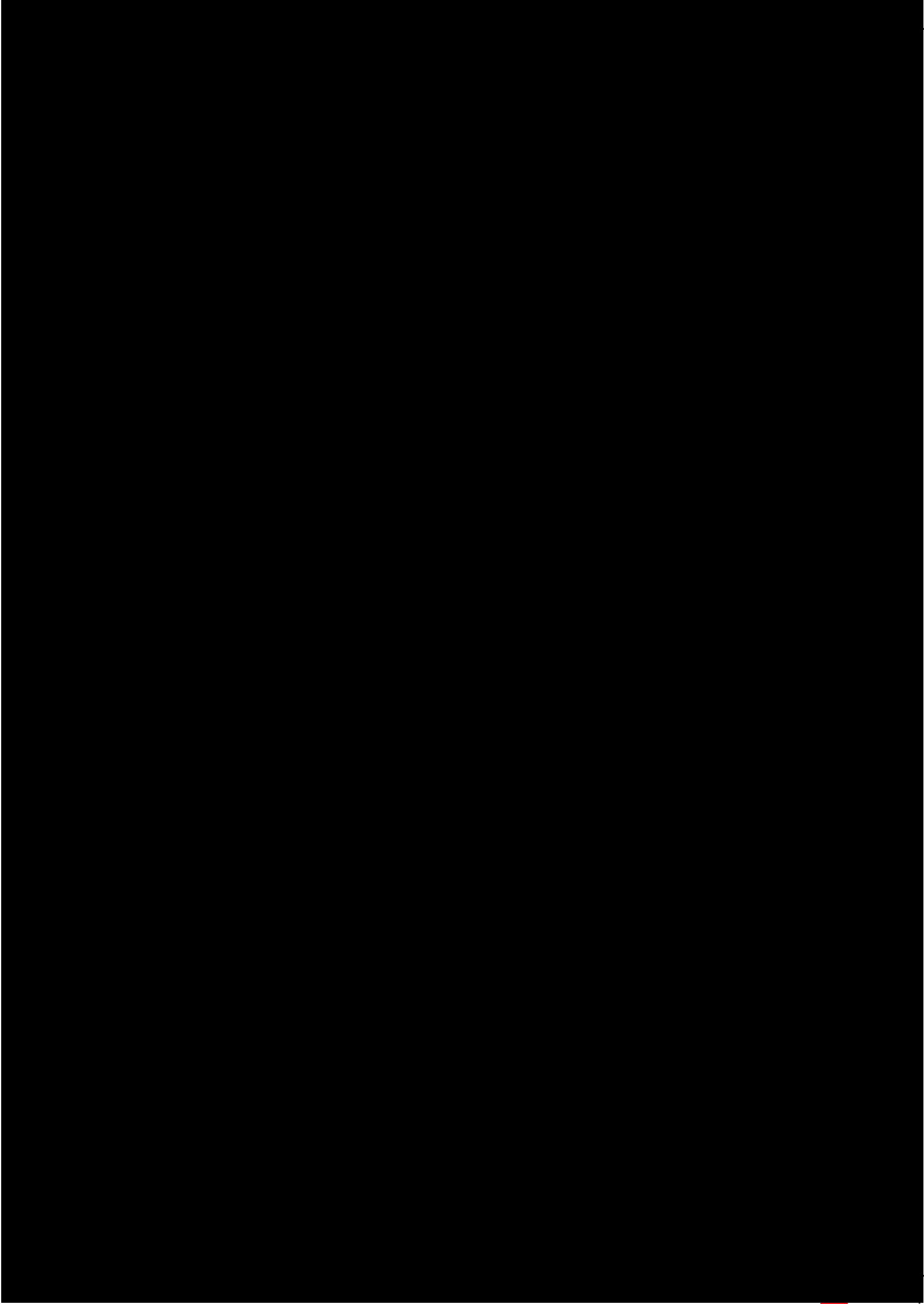


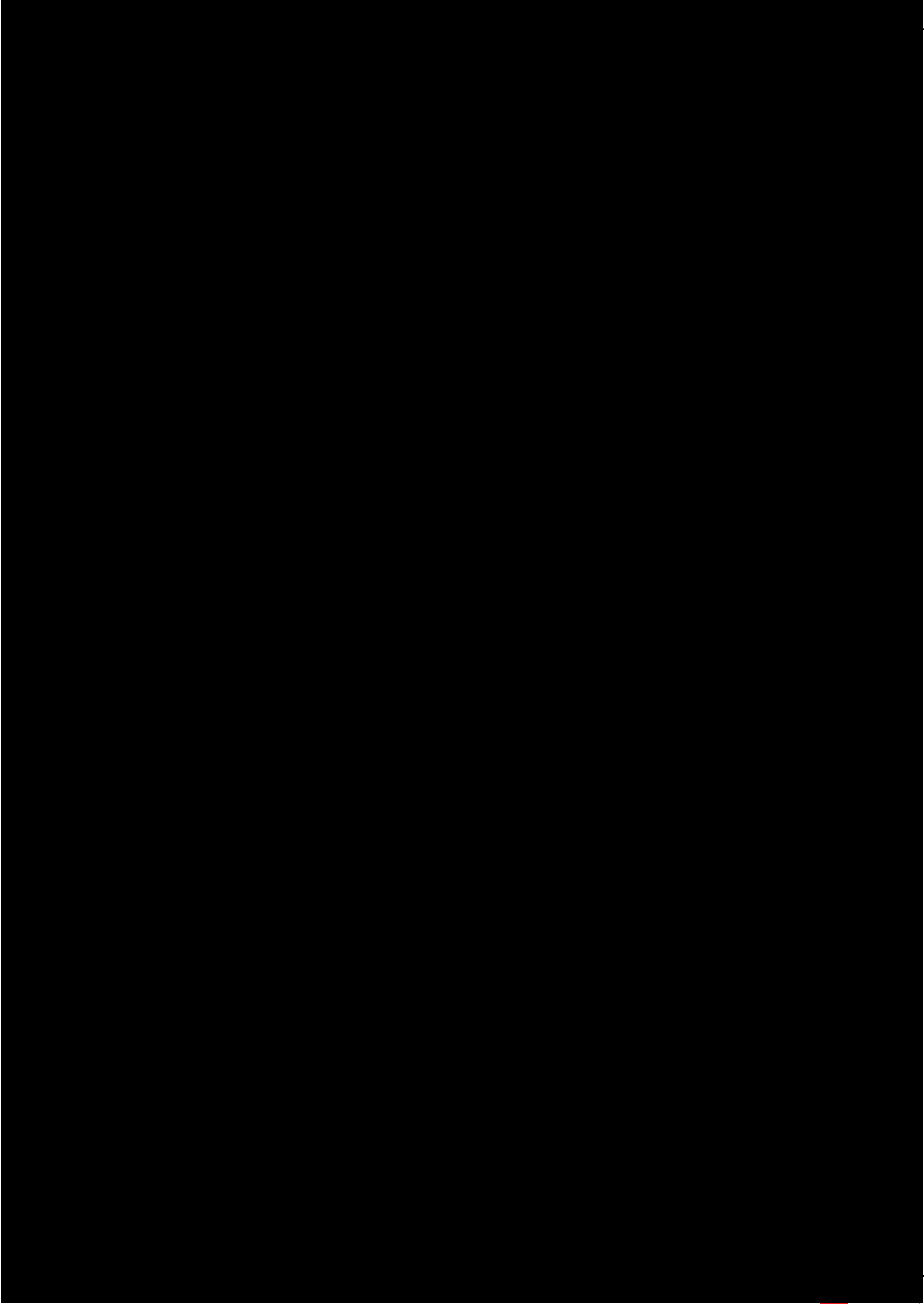


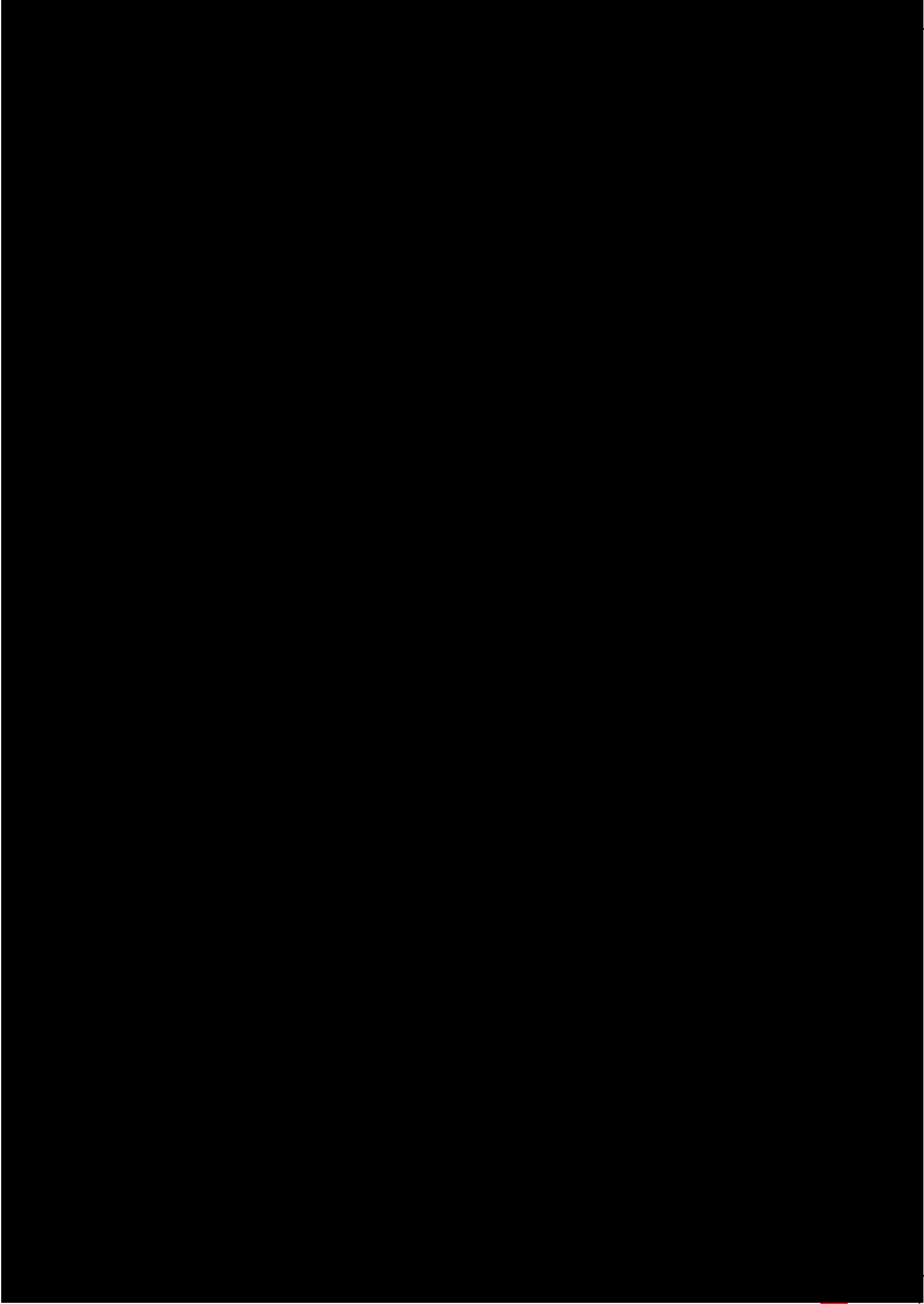


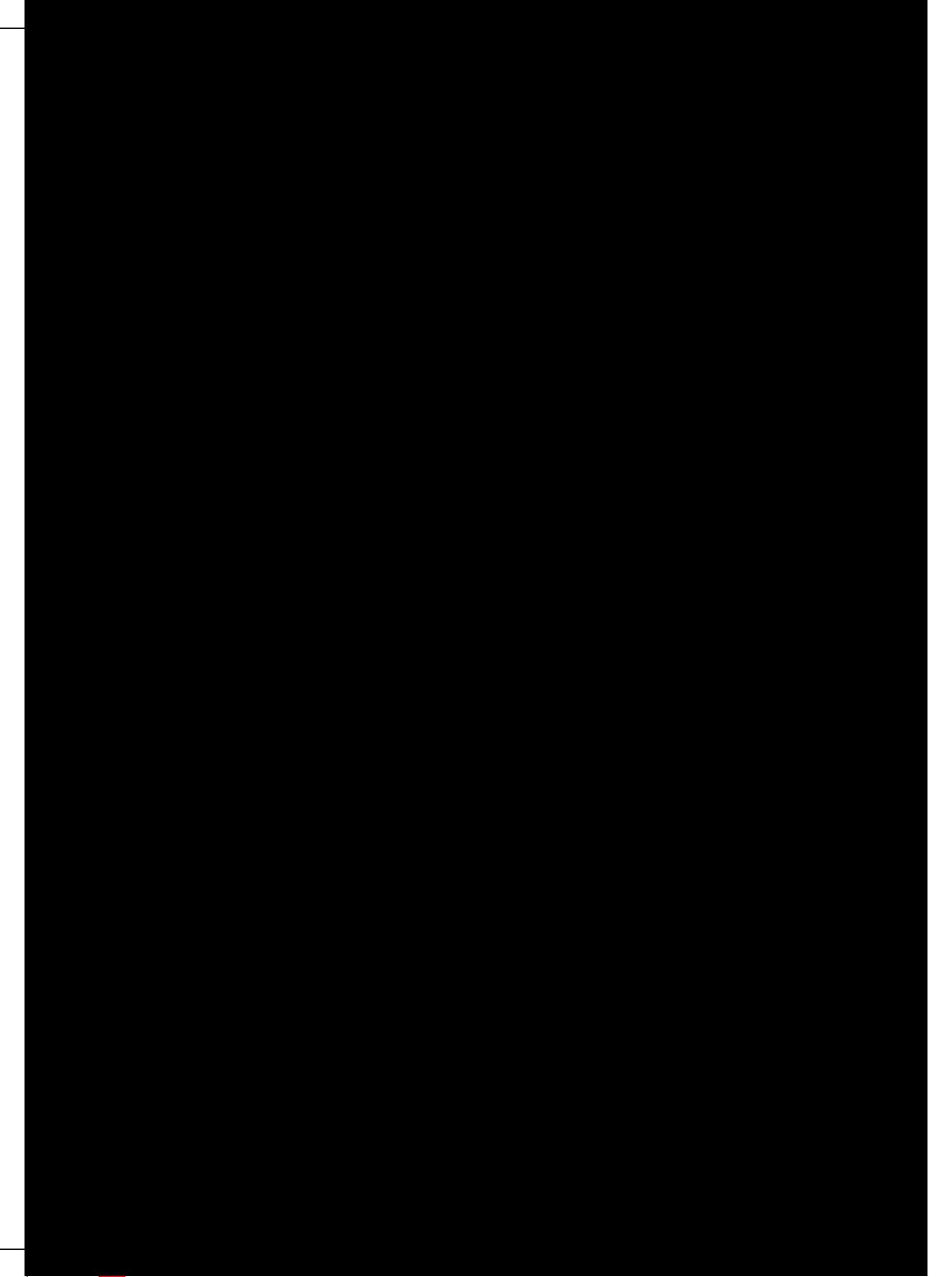


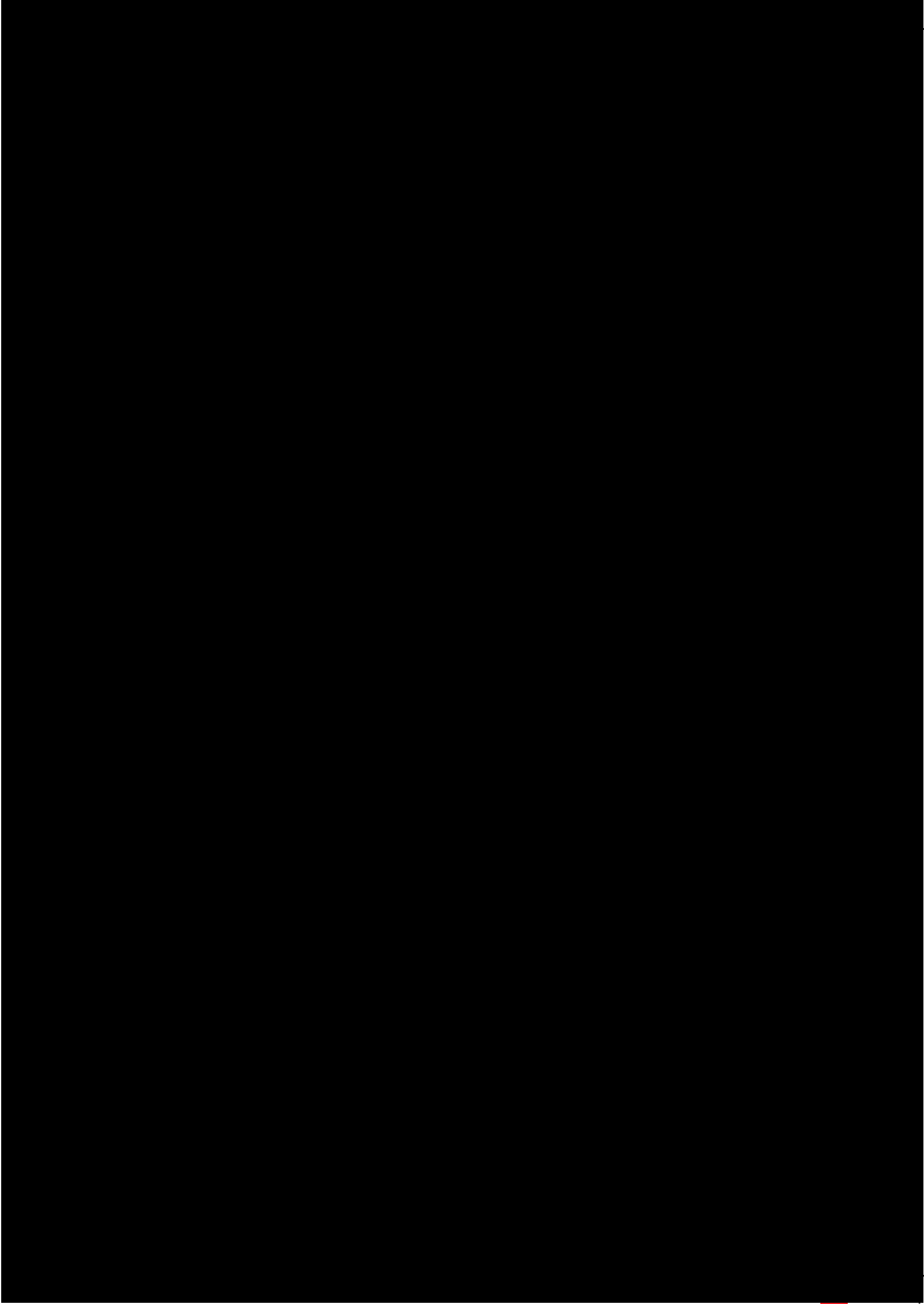


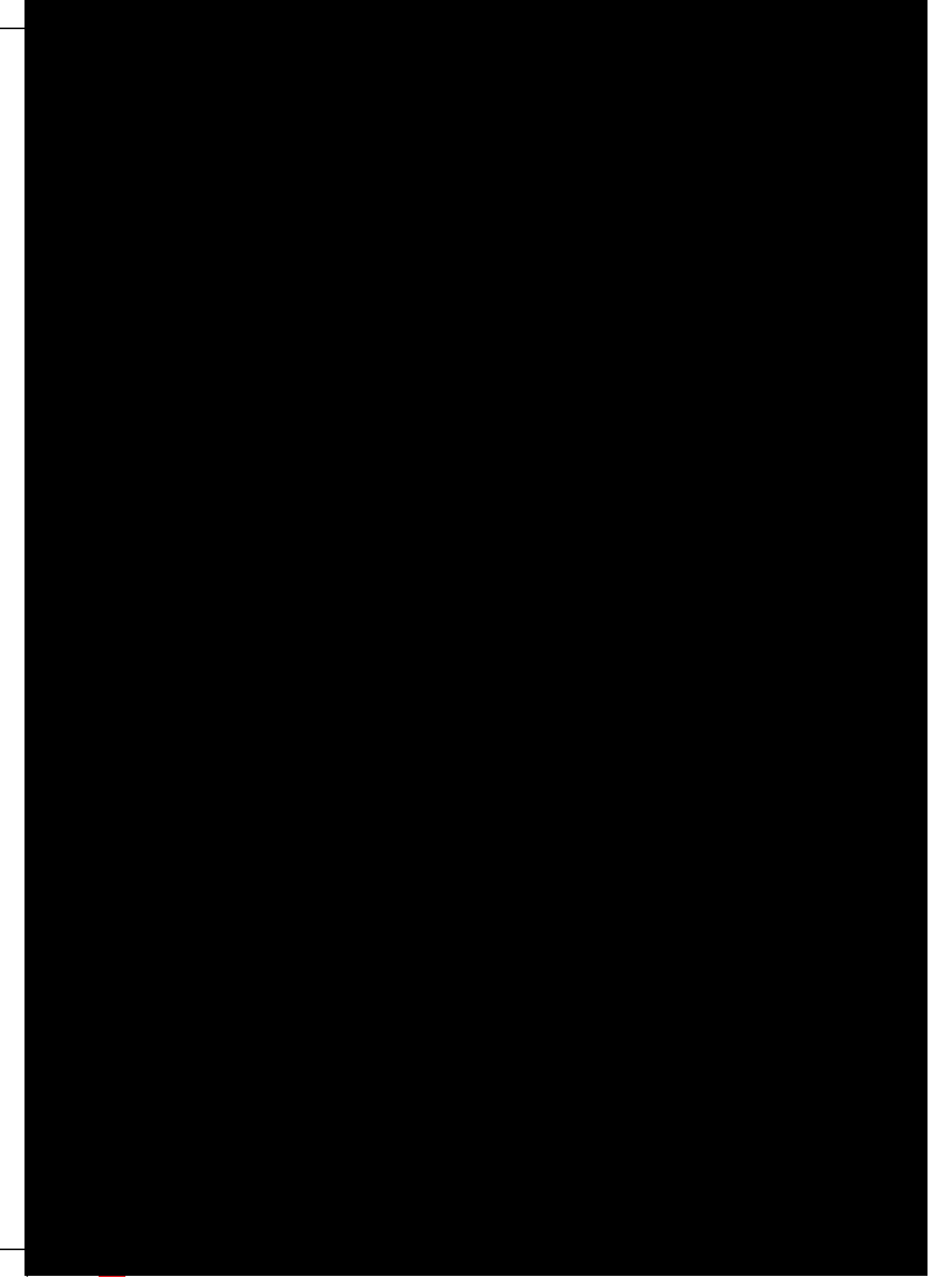


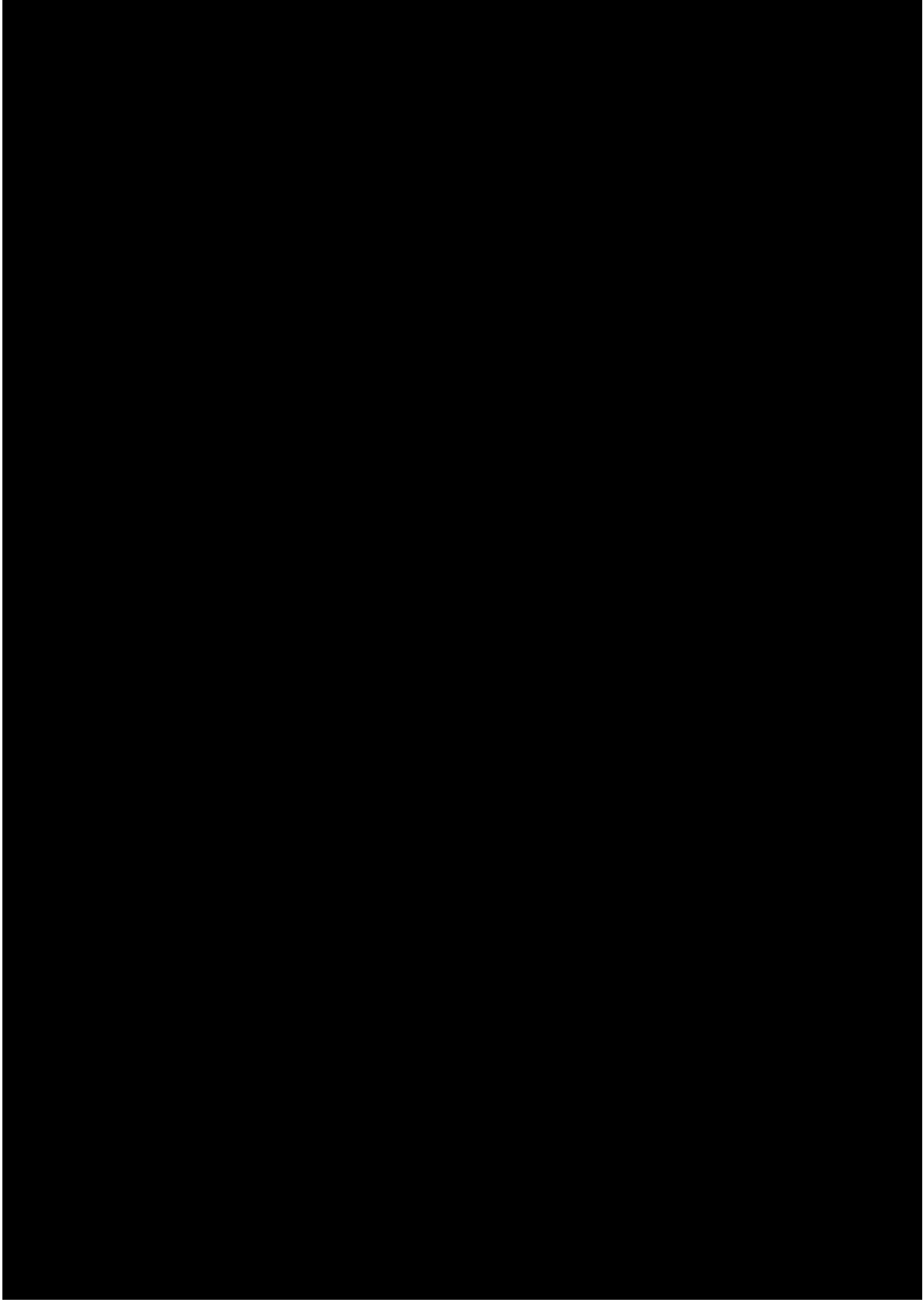


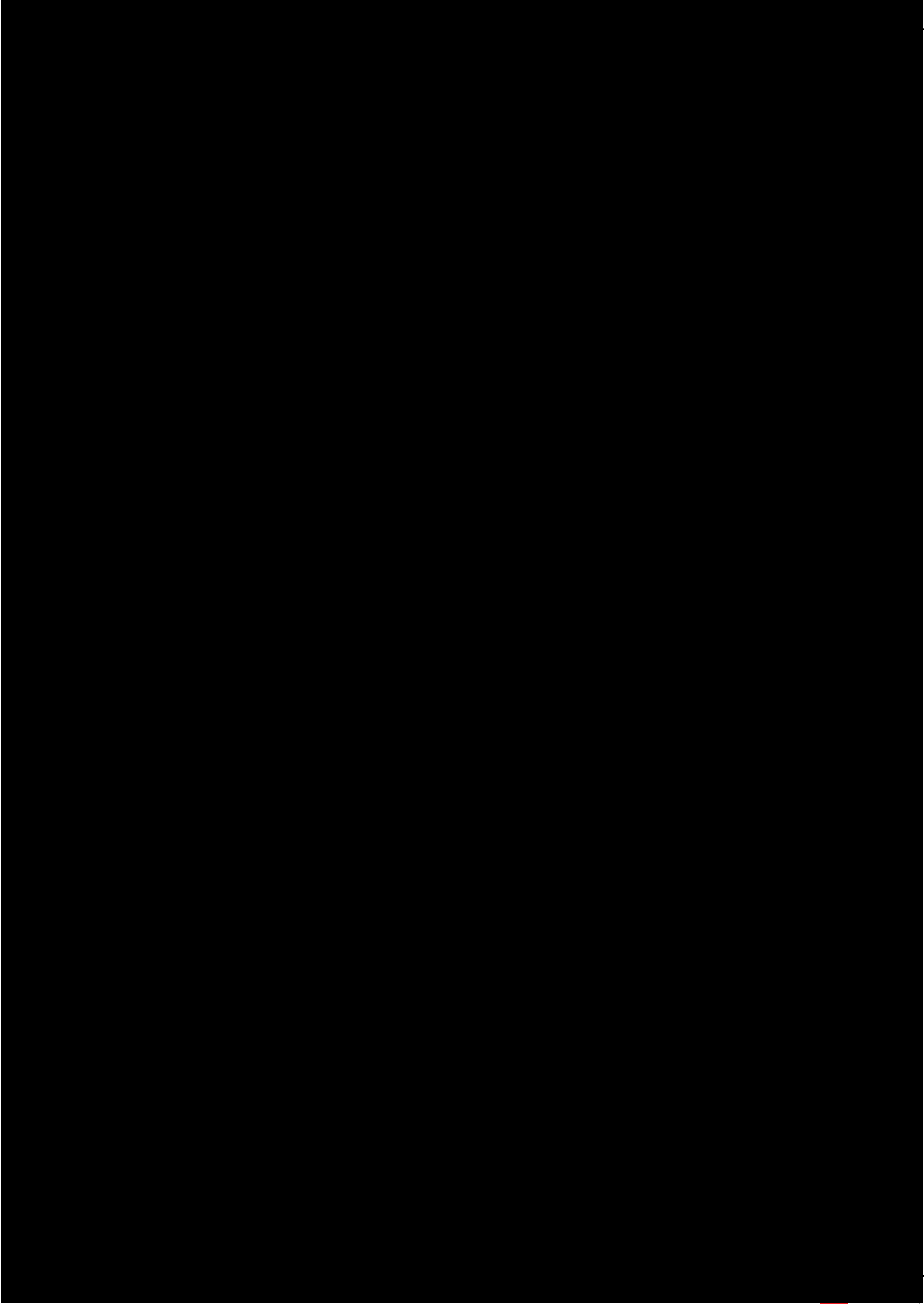


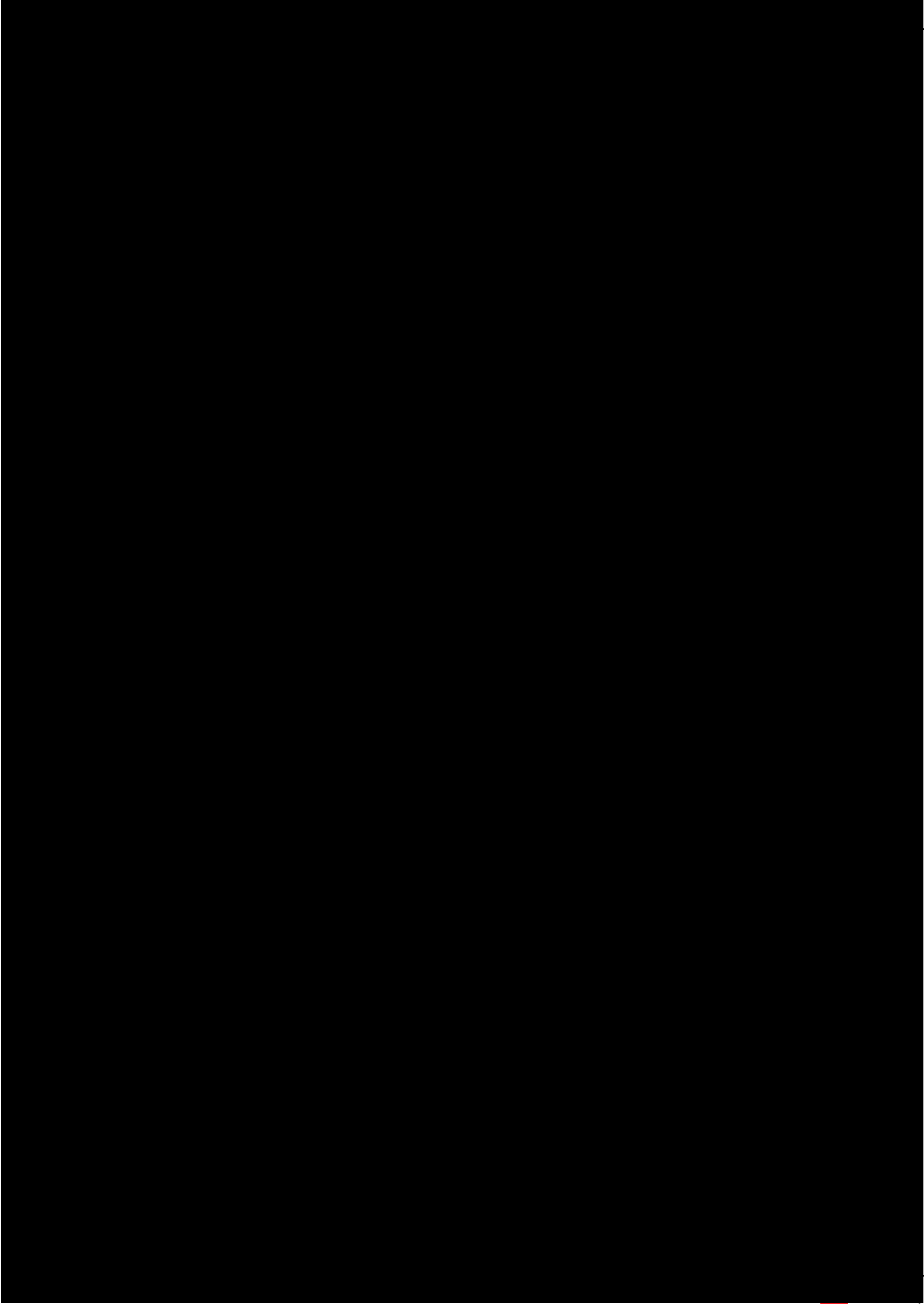












Question

1. Fill in the gaps in the following table illustrating differences between prokaryotic and eukaryotic cells.

Prokaryotic Cell	Eukaryotic Cell
1. Size : generally small (1-10 μm) $1 \mu\text{m} = 10^{-6} \text{m}$	1. Size: generally large (5-100 μm)
2. Nuclear region: _____ _____ and known as__	2. Nuclear region: well defined and surrounded by a nuclear membrane
3. Chromosome: single	3. More than one chromosome
4. Membrane-bound cell organelles absent	4. _____ _____ _____

5.2.5 CELL ORGANELLES

Every cell has a membrane around it to keep its own contents separate from the external environment. Large and complex cells, including cells from multicellular organisms, need a lot of chemical activities to support their complicated structure and function. To keep these activities of different kinds separate from each other, these cells use membrane-bound little structures (or 'organelles') within themselves. This is one of the features of the eukaryotic cells that distinguish them from prokaryotic cells. Some of these organelles are visible only with an electron microscope.

We have talked about the nucleus in a previous section. Some important examples of cell organelles which we will discuss now are: endoplasmic reticulum, Golgi apparatus, lysosomes, mitochondria and plastids. They are important because they carry out some very crucial functions in cells.

5.2.5 (i) ENDOPLASMIC RETICULUM (ER)

The endoplasmic reticulum (ER) is a large network of membrane-bound tubes and sheets. It looks like long tubules or round or oblong bags (vesicles). The ER membrane is similar in structure to the plasma membrane. There are two types of ER—rough endoplasmic reticulum (RER) and smooth endoplasmic reticulum (SER). RER looks rough under a microscope because it has particles called ribosomes attached to its surface. The ribosomes, which are present in all active cells, are the sites of protein manufacture. The manufactured proteins are then sent to various places in the cell depending on need, using the ER. The SER helps in the manufacture of fat molecules, or lipids, important for cell function. Some of these proteins and lipids help in building the cell membrane. This process is known as membrane biogenesis. Some other proteins and lipids function as enzymes and hormones. Although the ER varies greatly in appearance in different cells, it always forms a network system.

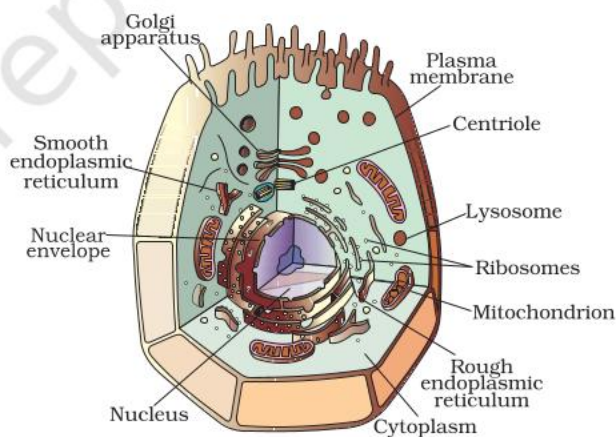


Fig. 5.5: Animal cell

Thus, one function of the ER is to serve as channels for the transport of materials (especially proteins) between various regions of the cytoplasm or between the cytoplasm and the nucleus. The ER also functions as a cytoplasmic framework providing a surface

for some of the biochemical activities of the cell. In the liver cells of the group of animals called vertebrates (see Chapter 7), SER plays a crucial role in detoxifying many poisons and drugs.

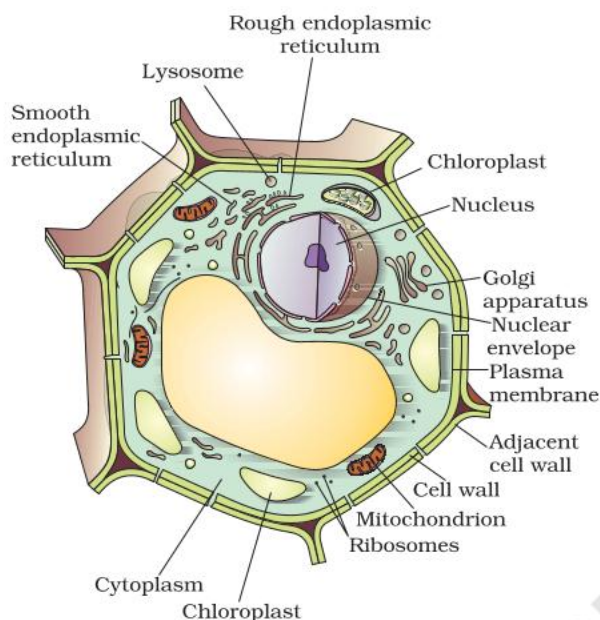


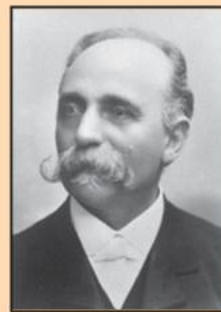
Fig. 5.6: Plant cell

5.2.5 (ii) GOLGI APPARATUS

The Golgi apparatus, first described by Camillo Golgi, consists of a system of membrane-bound vesicles (flattened sacs) arranged approximately parallel to each other in stacks called cisterns. These membranes often have connections with the membranes of ER and therefore constitute another portion of a complex cellular membrane system.

The material synthesised near the ER is packaged and dispatched to various targets inside and outside the cell through the Golgi apparatus. Its functions include the storage, modification and packaging of products in vesicles. In some cases, complex sugars may be made from simple sugars in the Golgi apparatus. The Golgi apparatus is also involved in the formation of lysosomes [see 5.2.5 (iii)].

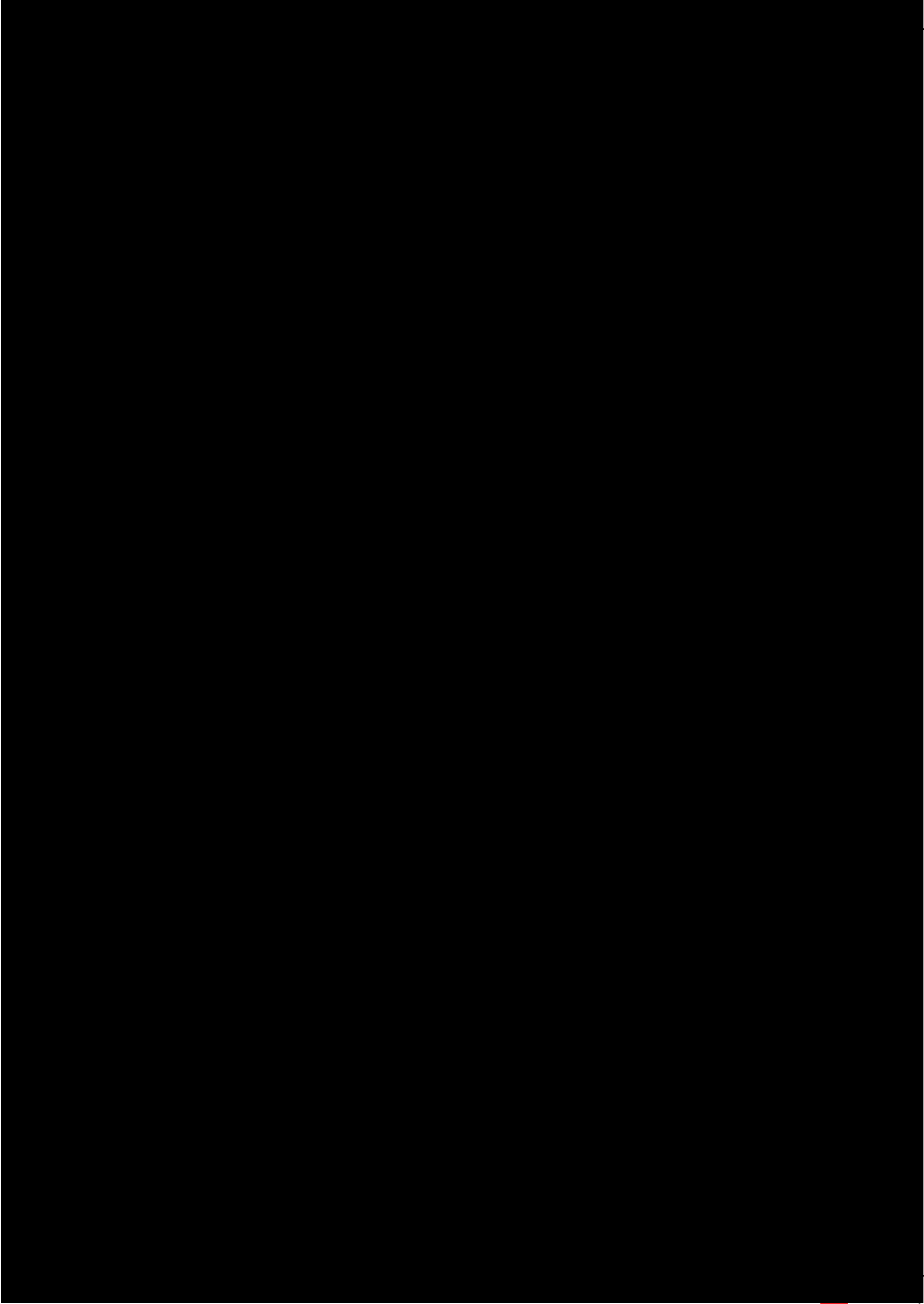
Camillo Golgi was born at Corteno near Brescia in 1843. He studied medicine at the University of Pavia. After graduating in 1865, he continued to work in Pavia at the Hospital of St. Matteo. At that time most of his investigations were

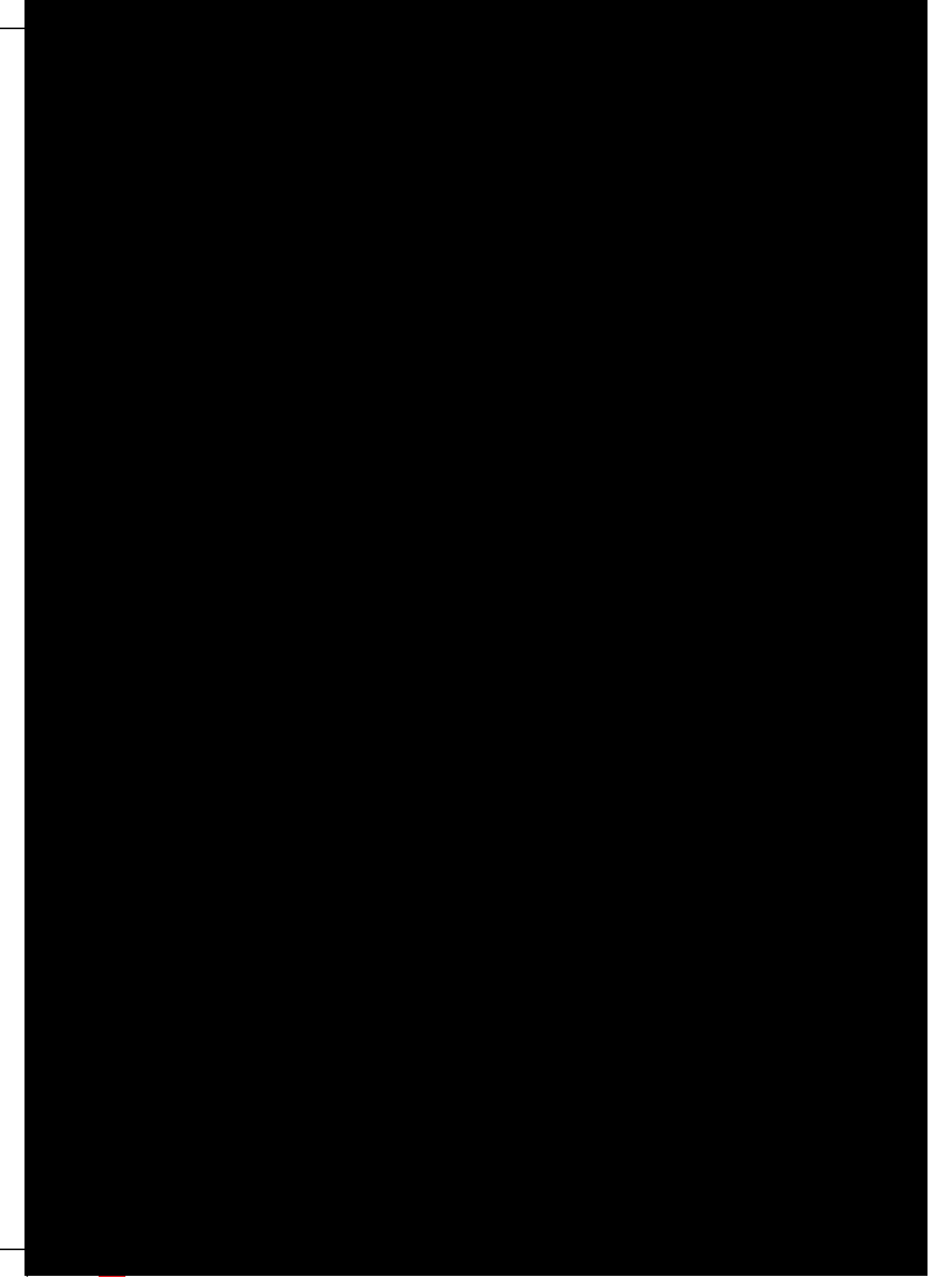


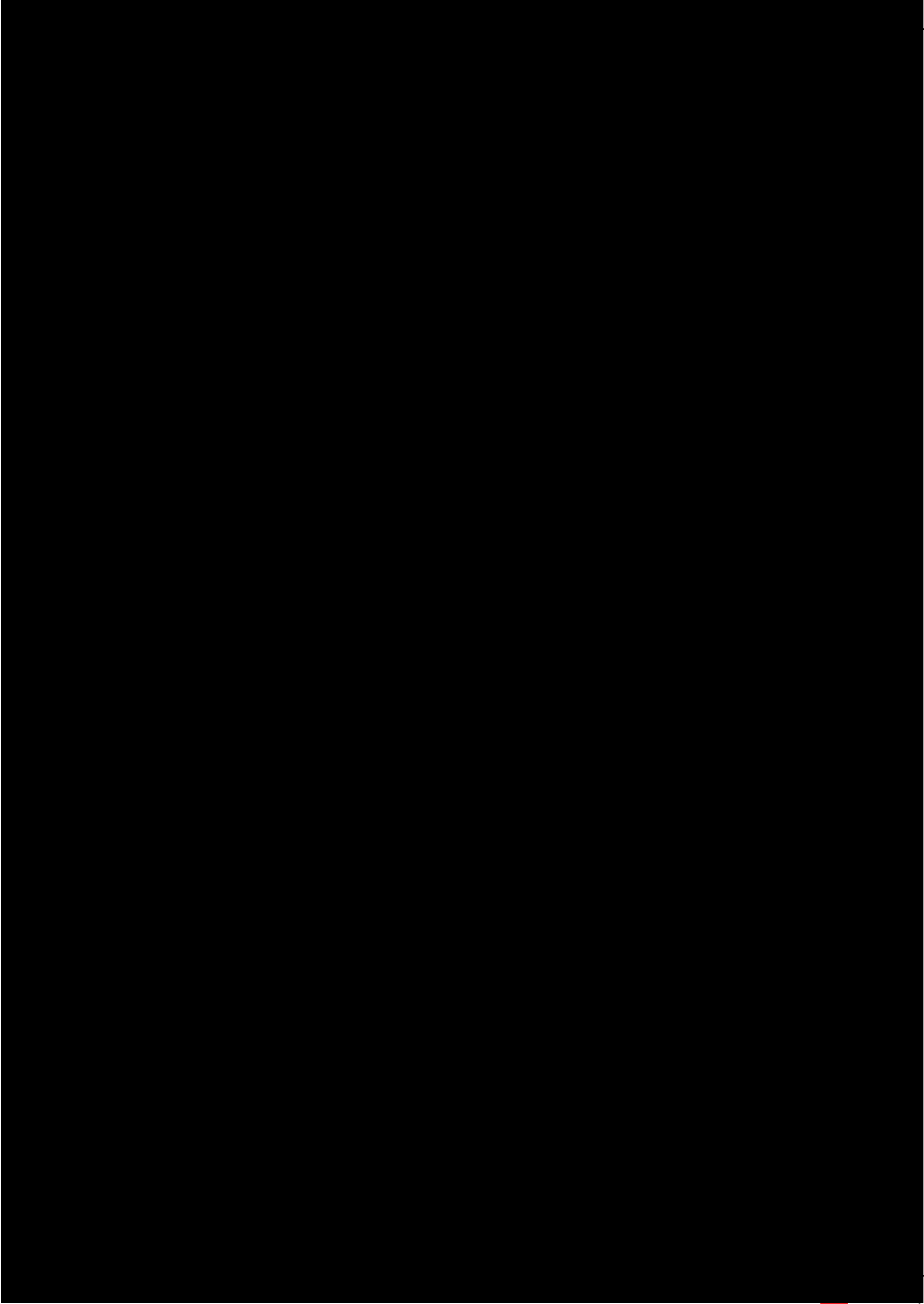
concerned with the nervous system. In 1872 he accepted the post of Chief Medical Officer at the Hospital for the Chronically Sick at Abbiategrasso. He first started his investigations into the nervous system in a little kitchen of this hospital, which he had converted into a laboratory. However, the work of greatest importance, which Golgi carried out was a revolutionary method of staining individual nerve and cell structures. This method is referred to as the 'black reaction'. This method uses a weak solution of silver nitrate and is particularly valuable in tracing the processes and most delicate ramifications of cells. All through his life, he continued to work on these lines, modifying and improving this technique. Golgi received the highest honours and awards in recognition of his work. He shared the Nobel prize in 1906 with Santiago Ramon y Cajal for their work on the structure of the nervous system.

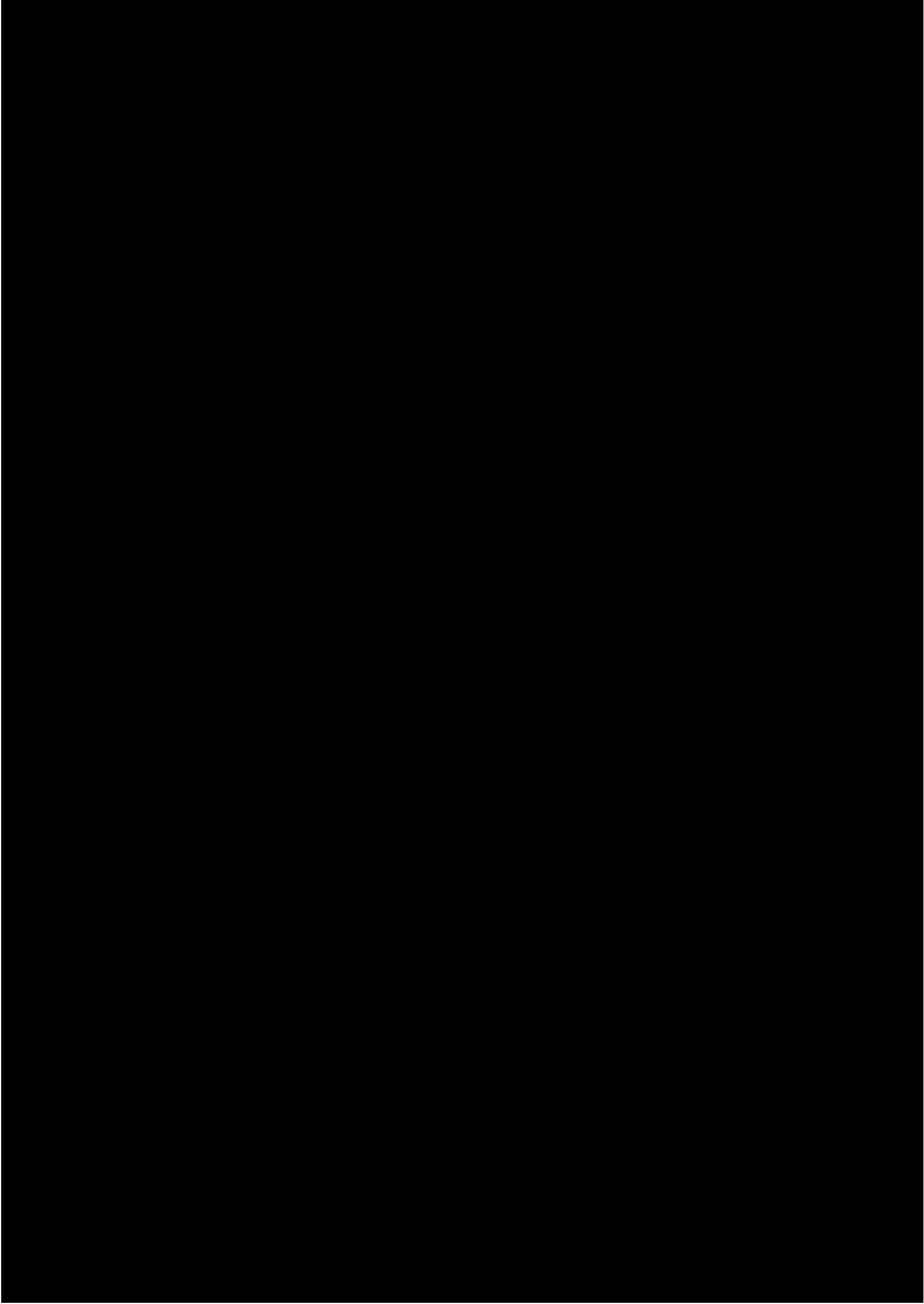
5.2.5 (iii) LYSOSOMES

Structurally, lysosomes are membrane-bound sacs filled with digestive enzymes. These enzymes are made by RER. Lysosomes are a kind of waste disposal system of the cell. These help to keep the cell clean by digesting any foreign material as well as worn-out cell organelles. Foreign materials entering the cell, such as bacteria or food, as well as old organelles end up in the lysosomes, which break complex substances into simpler substances. Lysosomes are able to do this because they contain powerful digestive enzymes capable of breaking down all organic material. During the disturbance in cellular metabolism, for example, when the cell gets









Questions

1. What is a tissue?
2. What is the utility of tissues in multi-cellular organisms?

6.2 Plant Tissues

6.2.1 MERISTEMATIC TISSUE

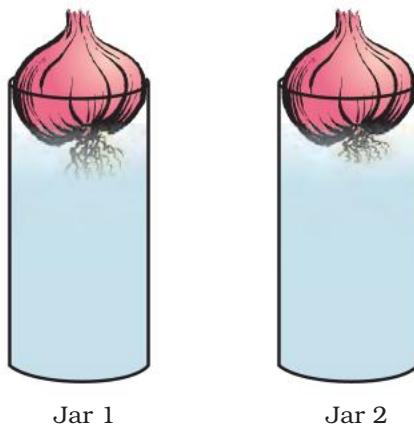


Fig. 6.1: Growth of roots in onion bulbs

Activity 6.1

- Take two glass jars and fill them with water.
- Now, take two onion bulbs and place one on each jar, as shown in Fig. 6.1.
- Observe the growth of roots in both the bulbs for a few days.
- Measure the length of roots on day 1, 2 and 3.
- On day 4, cut the root tips of the onion bulb in jar 2 by about 1 cm. After this, observe the growth of roots in both the jars and measure their lengths each day for five more days and record the observations in tables, like the table below:

Length	Day 1	Day 2	Day 3	Day 4	Day 5
Jar 1					
Jar 2					

From the above observations, answer the following questions:

1. Which of the two onions has longer roots? Why?
2. Do the roots continue growing even after we have removed their tips?
3. Why would the tips stop growing in jar 2 after we cut them?

The growth of plants occurs only in certain specific regions. This is because the dividing tissue, also known as meristematic tissue, is located only at these points. Depending on the region where they are present, meristematic tissues are classified as apical, lateral and intercalary (Fig. 6.2). New cells produced by meristem are initially like those of meristem itself, but as they grow and mature, their characteristics slowly change and they become differentiated as components of other tissues.

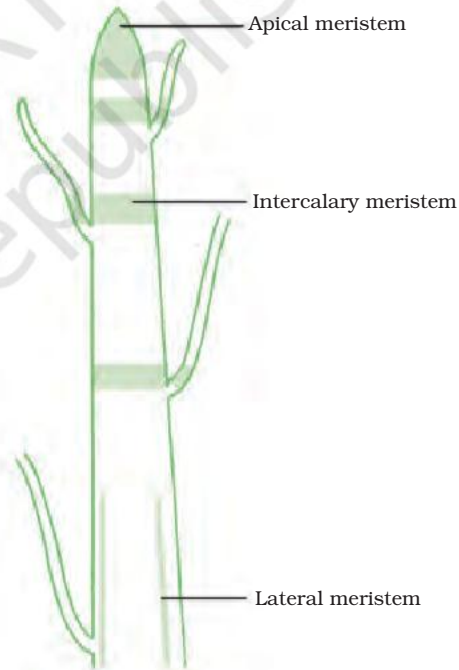
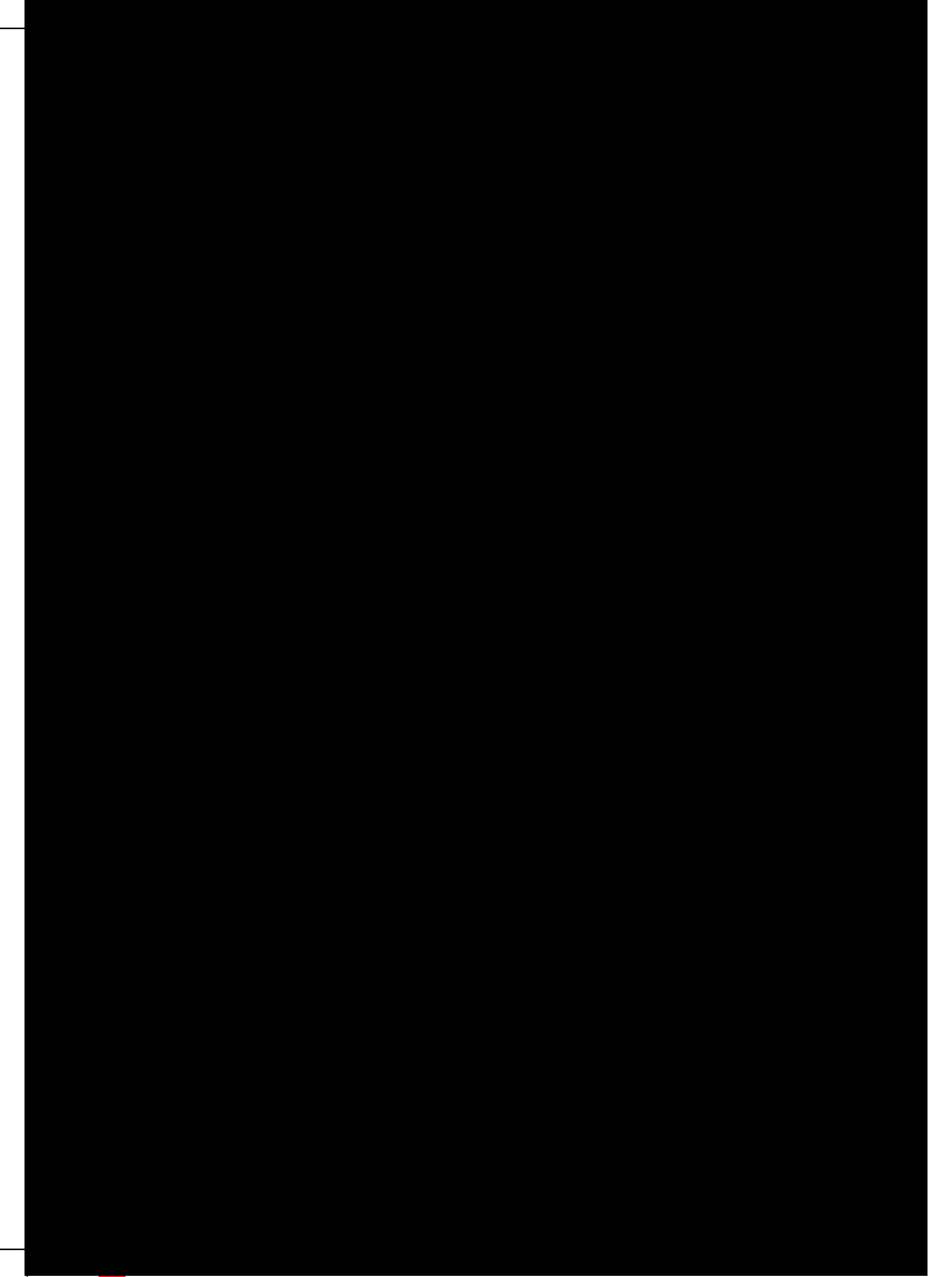
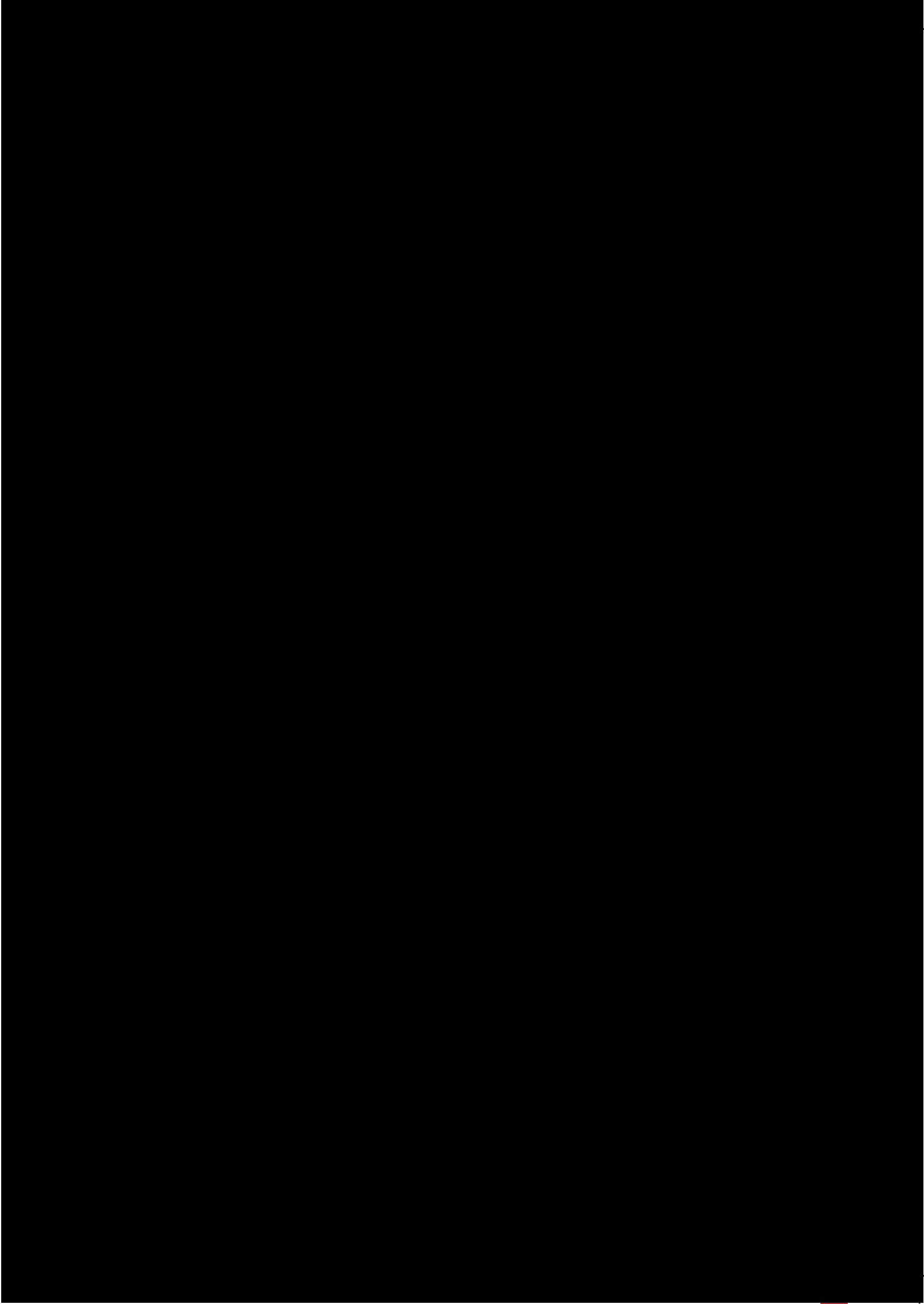
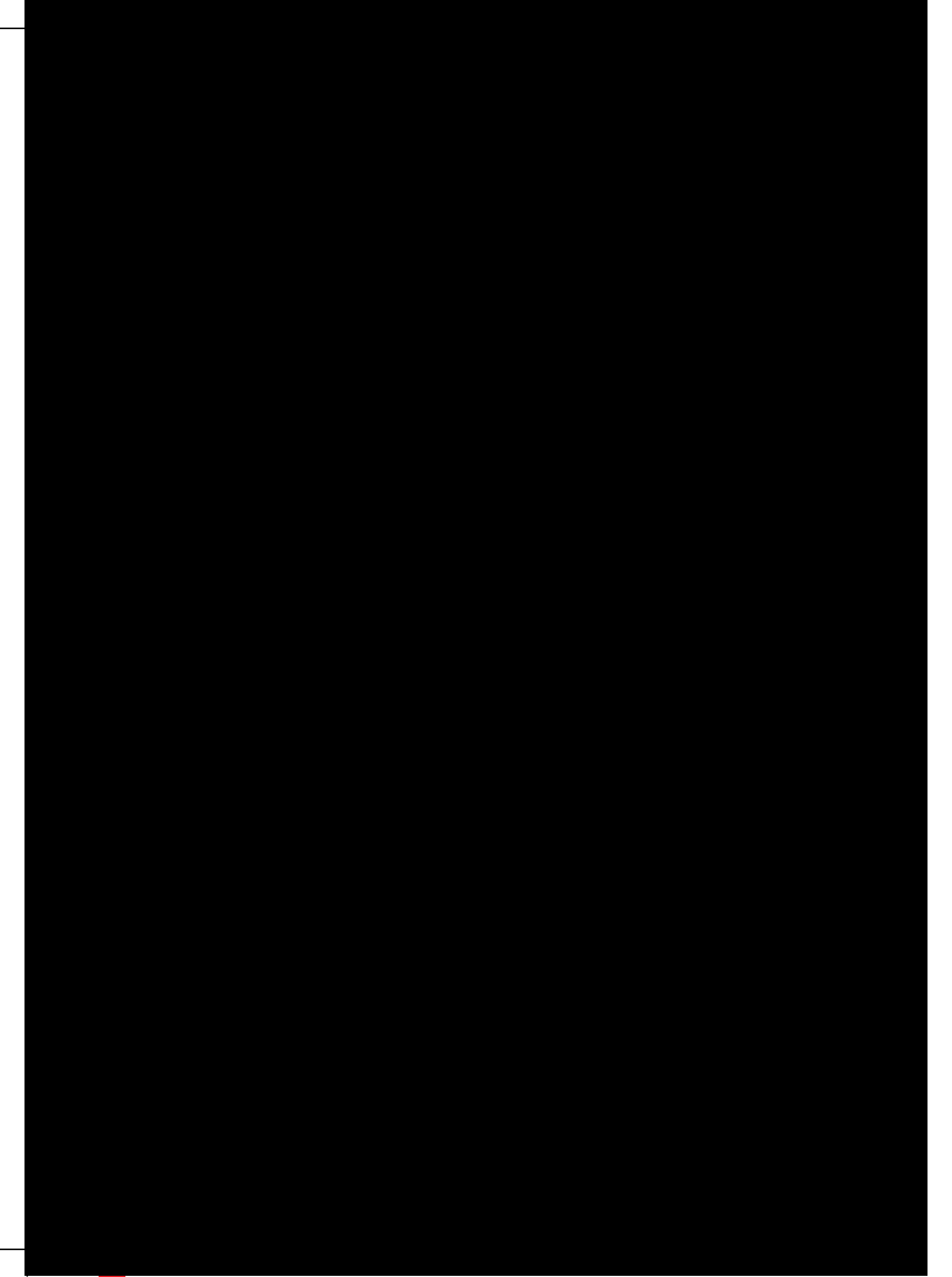


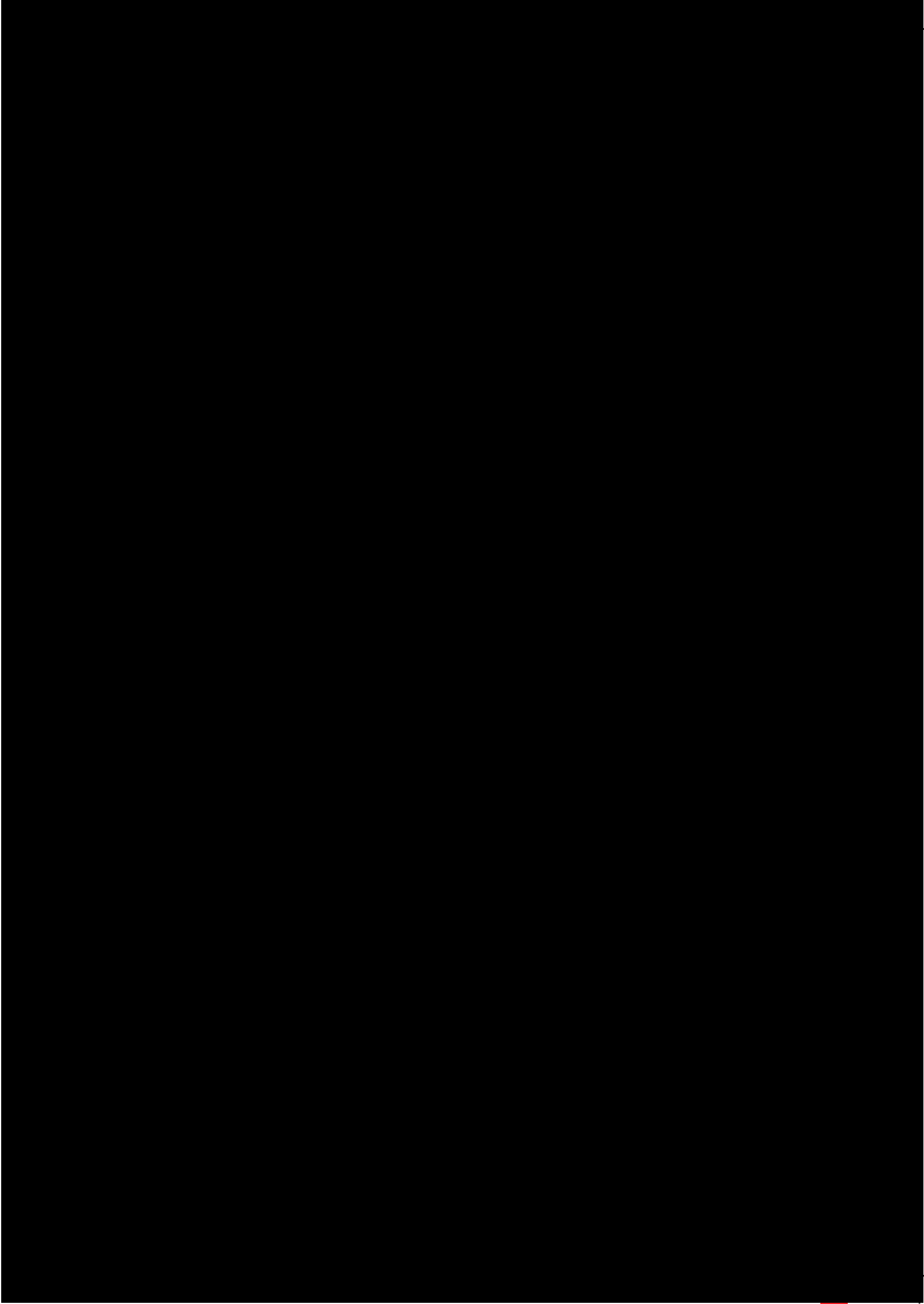
Fig. 6.2: Location of meristematic tissue in plant body

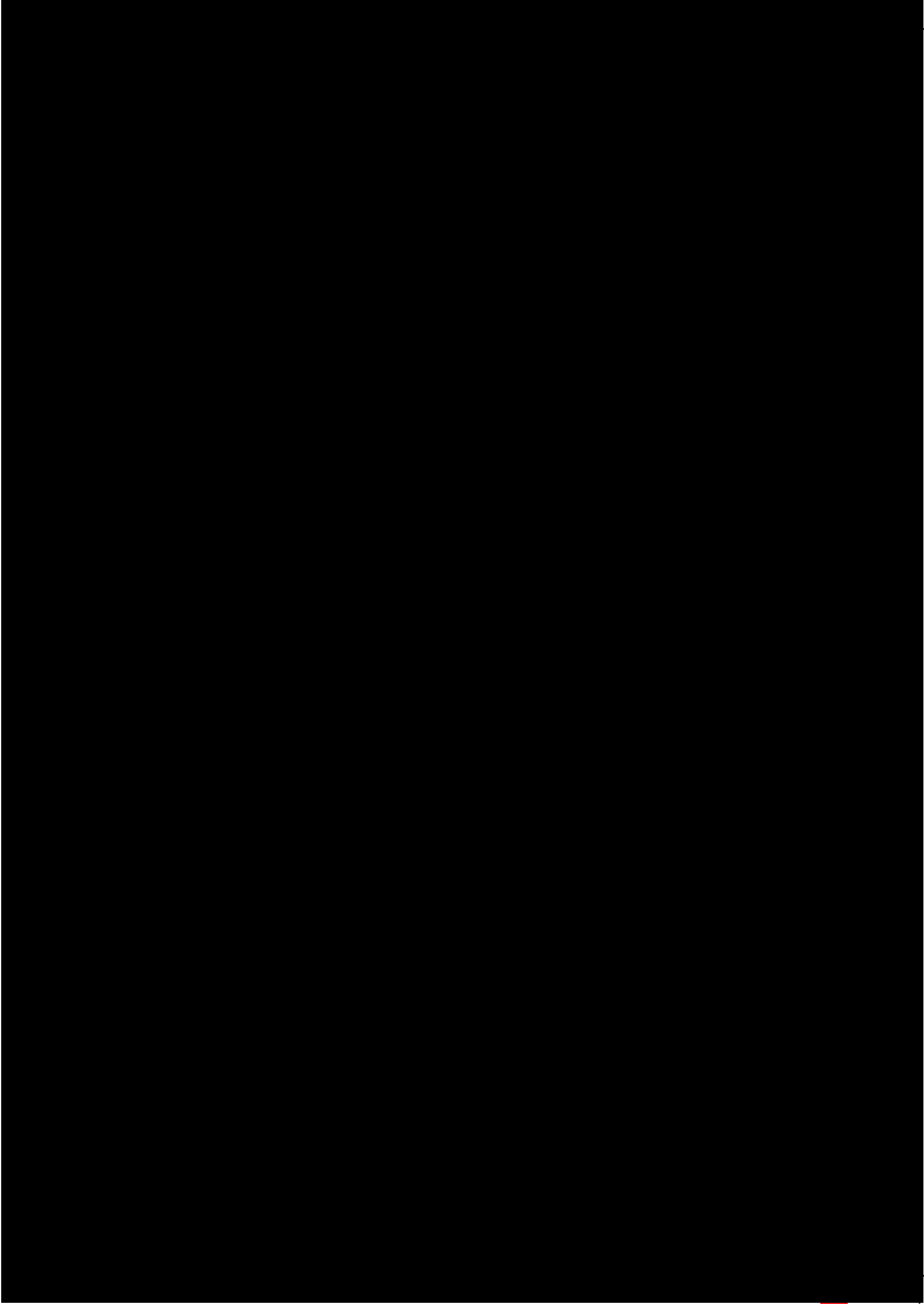
Apical meristem is present at the growing tips of stems and roots and increases the length of the stem and the root. The girth of the stem or root increases due to lateral meristem (cambium). Intercalary meristem seen in some plants is located near the node.

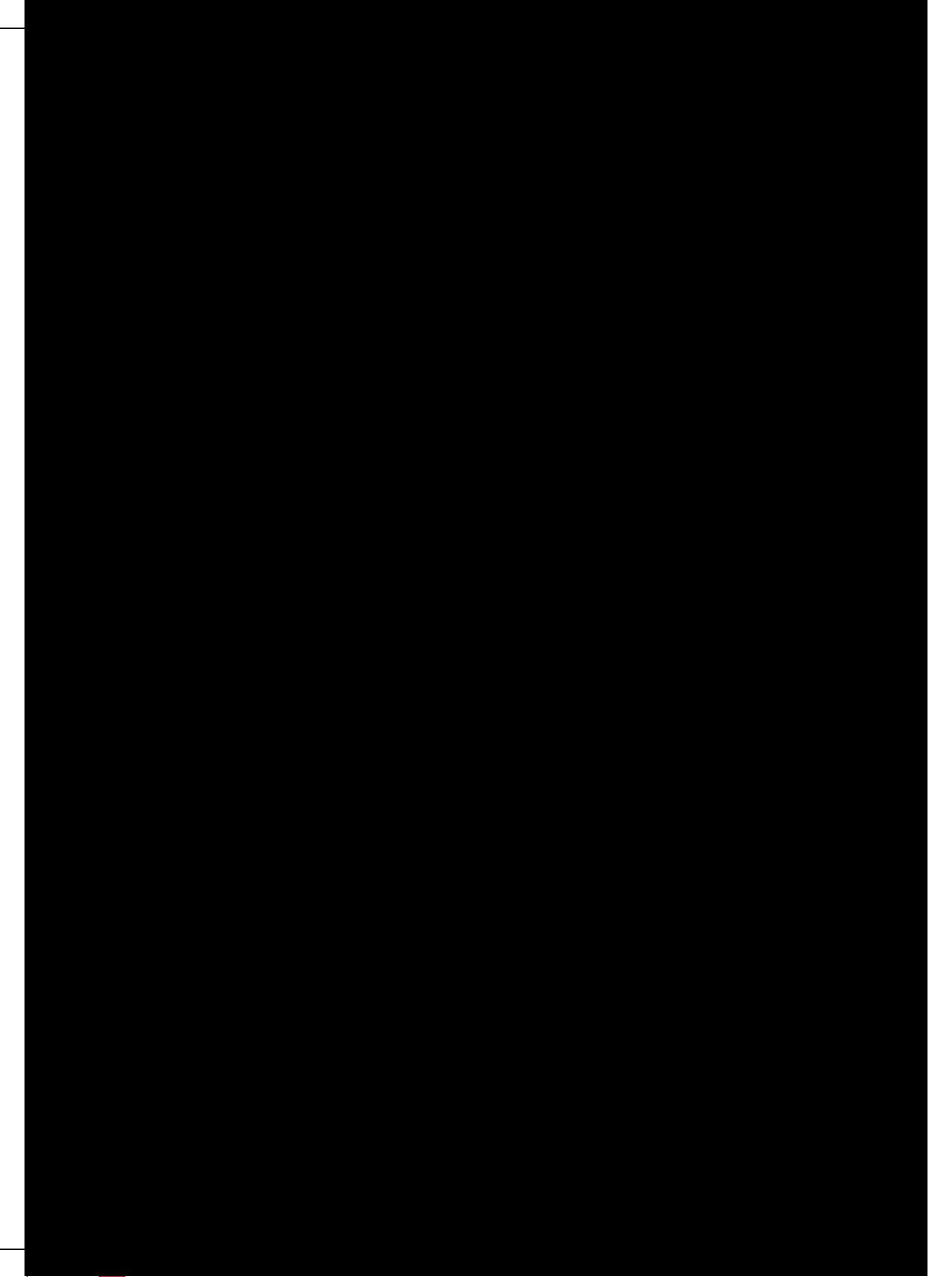


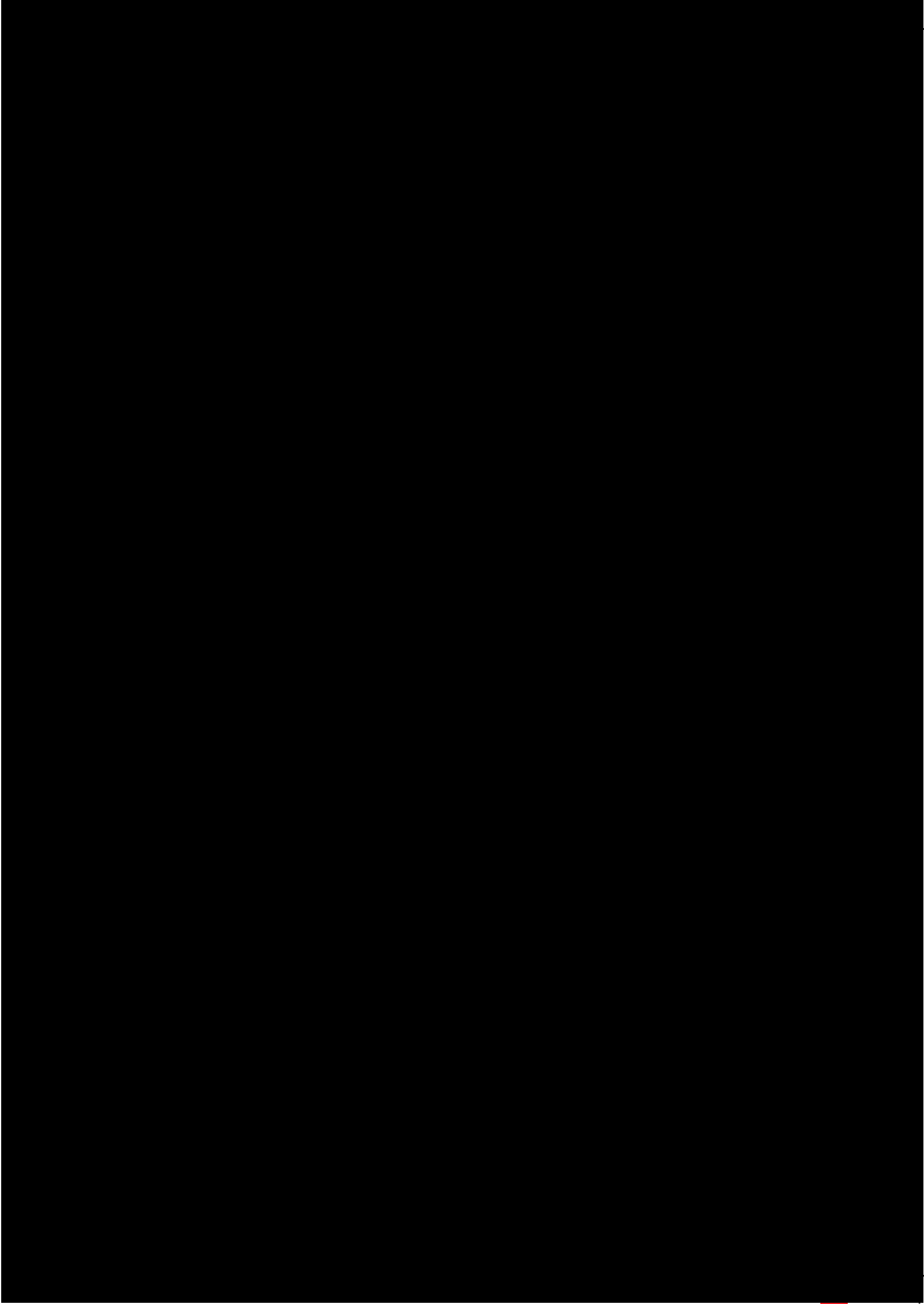


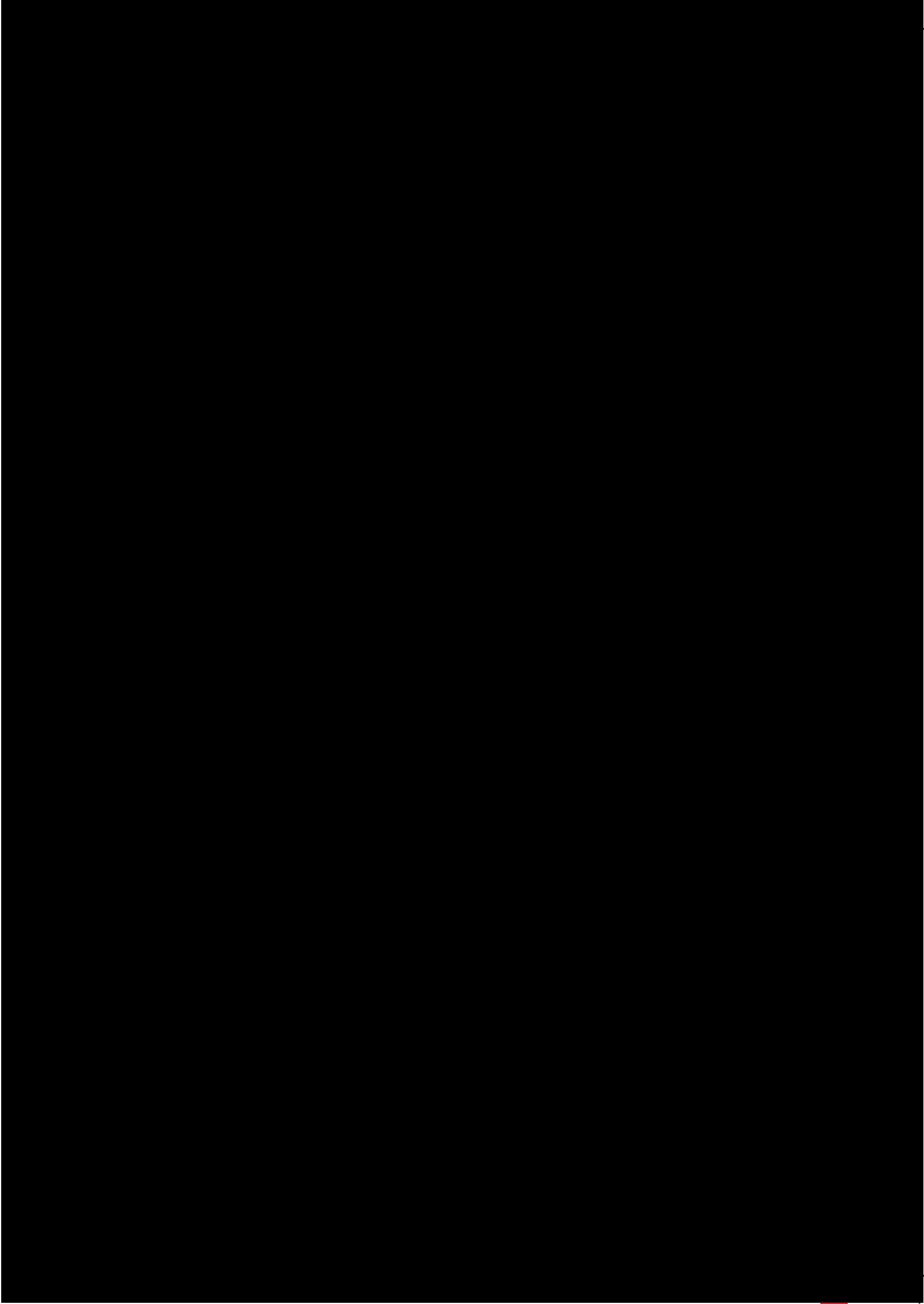


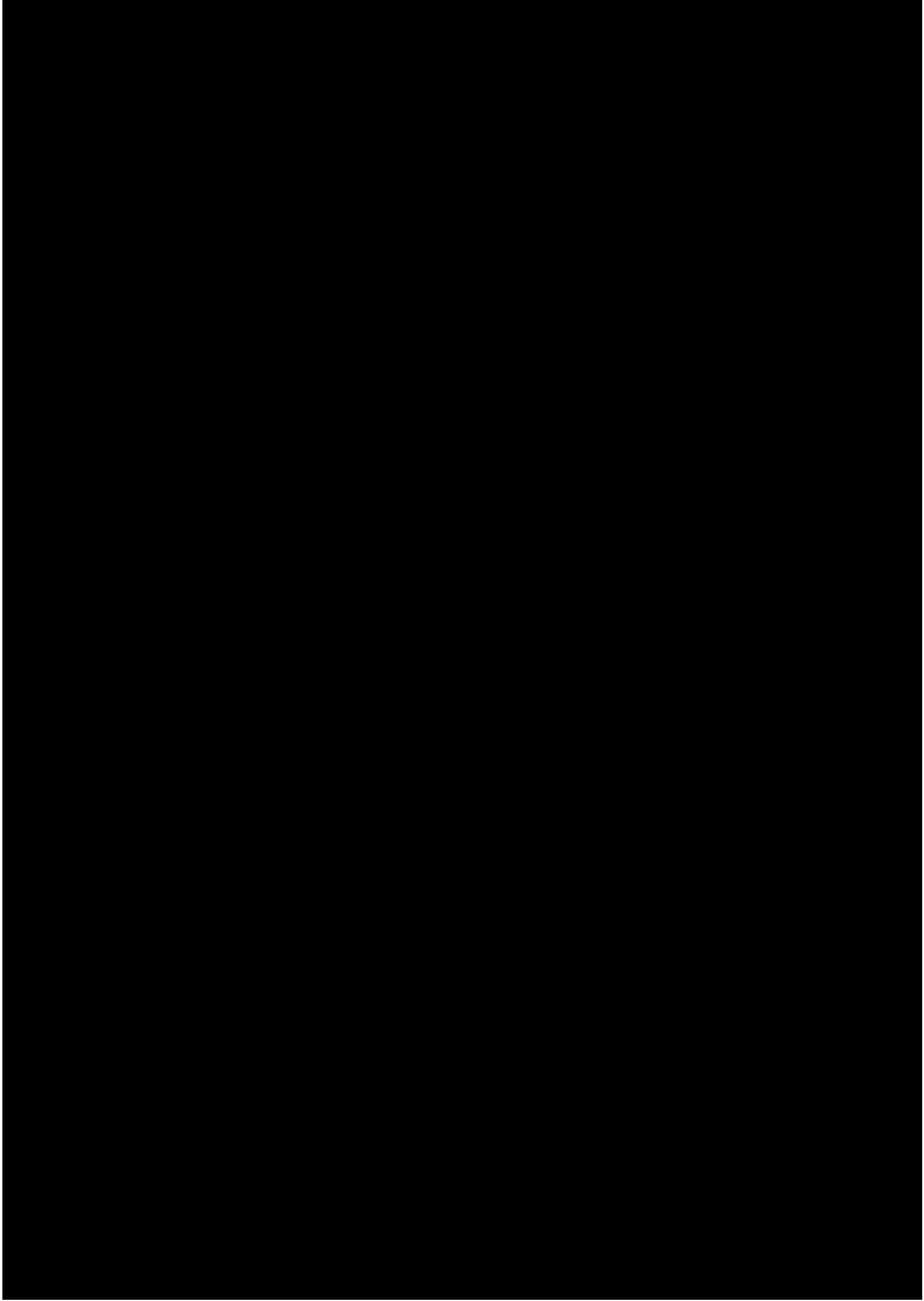


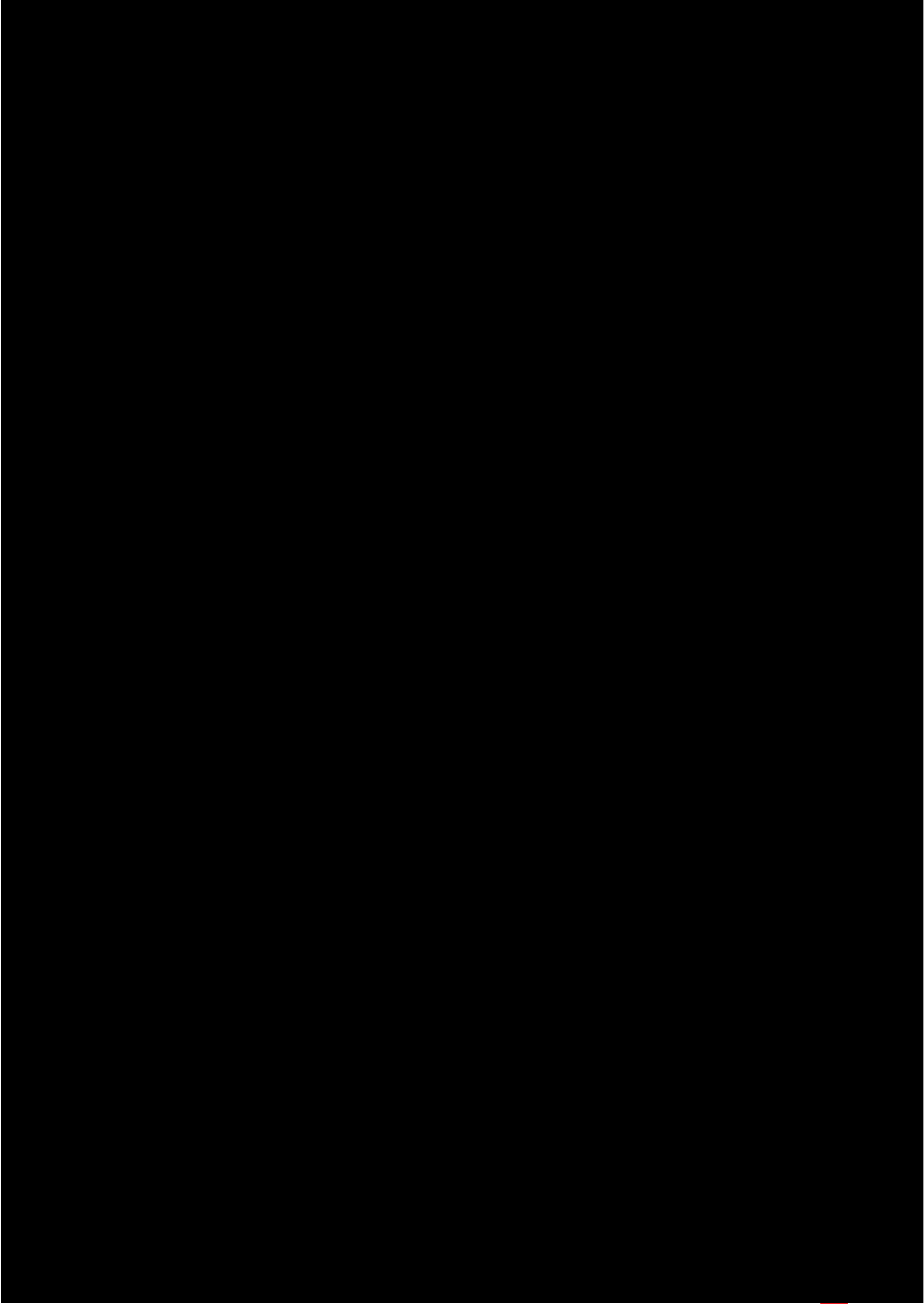


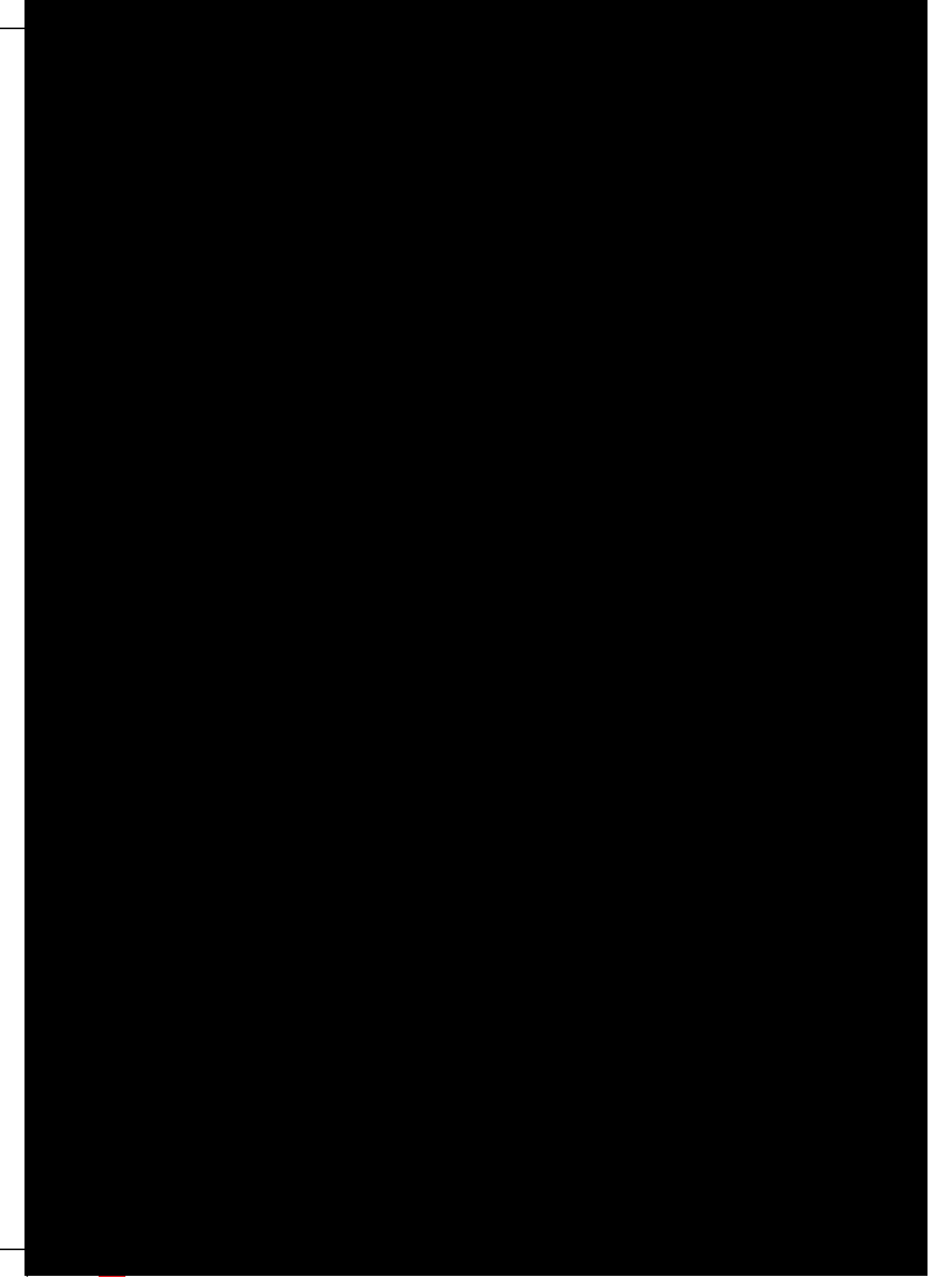


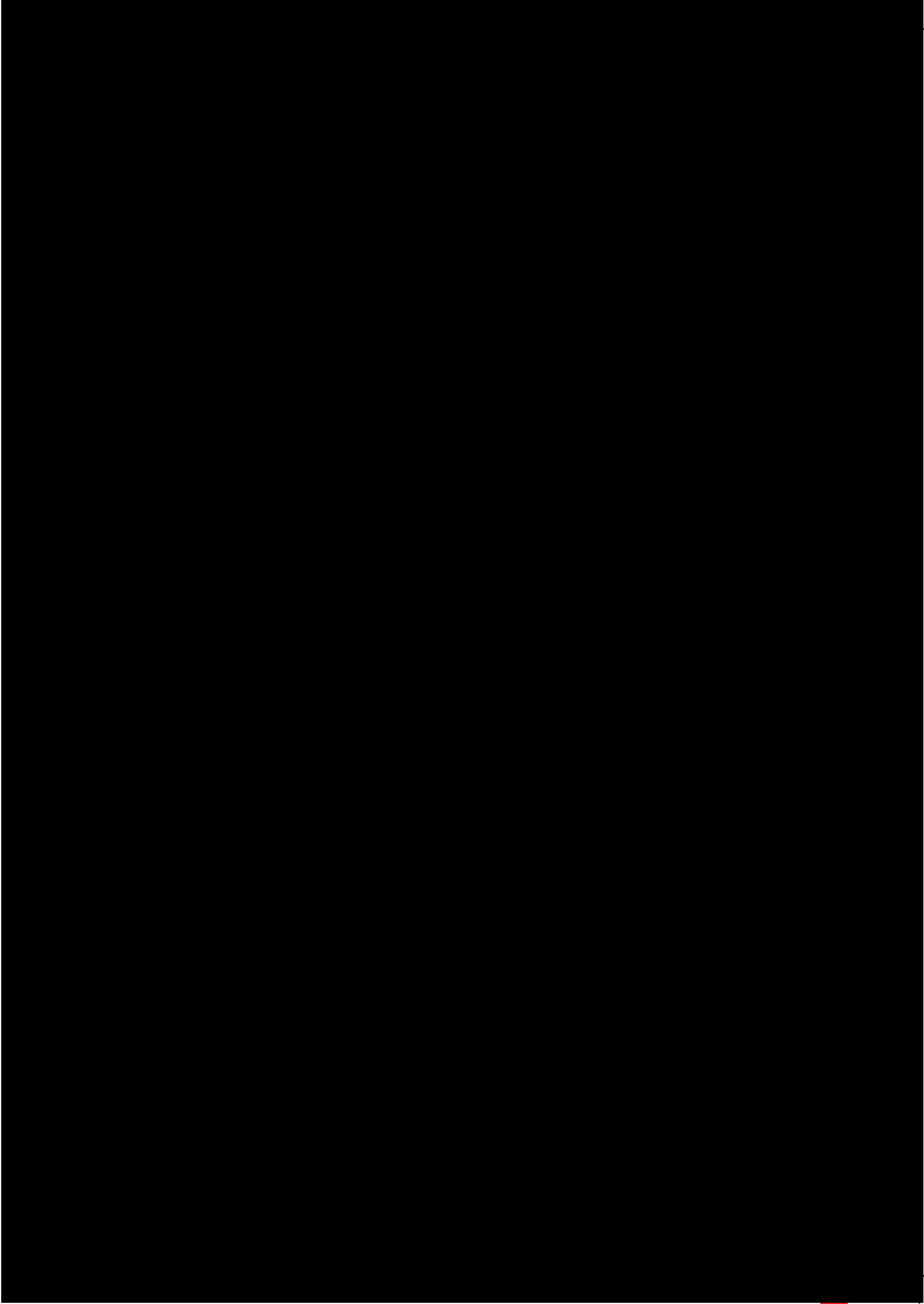


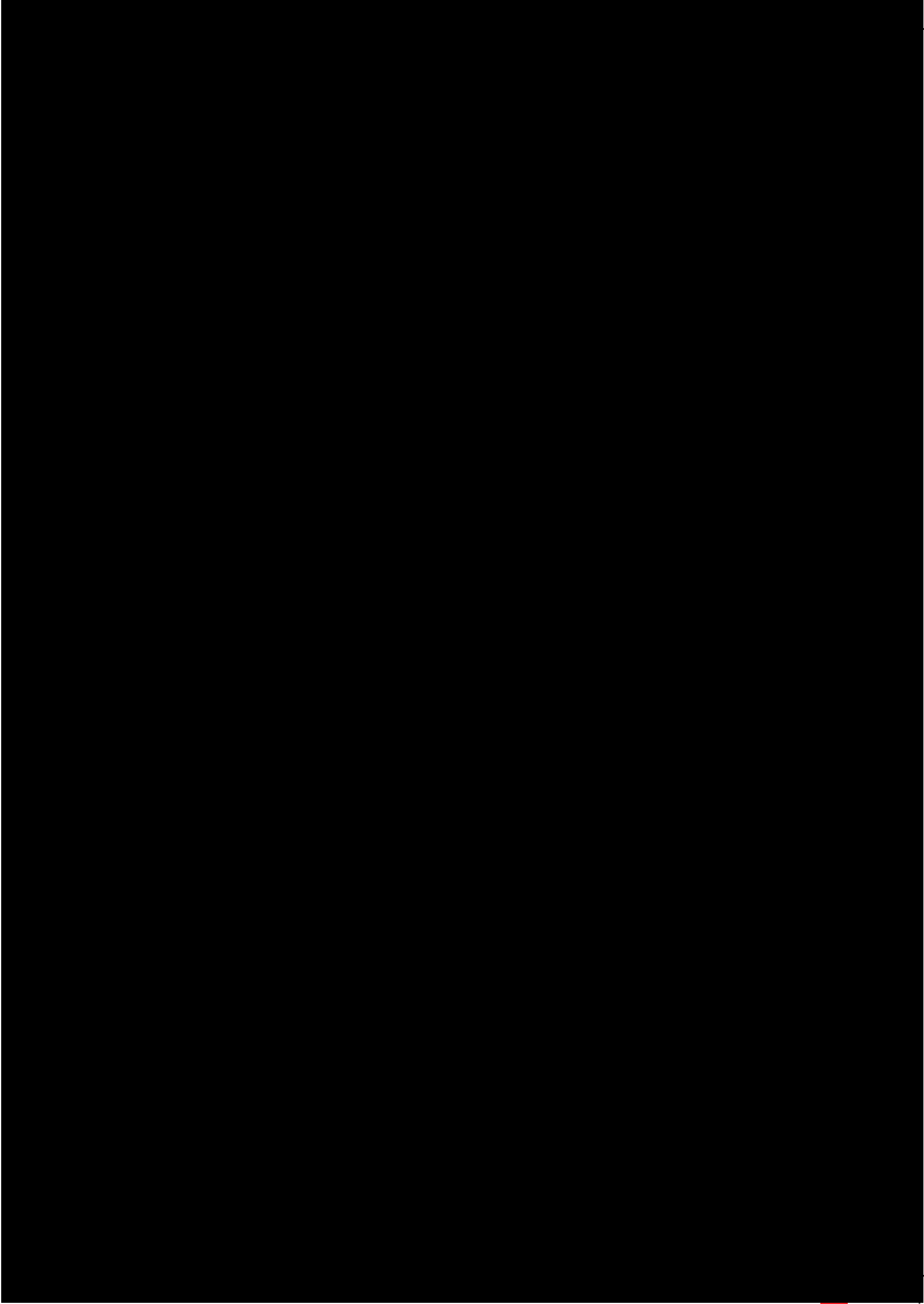


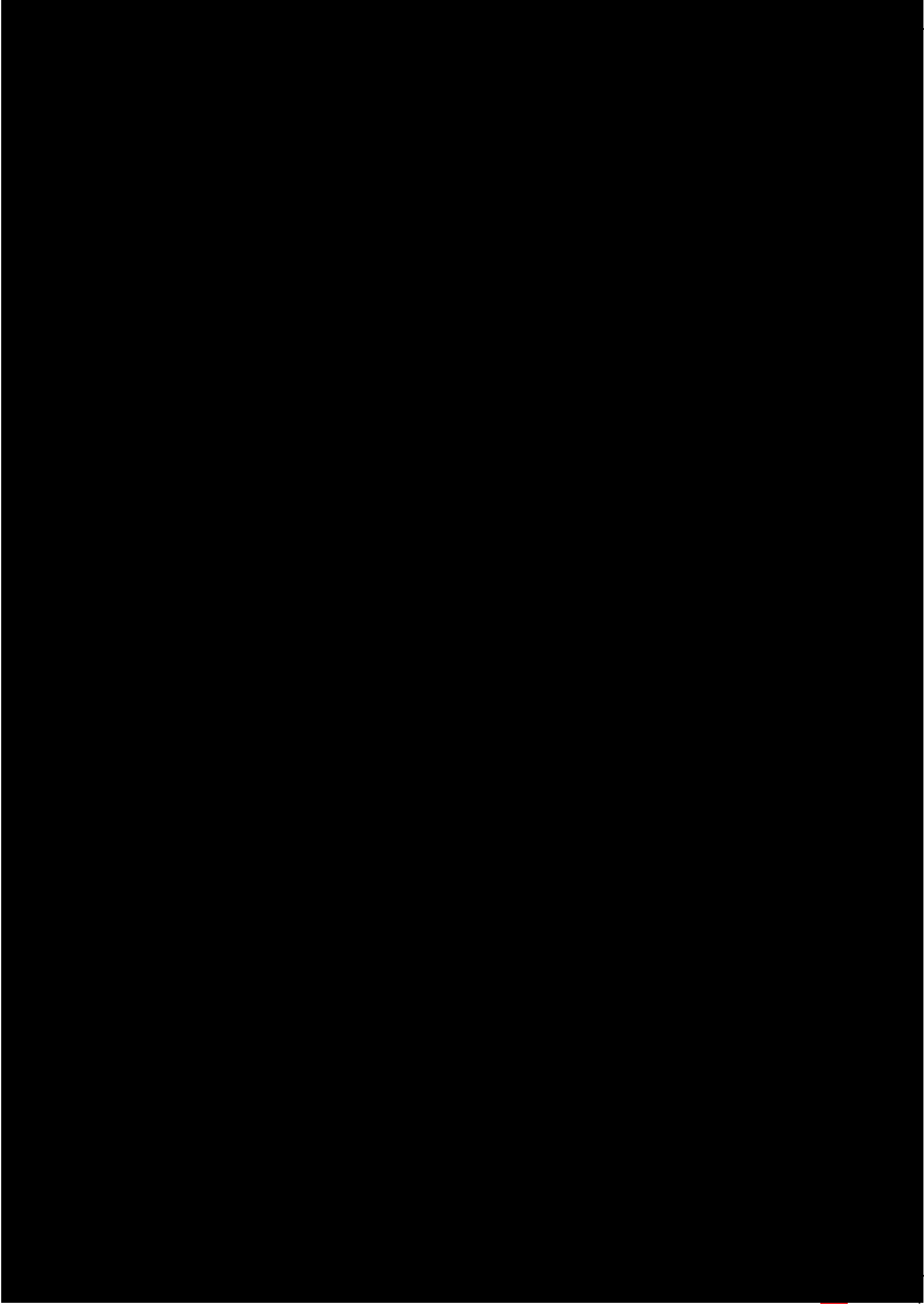


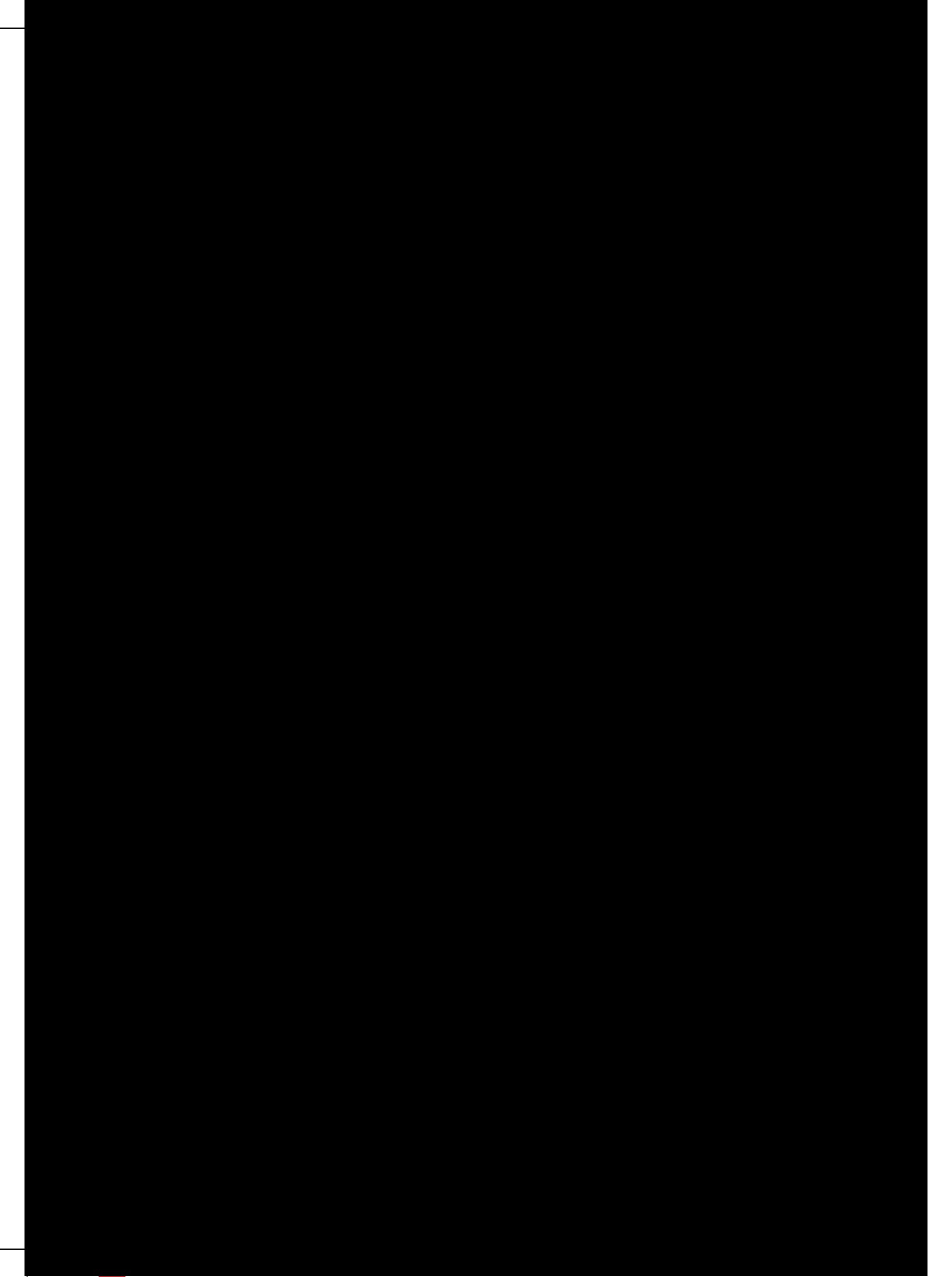


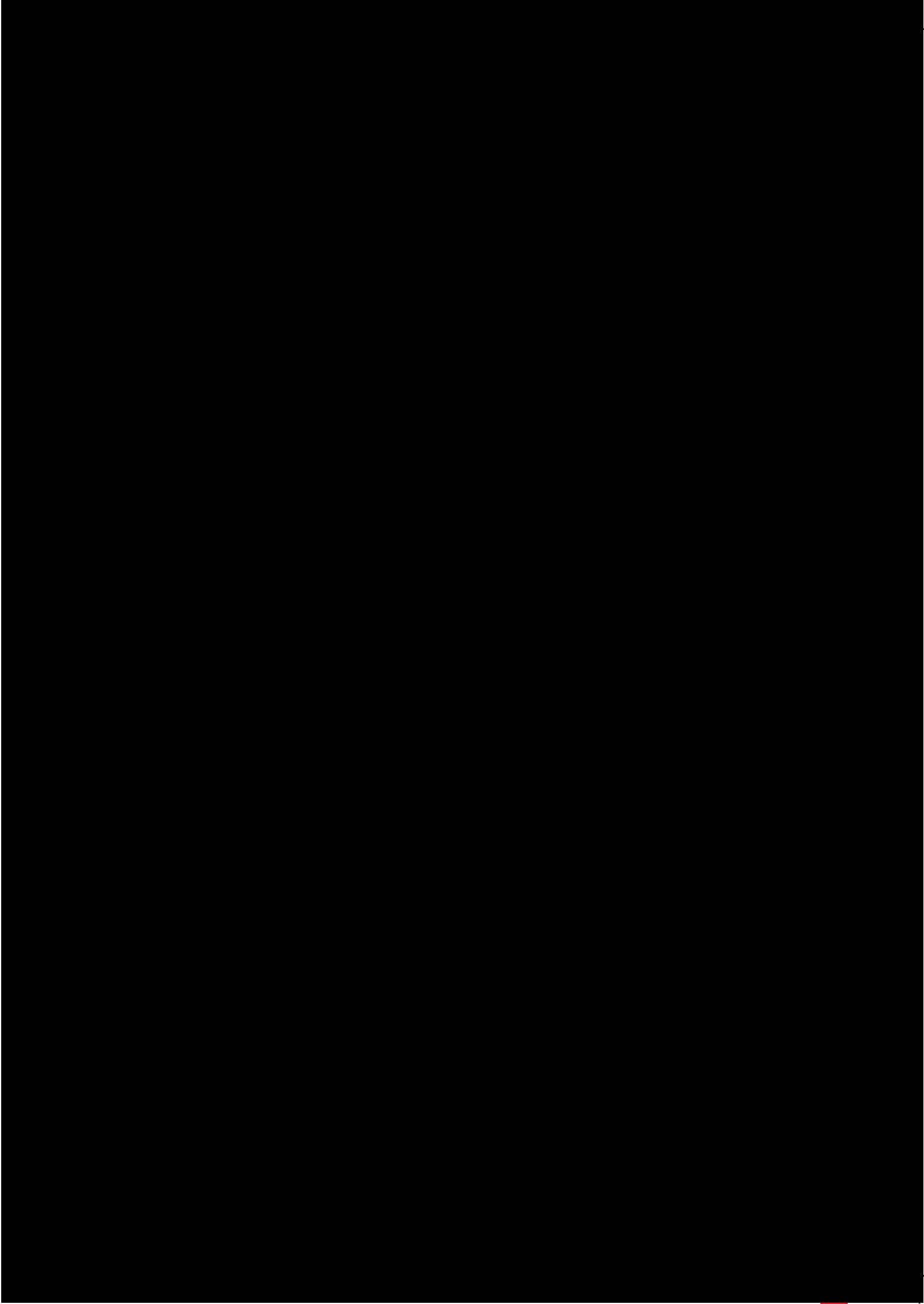


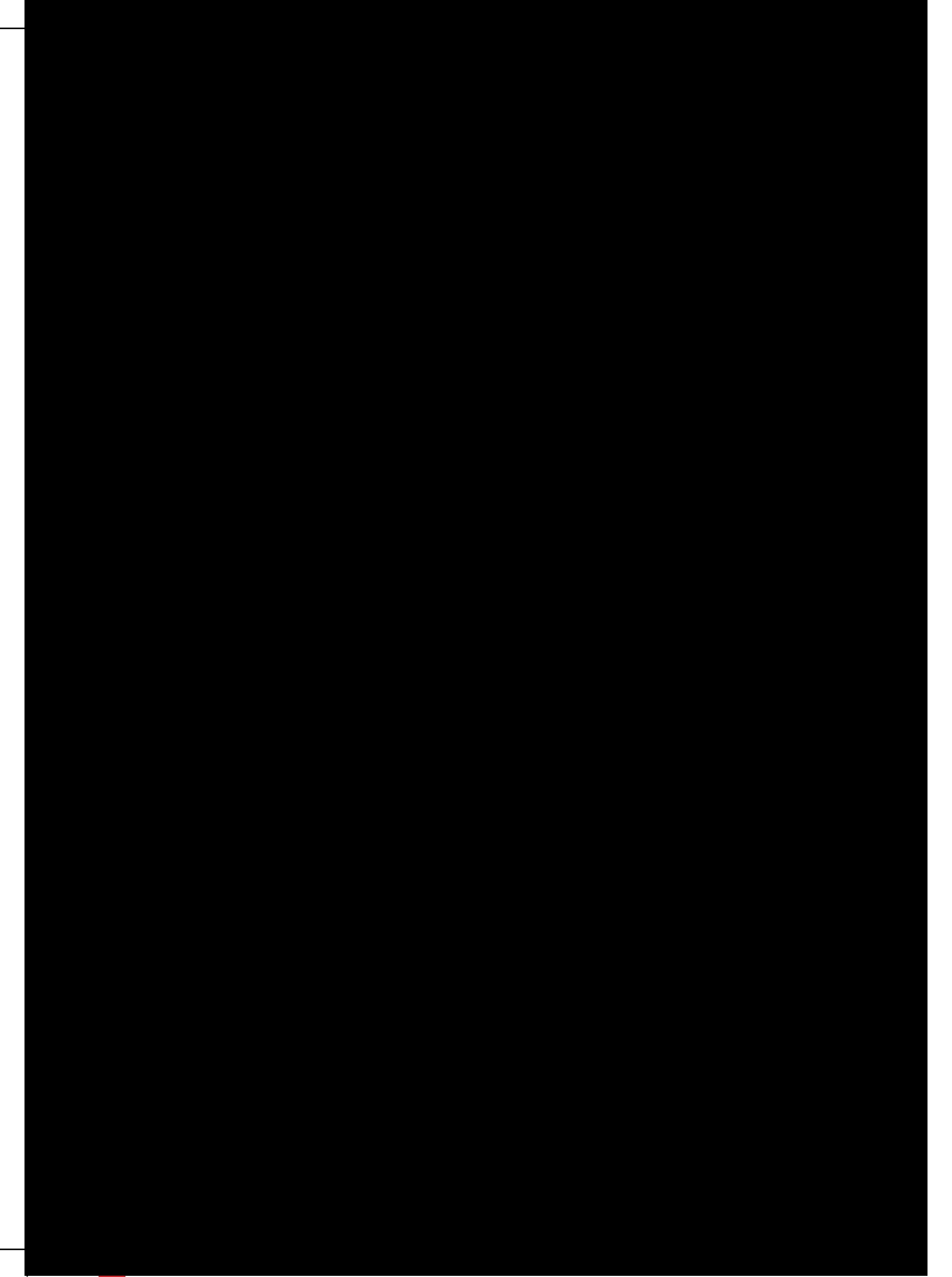


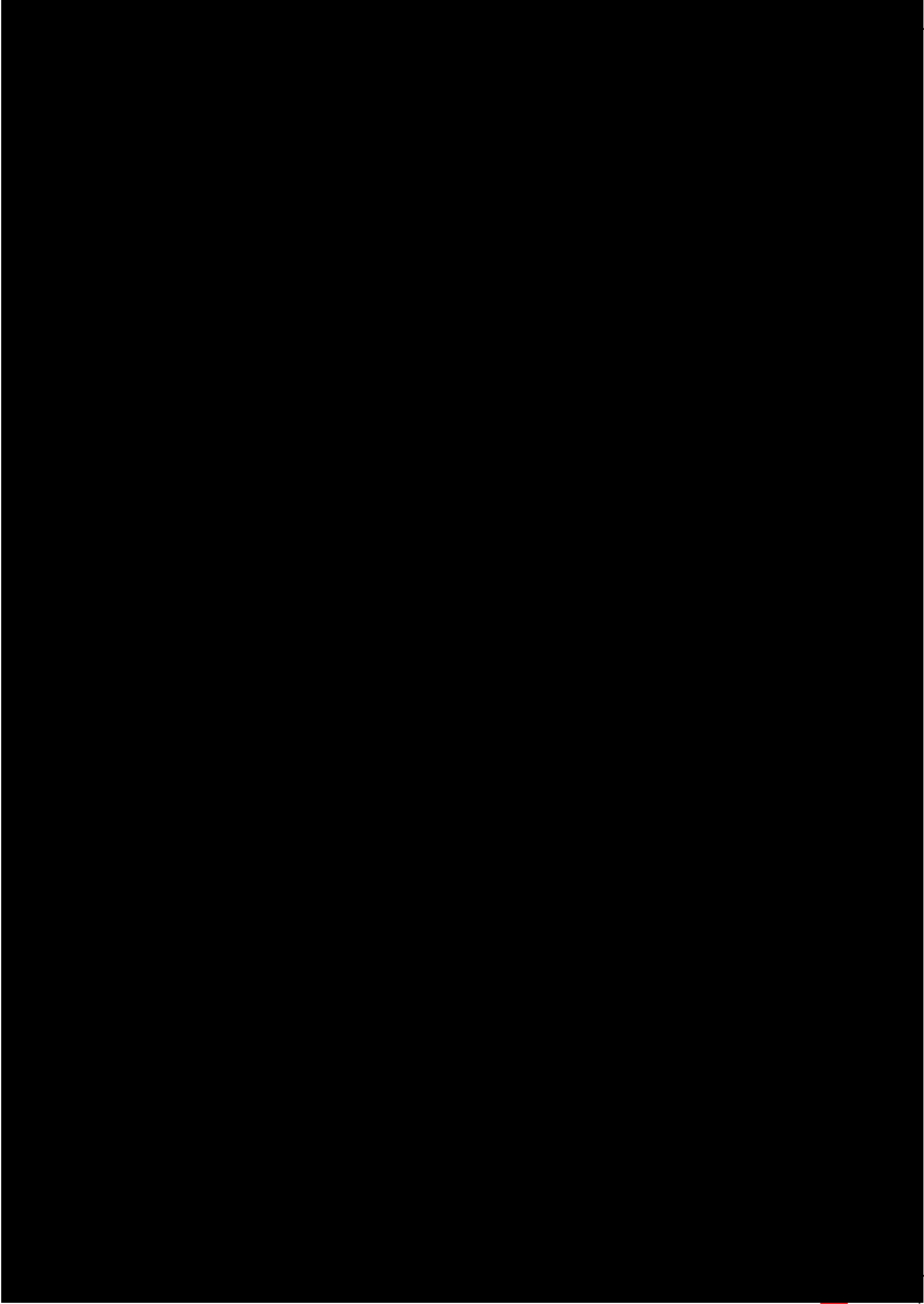


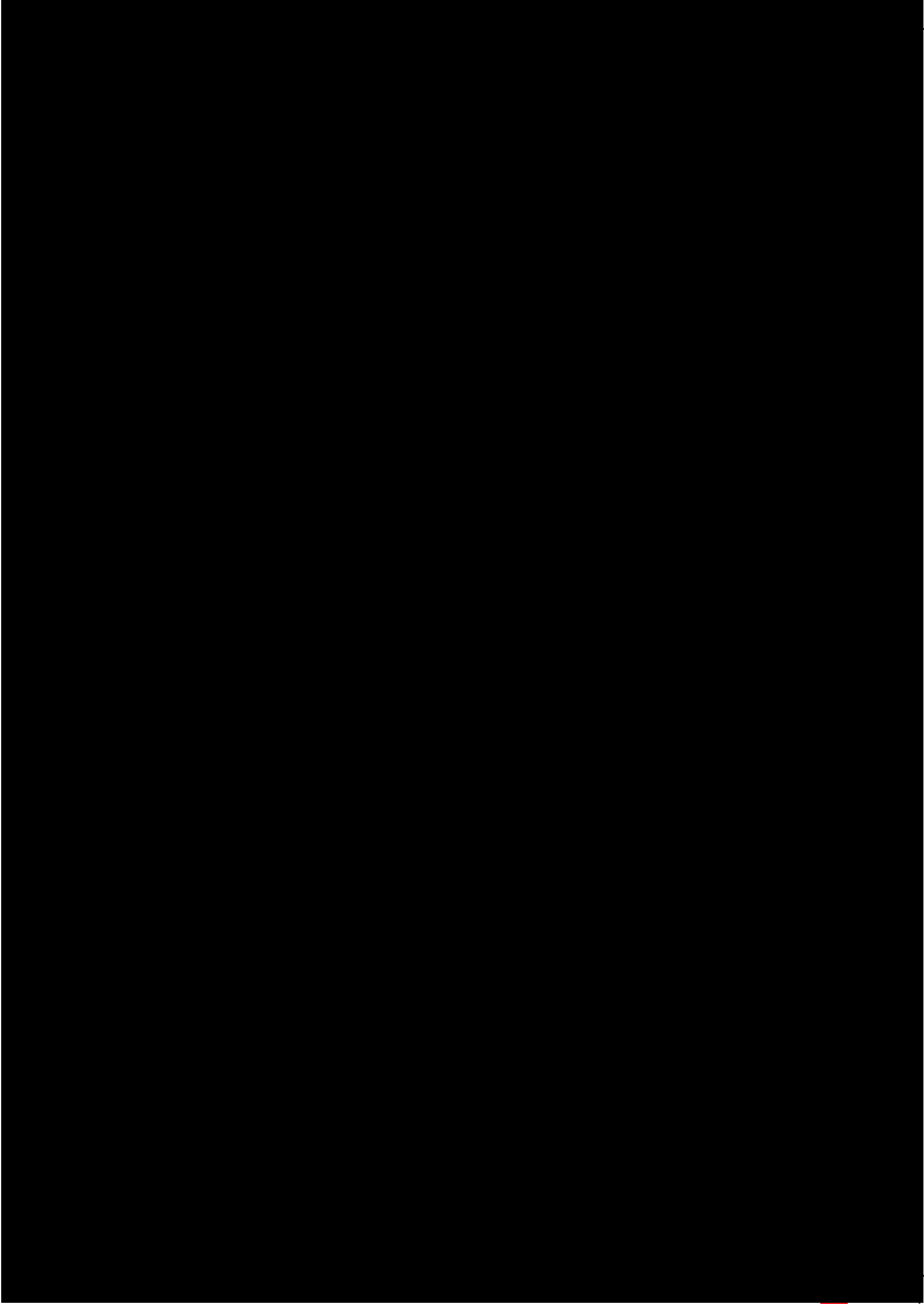


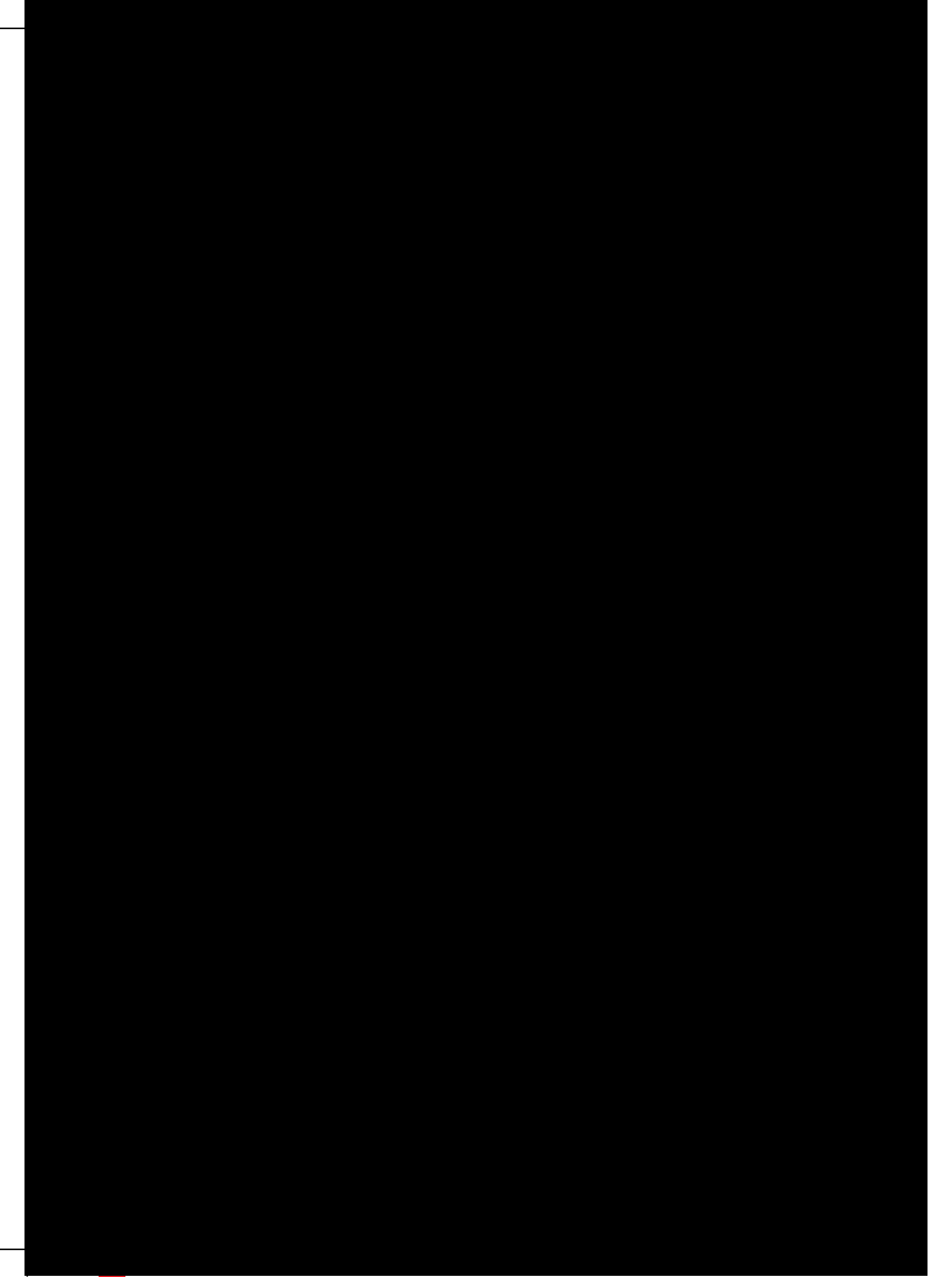












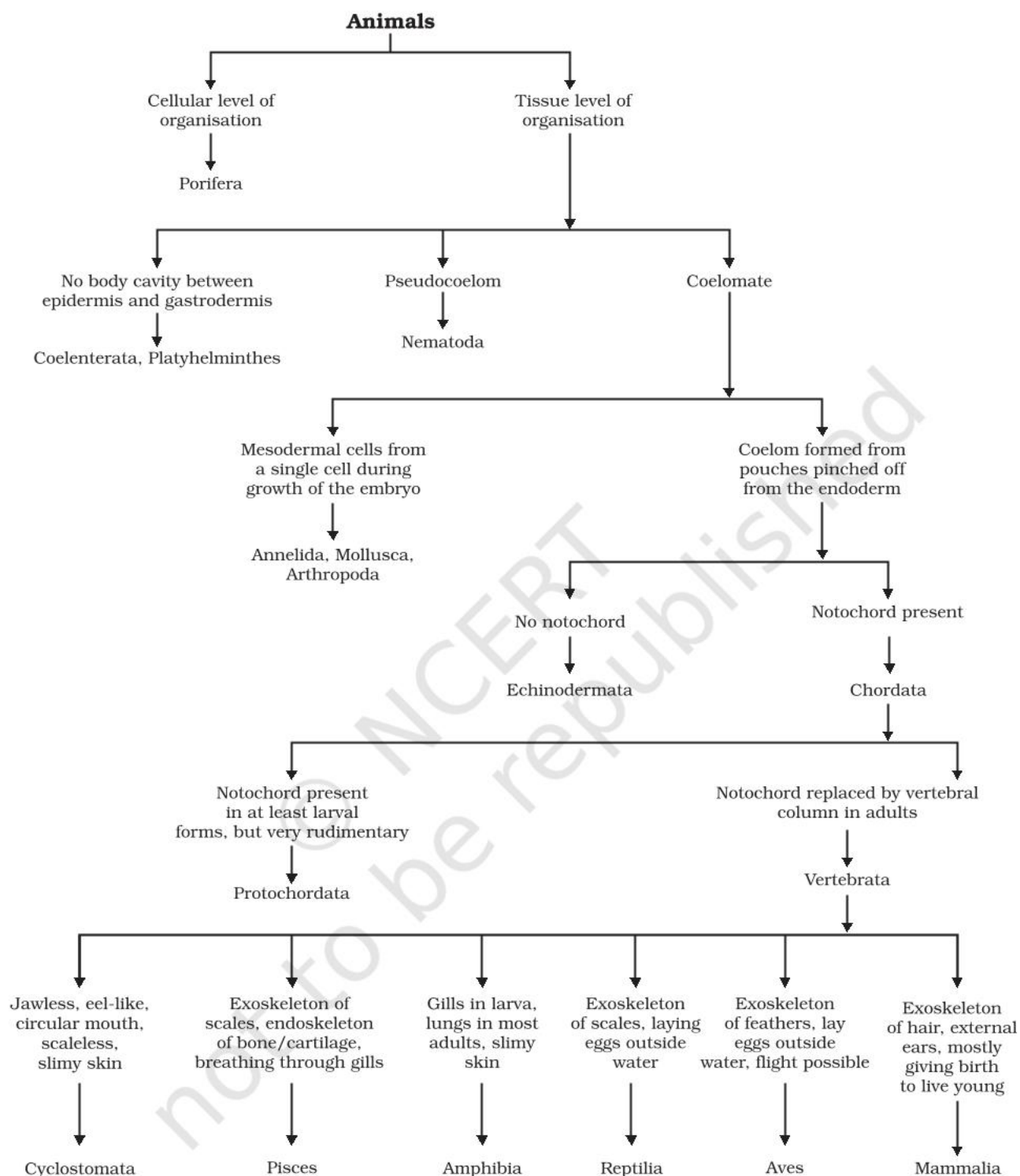
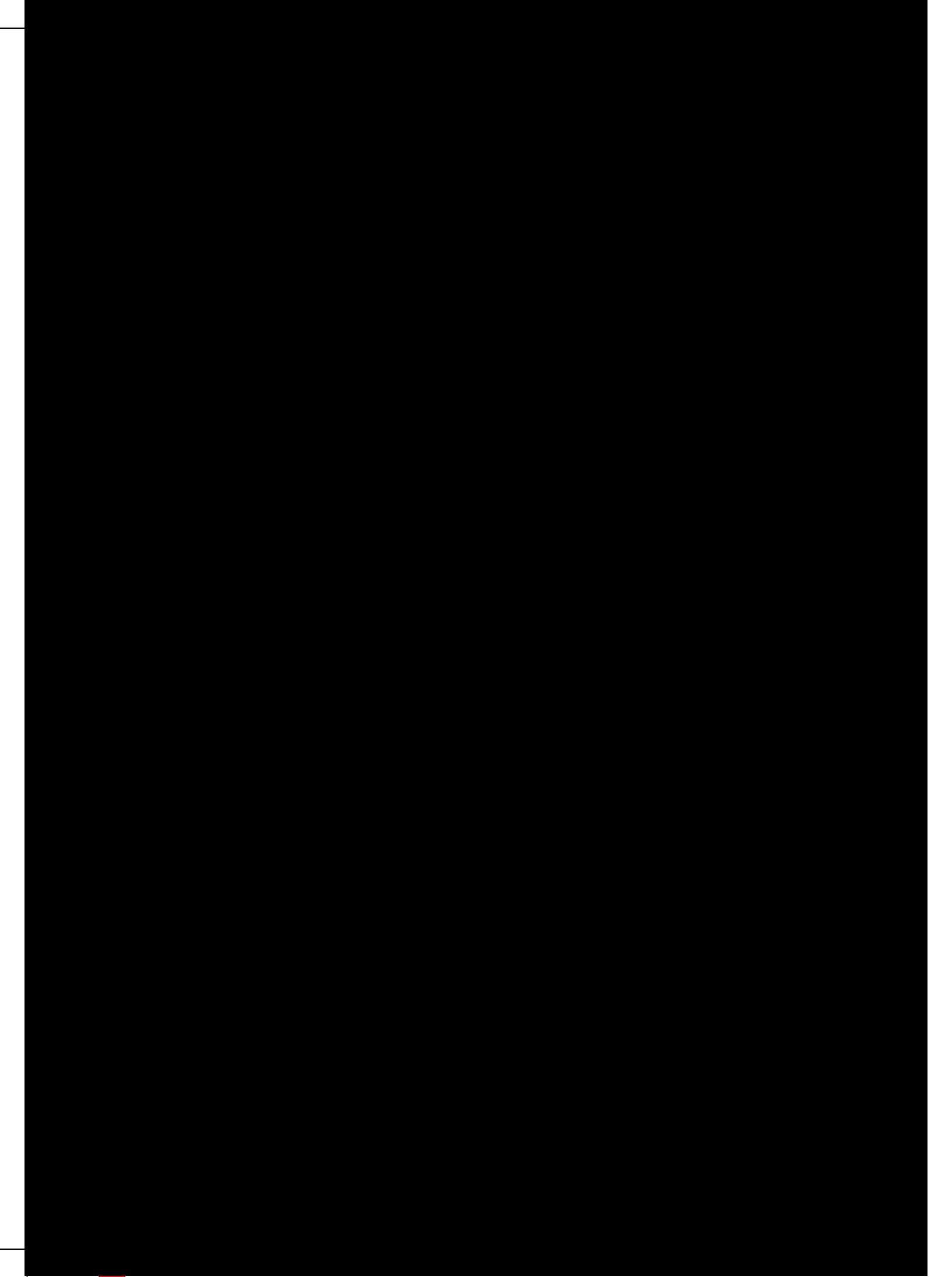
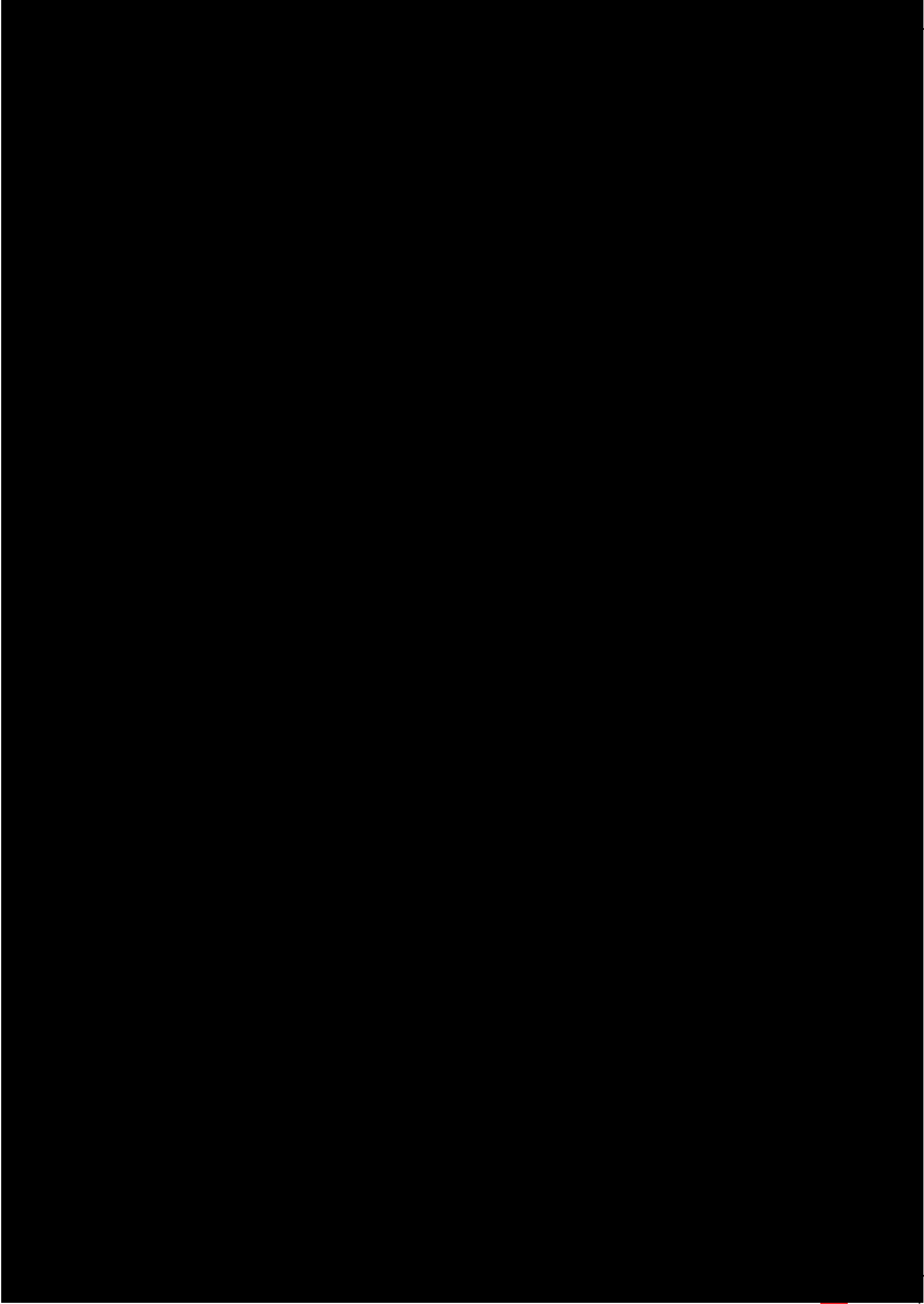
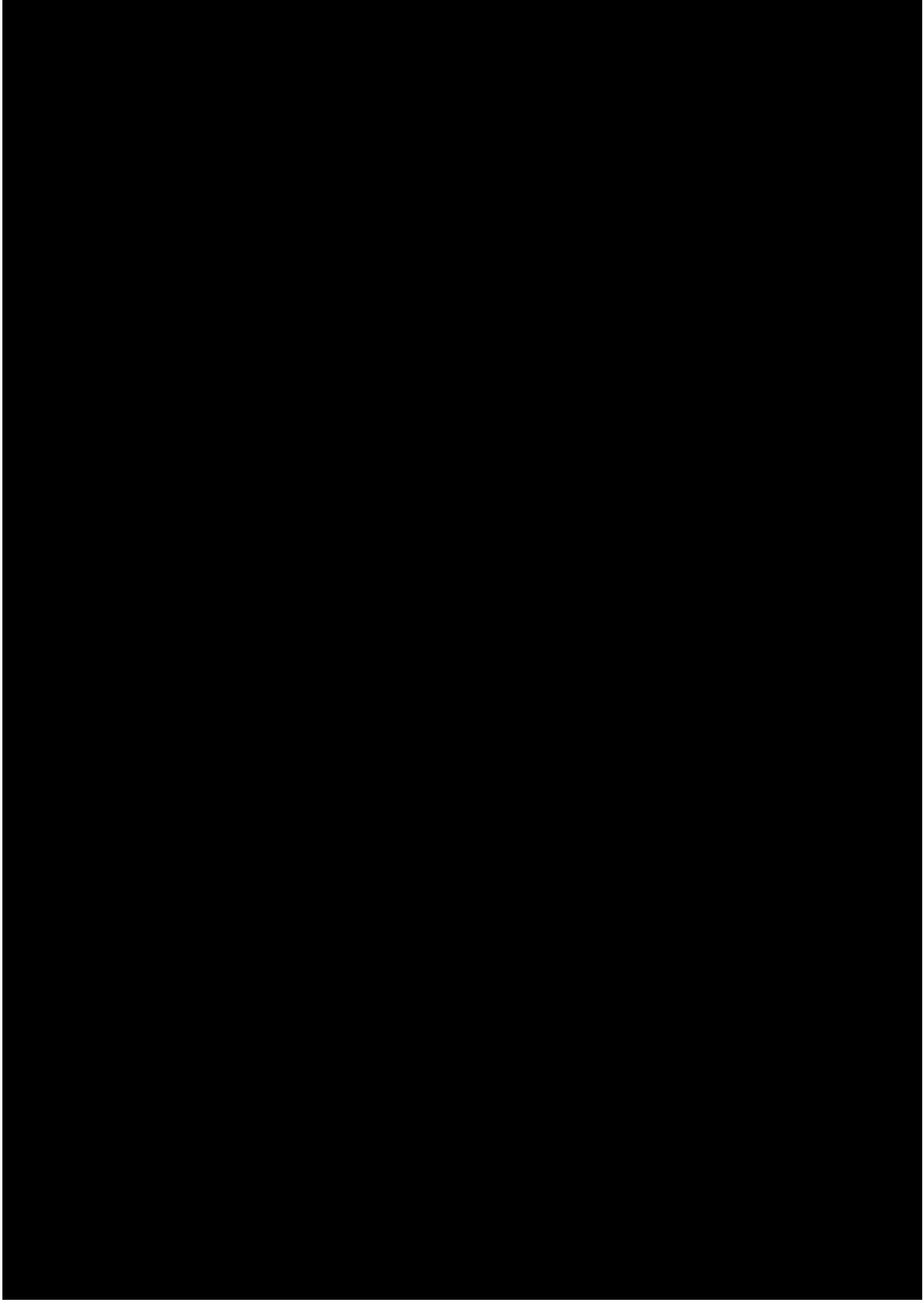
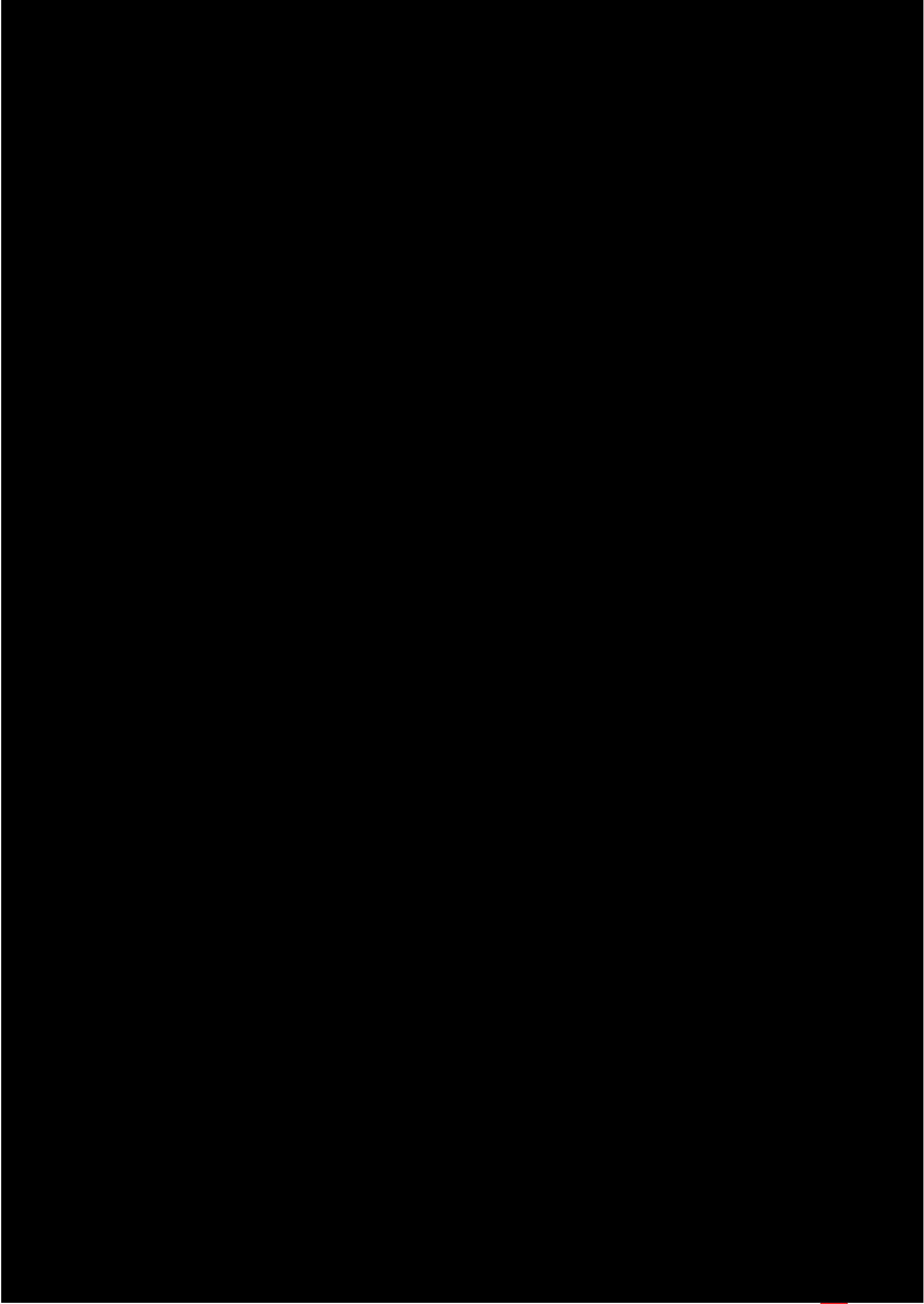


Fig. 7.27: Classification of animals









Questions

1. An object has moved through a distance. Can it have zero displacement? If yes, support your answer with an example.
2. A farmer moves along the boundary of a square field of side 10 m in 40 s. What will be the magnitude of displacement of the farmer at the end of 2 minutes 20 seconds from his initial position?
3. Which of the following is true for displacement?
 - (a) It cannot be zero.
 - (b) Its magnitude is greater than the distance travelled by the object.

8.1.2 UNIFORM MOTION AND NON-UNIFORM MOTION

Consider an object moving along a straight line. Let it travel 5 m in the first second, 5 m more in the next second, 5 m in the third second and 5 m in the fourth second. In this case, the object covers 5 m in each second. As the object covers equal distances in equal intervals of time, it is said to be in uniform motion. The time interval in this motion should be small. In our day-to-day life, we come across motions where objects cover unequal distances in equal intervals of time, for example, when a car is moving on a crowded street or a person is jogging in a park. These are some instances of non-uniform motion.

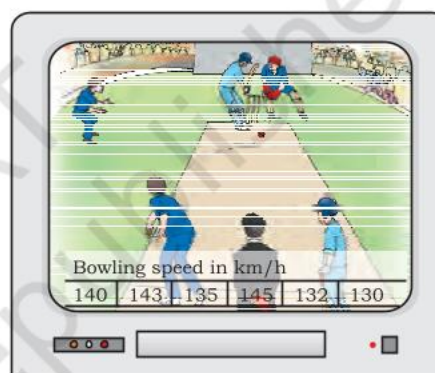
Activity 8.5

- The data regarding the motion of two different objects A and B are given in Table 8.1.
- Examine them carefully and state whether the motion of the objects is uniform or non-uniform.

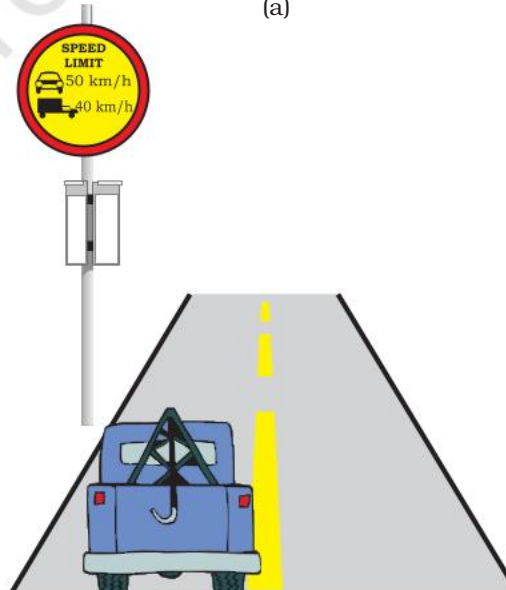
Table 8.1

Time	Distance travelled by object A in m	Distance travelled by object B in m
9:30 am	10	12
9:45 am	20	19
10:00 am	30	23
10:15 am	40	35
10:30 am	50	37
10:45 am	60	41
11:00 am	70	44

8.2 Measuring the Rate of Motion

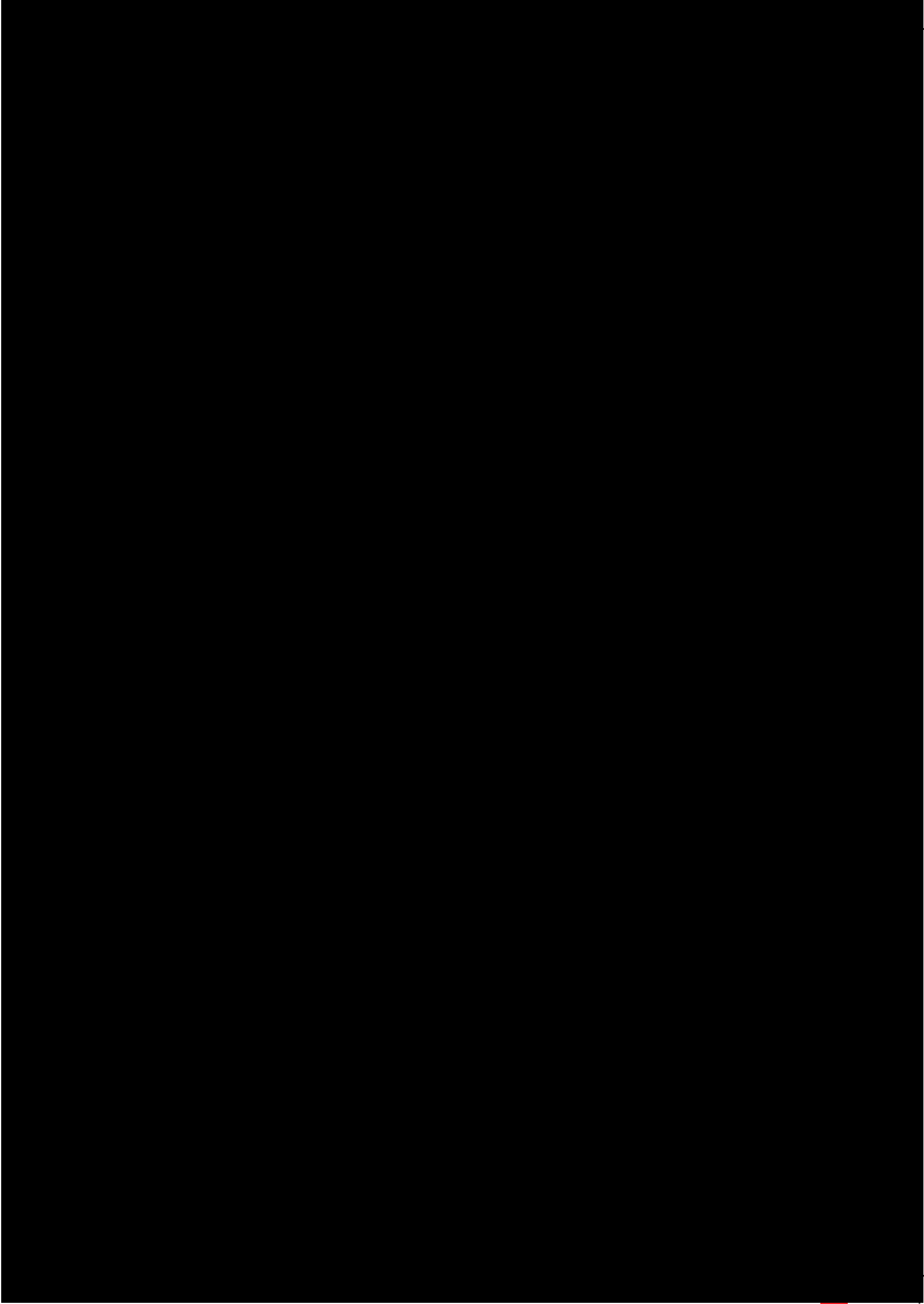


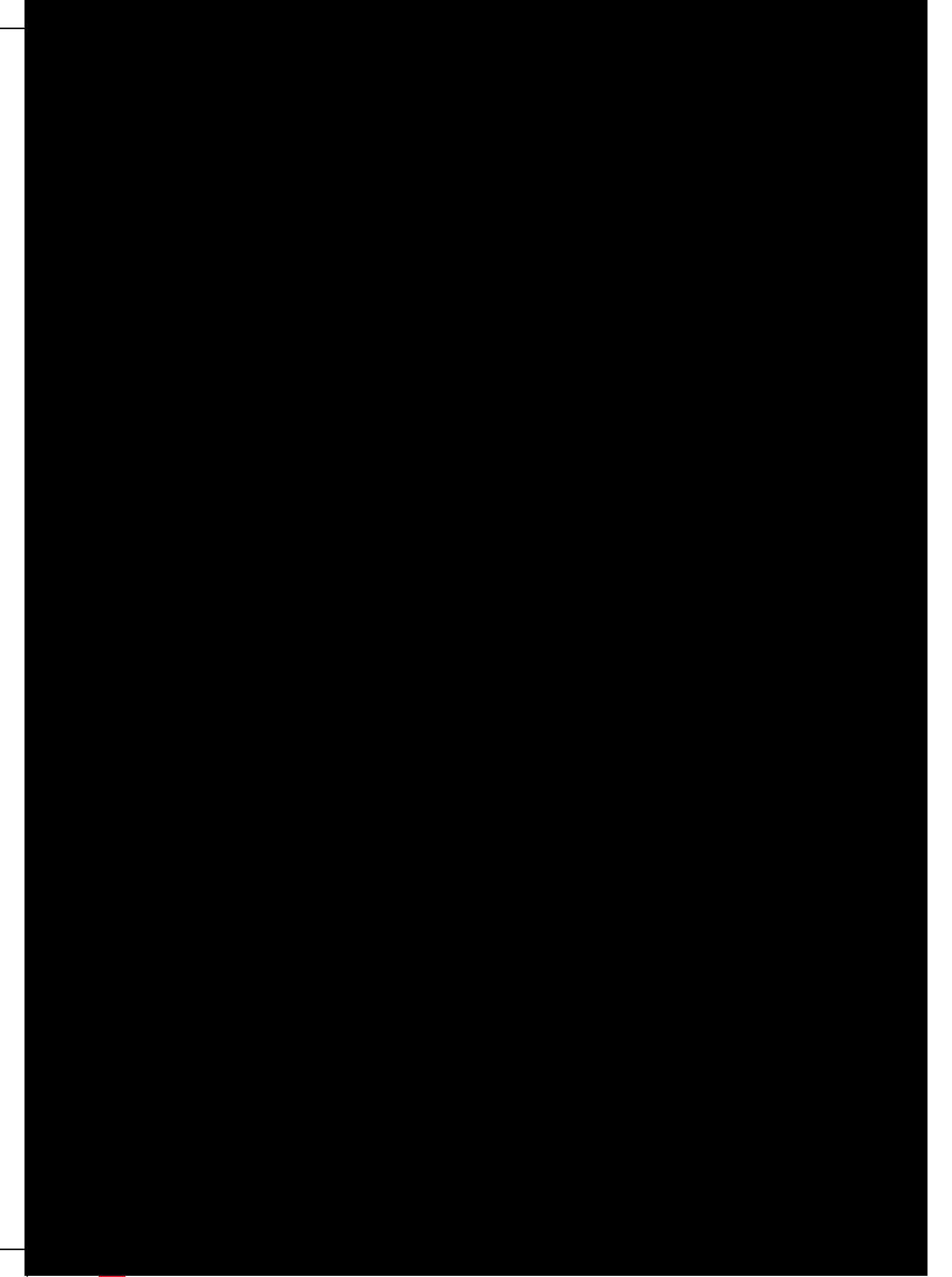
(a)

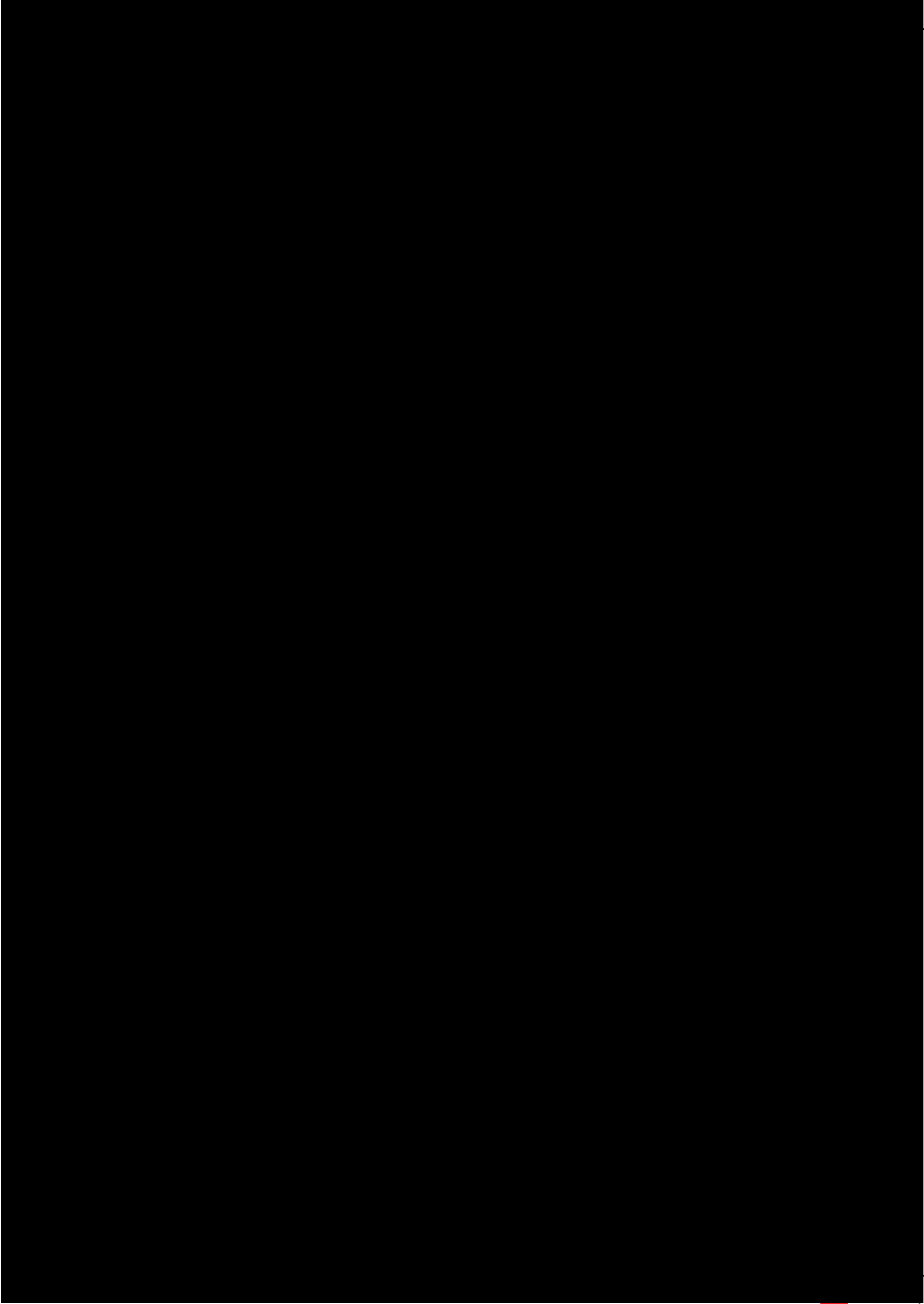


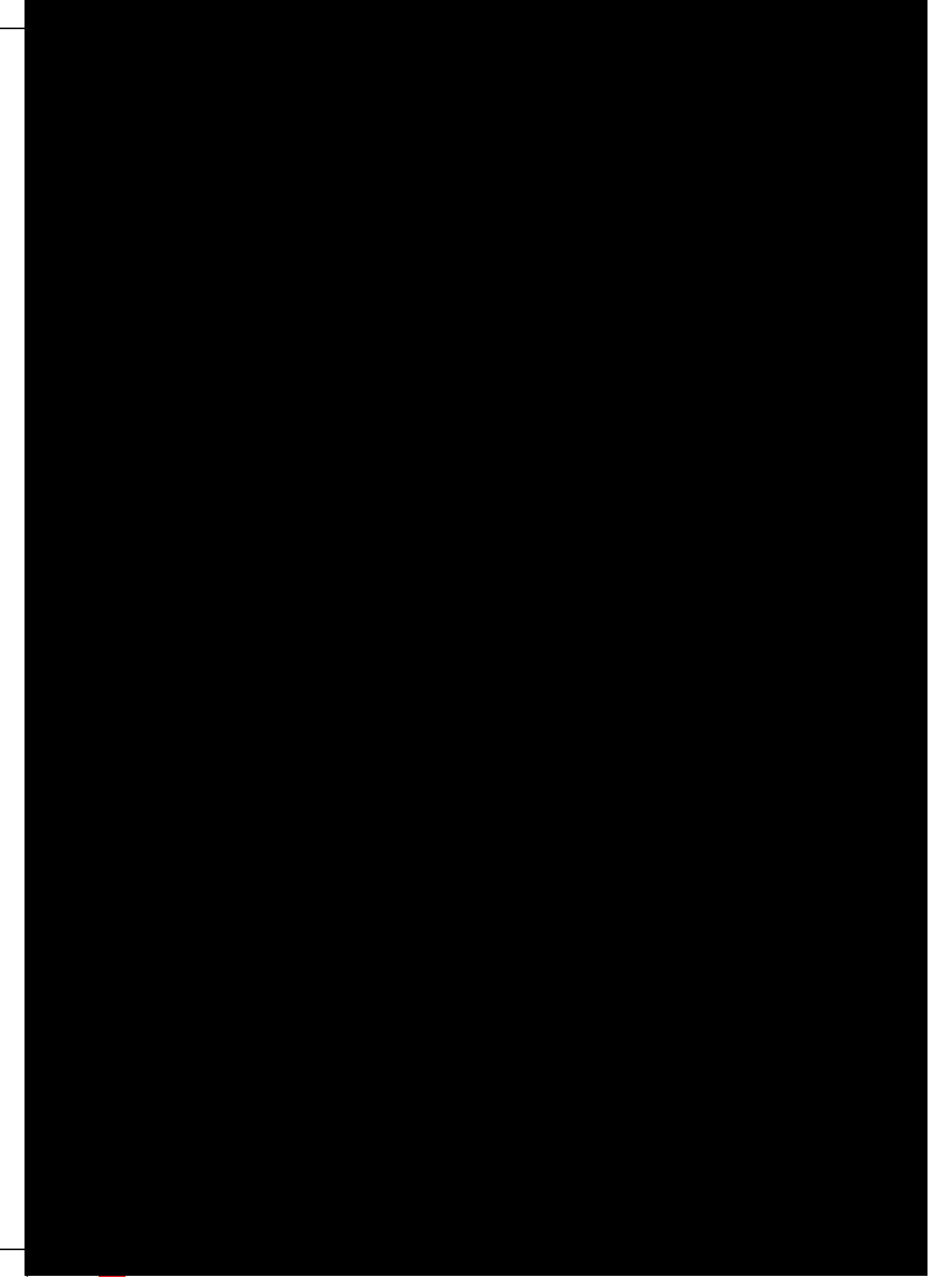
(b)

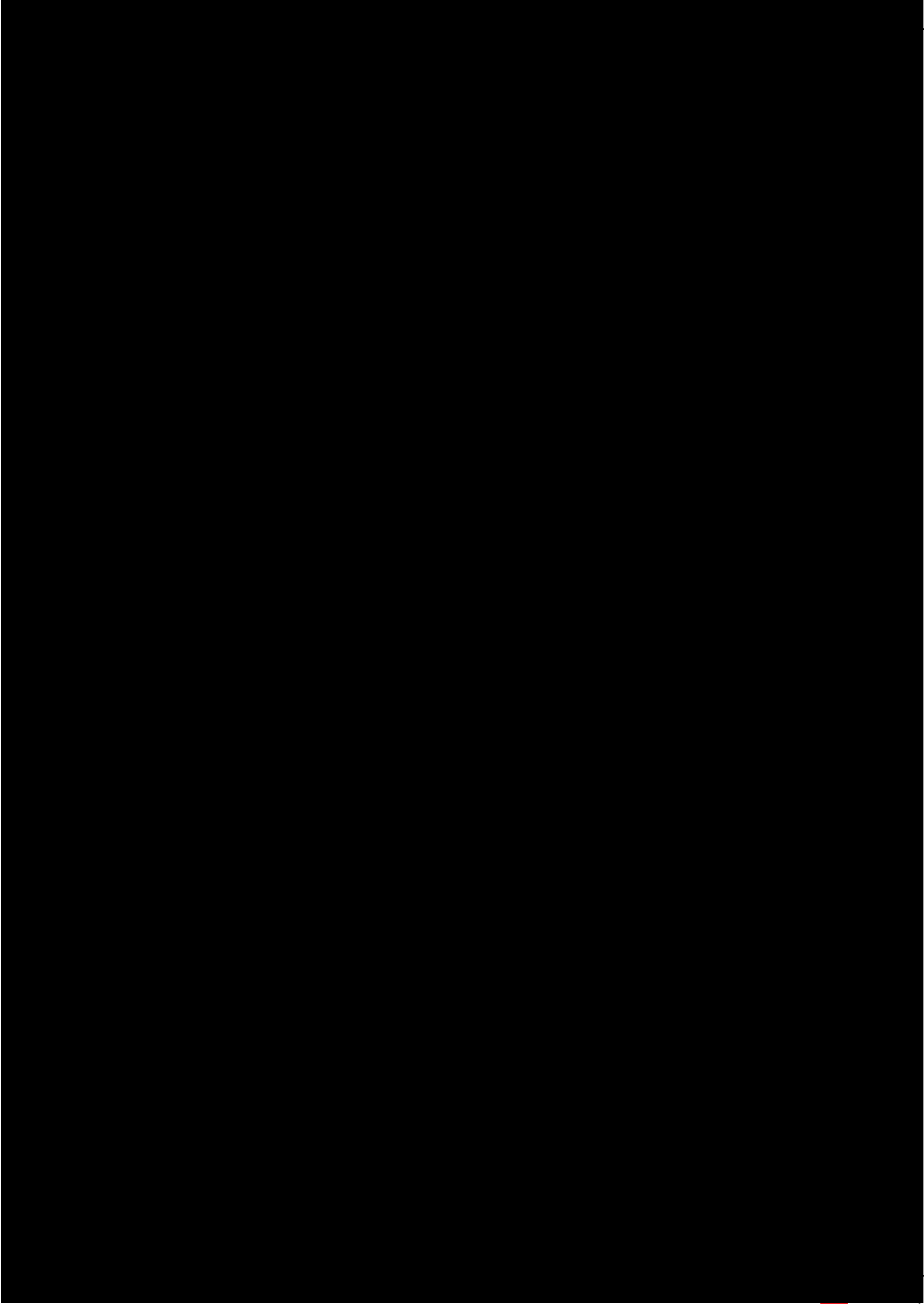
Fig. 8.2

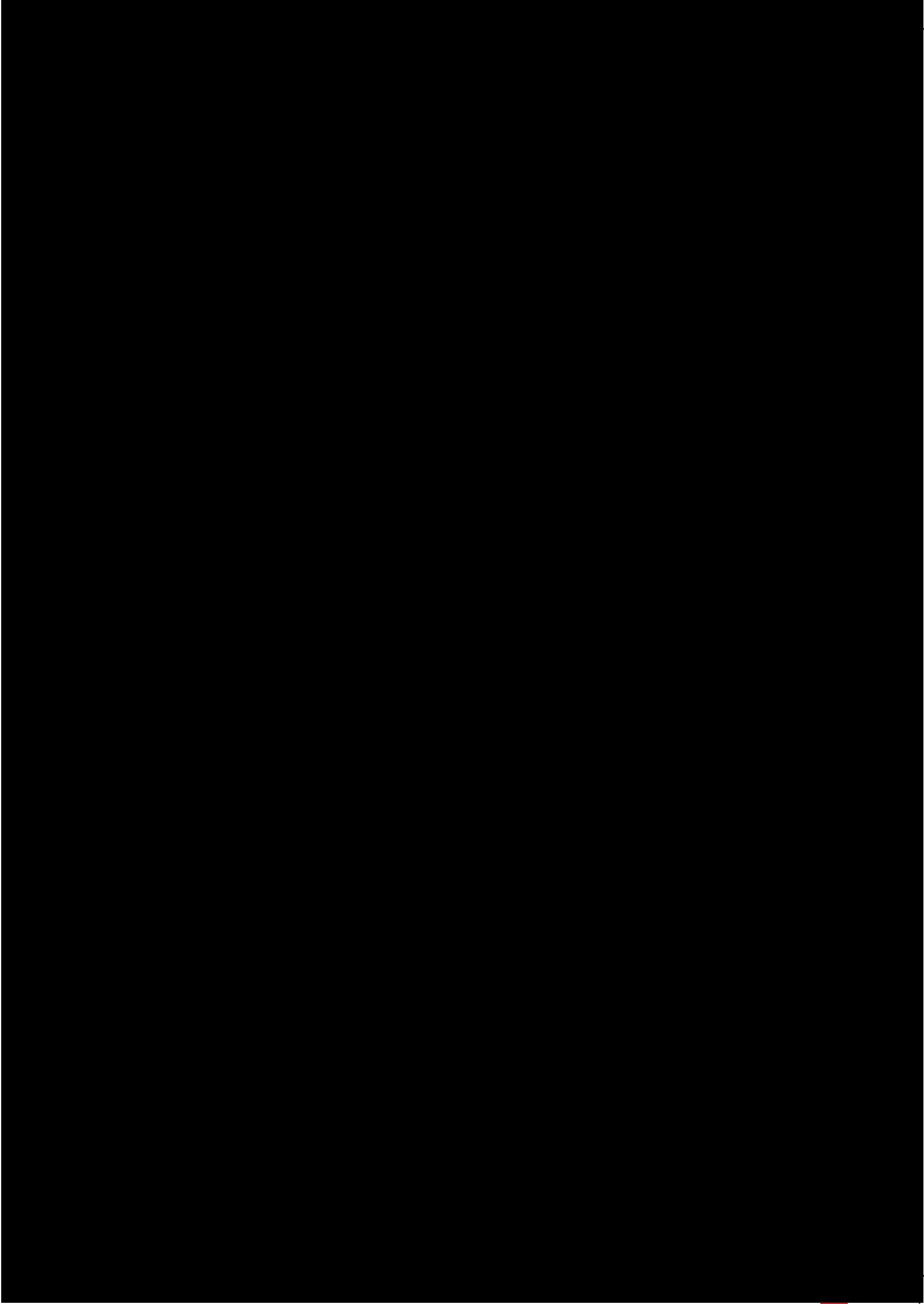


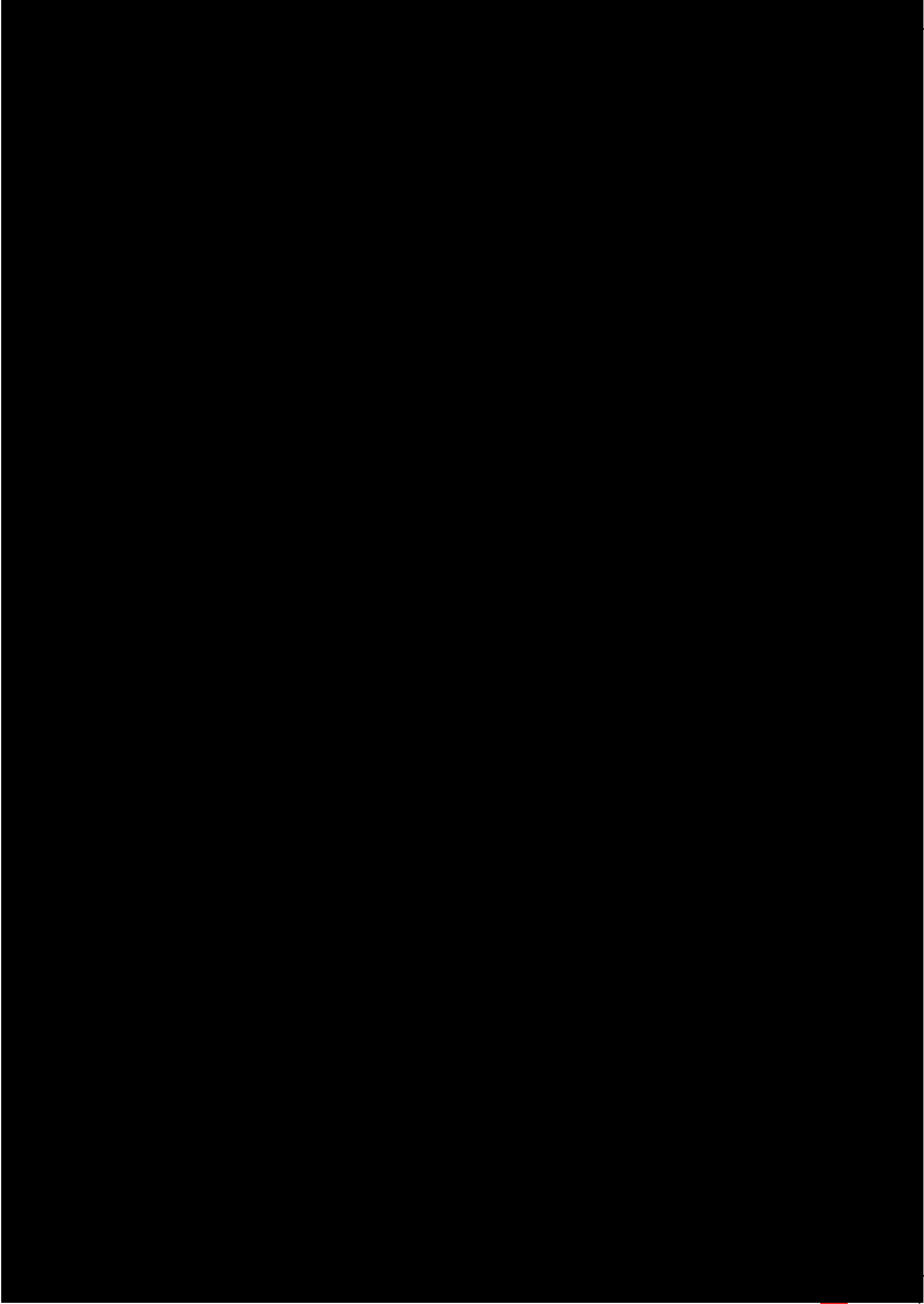


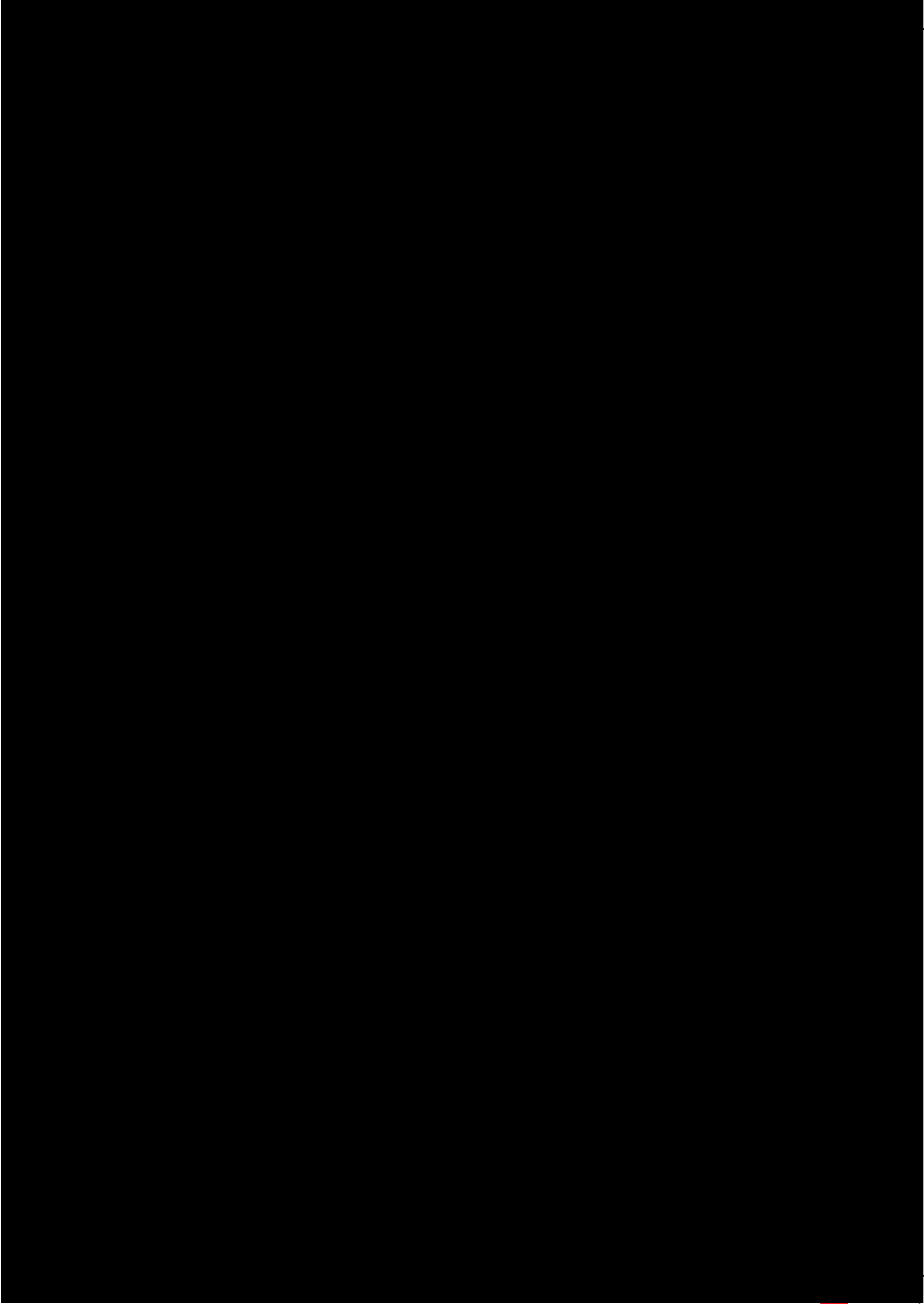


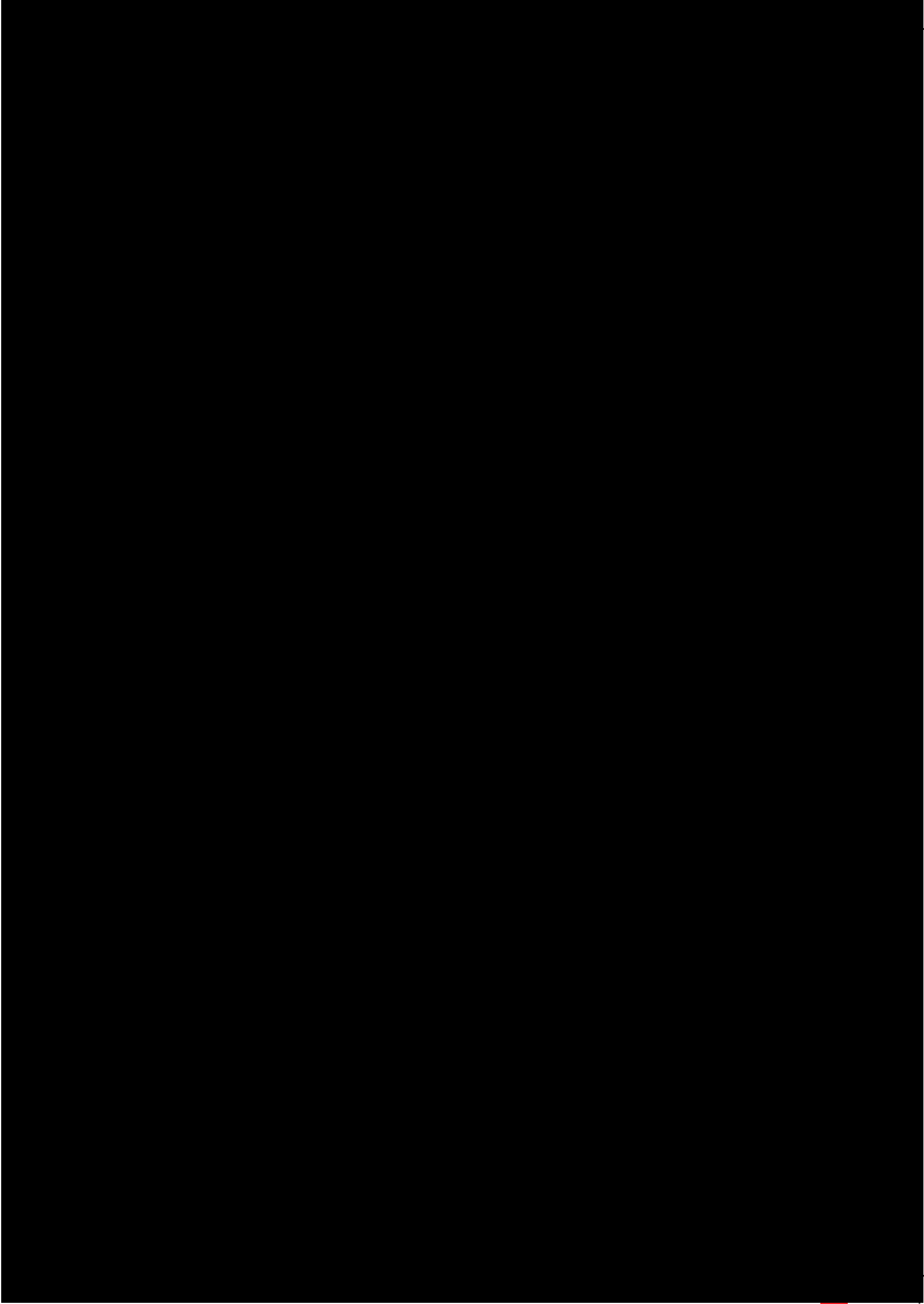












Chapter 9

FORCE AND LAWS OF MOTION

In the previous chapter, we described the motion of an object along a straight line in terms of its position, velocity and acceleration. We saw that such a motion can be uniform or non-uniform. We have not yet discovered what causes the motion. Why does the speed of an object change with time? Do all motions require a cause? If so, what is the nature of this cause? In this chapter we shall make an attempt to quench all such curiosities.

For many centuries, the problem of motion and its causes had puzzled scientists and philosophers. A ball on the ground, when given a small hit, does not move forever. Such observations suggest that rest is the “natural state” of an object. This remained the belief until Galileo Galilei and Isaac Newton developed an entirely different approach to understand motion.

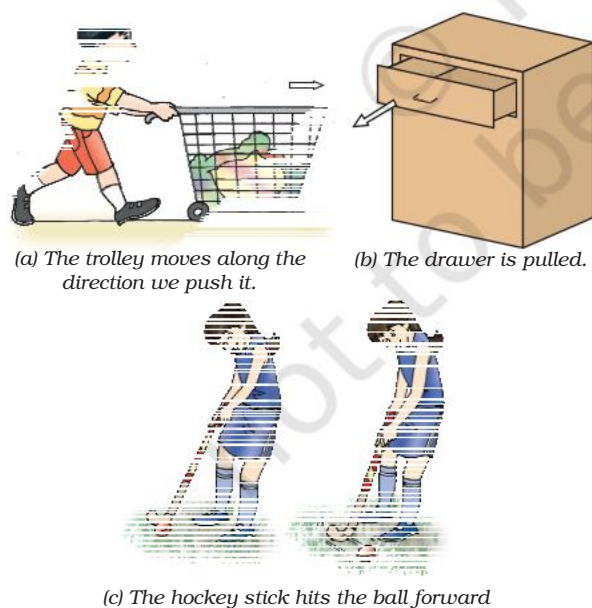


Fig. 9.1: Pushing, pulling, or hitting objects change their state of motion.

In our everyday life we observe that some effort is required to put a stationary object into motion or to stop a moving object. We ordinarily experience this as a muscular effort and say that we must push or hit or pull on an object to change its state of motion. The concept of force is based on this push, hit or pull. Let us now ponder about a ‘force’. What is it? In fact, no one has seen, tasted or felt a force. However, we always see or feel the effect of a force. It can only be explained by describing what happens when a force is applied to an object. Pushing, hitting and pulling of objects are all ways of bringing objects in motion (Fig. 9.1). They move because we make a force act on them.

From your studies in earlier classes, you are also familiar with the fact that a force can be used to change the magnitude of velocity of an object (that is, to make the object move faster or slower) or to change its direction of motion. We also know that a force can change the shape and size of objects (Fig. 9.2).

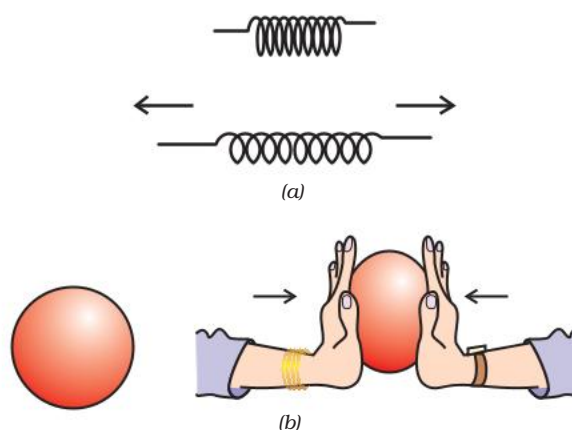


Fig. 9.2: (a) A spring expands on application of force; (b) A spherical rubber ball becomes oblong as we apply force on it.

9.1 Balanced and Unbalanced Forces

Fig. 9.3 shows a wooden block on a horizontal table. Two strings X and Y are tied to the two opposite faces of the block as shown. If we apply a force by pulling the string X, the block begins to move to the right. Similarly, if we pull the string Y, the block moves to the left. But, if the block is pulled from both the sides with equal forces, the block will not move. Such forces are called balanced forces and do not change the state of rest or of motion of an object. Now, let us consider a situation in which two opposite forces of different magnitudes pull the block. In this case, the block would begin to move in the direction of the greater force. Thus, the two forces are not balanced and the unbalanced force acts in the direction the block moves. This suggests that an unbalanced force acting on an object brings it in motion.

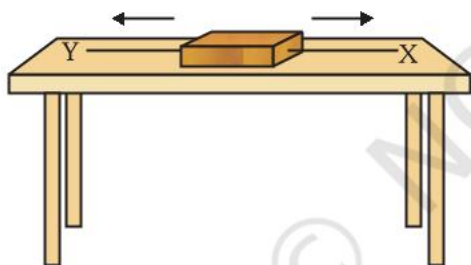


Fig. 9.3: Two forces acting on a wooden block

What happens when some children try to push a box on a rough floor? If they push the

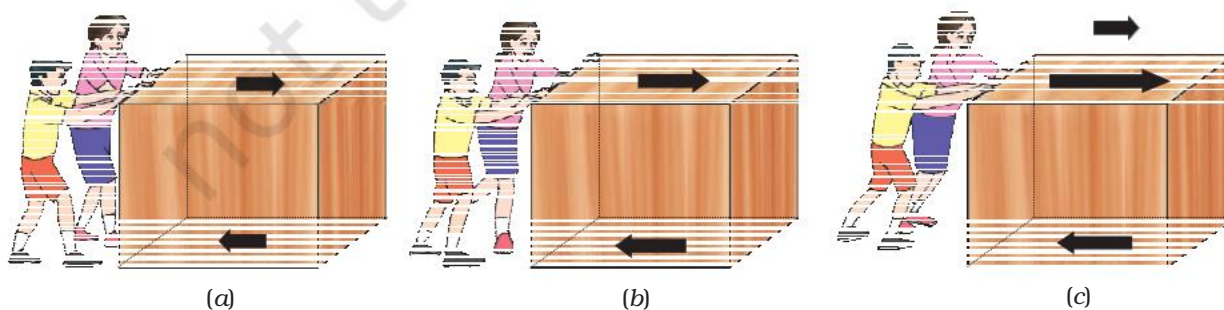


Fig. 9.4

box with a small force, the box does not move because of friction acting in a direction opposite to the push [Fig. 9.4(a)]. This friction force arises between two surfaces in contact; in this case, between the bottom of the box and floor's rough surface. It balances the pushing force and therefore the box does not move. In Fig. 9.4(b), the children push the box harder but the box still does not move. This is because the friction force still balances the pushing force. If the children push the box harder still, the pushing force becomes bigger than the friction force [Fig. 9.4(c)]. There is an unbalanced force. So the box starts moving.

What happens when we ride a bicycle? When we stop pedalling, the bicycle begins to slow down. This is again because of the friction forces acting opposite to the direction of motion. In order to keep the bicycle moving, we have to start pedalling again. It thus appears that an object maintains its motion under the continuous application of an unbalanced force. However, it is quite incorrect. An object moves with a uniform velocity when the forces (pushing force and frictional force) acting on the object are balanced and there is no net external force on it. If an unbalanced force is applied on the object, there will be a change either in its speed or in the direction of its motion. Thus, to accelerate the motion of an object, an unbalanced force is required. And the change in its speed (or in the direction of motion) would continue as long as this unbalanced force is applied. However, if this force is

removed completely, the object would continue to move with the velocity it has acquired till then.

9.2 First Law of Motion

By observing the motion of objects on an inclined plane Galileo deduced that objects move with a constant speed when no force acts on them. He observed that when a marble rolls down an inclined plane, its velocity increases [Fig. 9.5(a)]. In the next chapter, you will learn that the marble falls under the unbalanced force of gravity as it rolls down and attains a definite velocity by the time it reaches the bottom. Its velocity decreases when it climbs up as shown in Fig. 9.5(b). Fig. 9.5(c) shows a marble resting on an ideal frictionless plane inclined on both sides. Galileo argued that when the marble is released from left, it would roll down the slope and go up on the opposite side to the same height from which it was released. If the inclinations of the planes on both sides are equal then the marble will climb the same distance that it covered while rolling down. If the angle of inclination of the right-side plane were gradually decreased, then the marble would travel further distances till it reaches the original height. If the right-side plane were ultimately made horizontal (that is, the slope is reduced to zero), the marble would continue to travel forever trying to reach the same height that it was released from. The unbalanced forces on the marble in this case are zero. It thus suggests that an unbalanced (external) force is required to change the motion of the marble but no net force is needed to sustain the uniform motion of the marble. In practical situations it is difficult to achieve a zero unbalanced force. This is because of the presence of the frictional force acting opposite to the direction of motion. Thus, in practice the marble stops after travelling some distance. The effect of the frictional force may be minimised by using a smooth marble and a smooth plane and providing a lubricant on top of the planes.

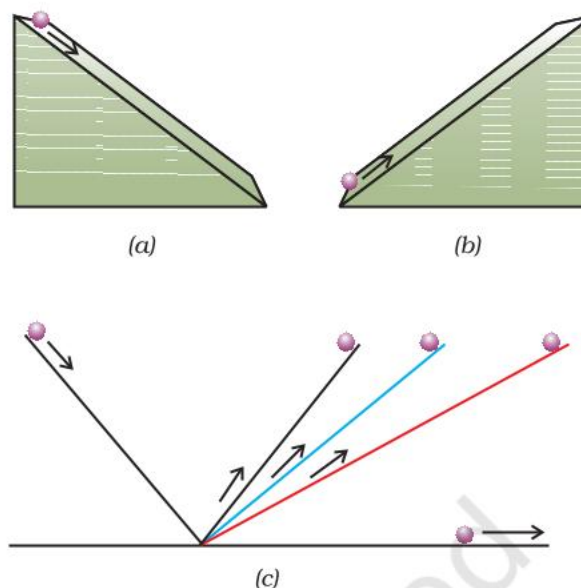


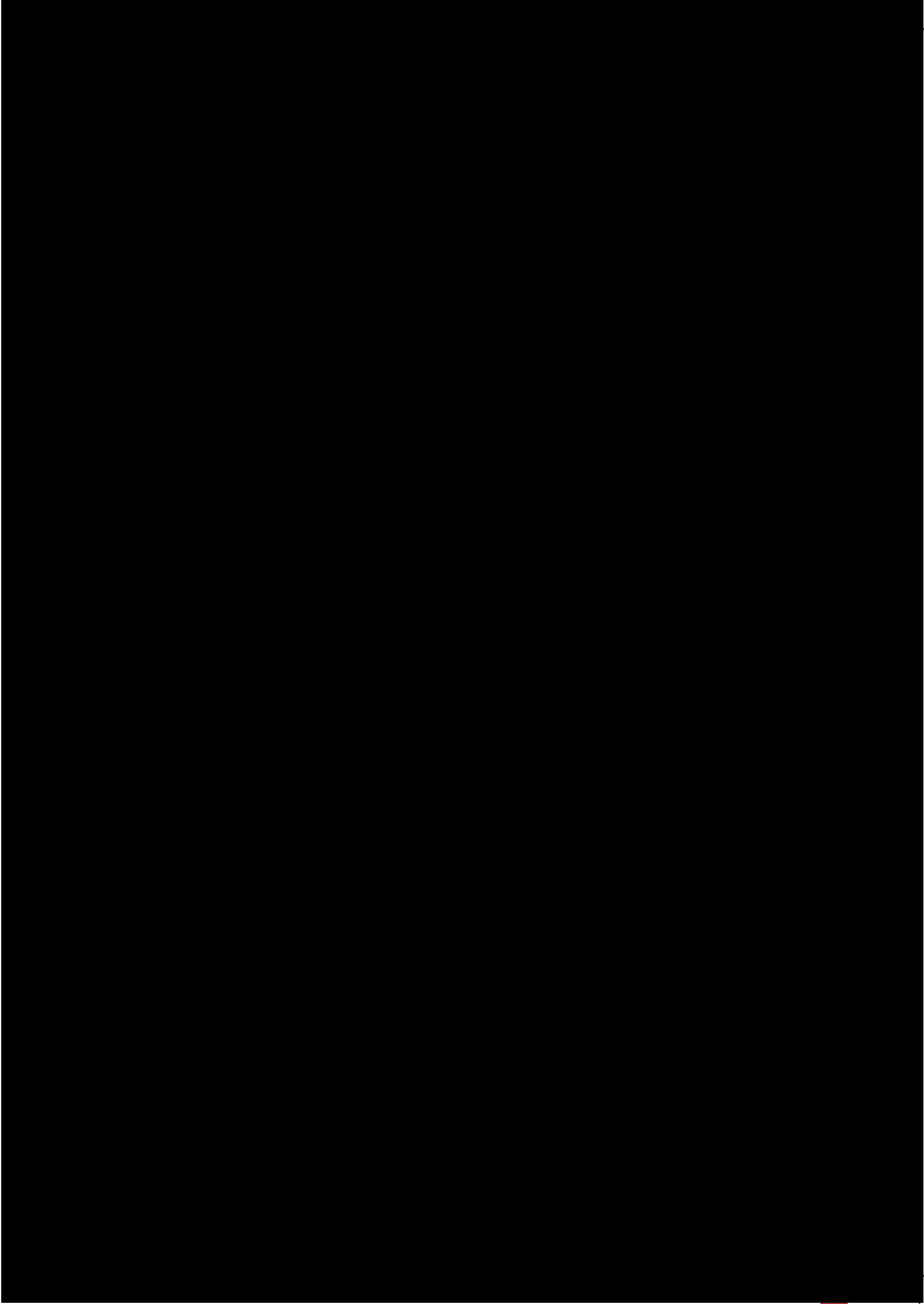
Fig. 9.5: (a) the downward motion; (b) the upward motion of a marble on an inclined plane; and (c) on a double inclined plane.

Newton further studied Galileo's ideas on force and motion and presented three fundamental laws that govern the motion of objects. These three laws are known as Newton's laws of motion. The first law of motion is stated as:

An object remains in a state of rest or of uniform motion in a straight line unless compelled to change that state by an applied force.

In other words, all objects resist a change in their *state of motion*. In a qualitative way, the tendency of undisturbed objects to stay at rest or to keep moving with the same velocity is called inertia. This is why, the first law of motion is also known as the law of inertia.

Certain experiences that we come across while travelling in a motorcar can be explained on the basis of the law of inertia. We tend to remain at rest with respect to the seat until the driver applies a braking force to stop the motorcar. With the application of brakes, the car slows down but our body tends to continue in the same state of motion because of its inertia. A sudden application of brakes may thus cause injury to us by



Activity 9.2

- Set a five-rupee coin on a stiff card covering an empty glass tumbler standing on a table as shown in Fig. 9.7.
- Give the card a sharp horizontal flick with a finger. If we do it fast then the card shoots away, allowing the coin to fall vertically into the glass tumbler due to its inertia.
- The inertia of the coin tries to maintain its state of rest even when the card flows off.

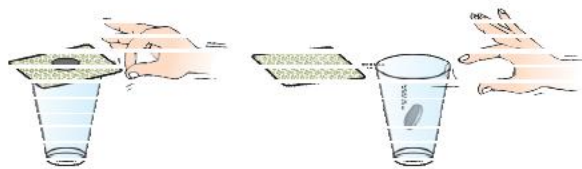


Fig. 9.7: When the card is flicked with the finger the coin placed over it falls in the tumbler.

Activity 9.3

- Place a water-filled tumbler on a tray.
- Hold the tray and turn around as fast as you can.
- We observe that the water spills. Why?

Observe that a groove is provided in a saucer for placing the tea cup. It prevents the cup from toppling over in case of sudden jerks.

9.3 Inertia and Mass

All the examples and activities given so far illustrate that there is a resistance offered by an object to change its state of motion. If it is at rest it tends to remain at rest; if it is moving it tends to keep moving. This property of an object is called its inertia. Do all bodies have the same inertia? We know that it is easier to push an empty box than a box full of books. Similarly, if we kick a football it flies away. But if we kick a stone of the same size with equal force, it hardly moves. We may, in fact, get an injury in our foot while doing so! Similarly, in activity 9.2, instead of a

five-rupees coin if we use a one-rupee coin, we find that a lesser force is required to perform the activity. A force that is just enough to cause a small cart to pick up a large velocity will produce a negligible change in the motion of a train. This is because, in comparison to the cart the train has a much lesser tendency to change its state of motion. Accordingly, we say that the train has more inertia than the cart. Clearly, heavier or more massive objects offer larger inertia. Quantitatively, the inertia of an object is measured by its mass. We may thus relate inertia and mass as follows:

Inertia is the natural tendency of an object to resist a change in its state of motion or of rest. The mass of an object is a measure of its inertia.

Questions

1. Which of the following has more inertia: (a) a rubber ball and a stone of the same size? (b) a bicycle and a train? (c) a five-rupees coin and a one-rupee coin?

2. In the following example, try to identify the number of times the velocity of the ball changes:

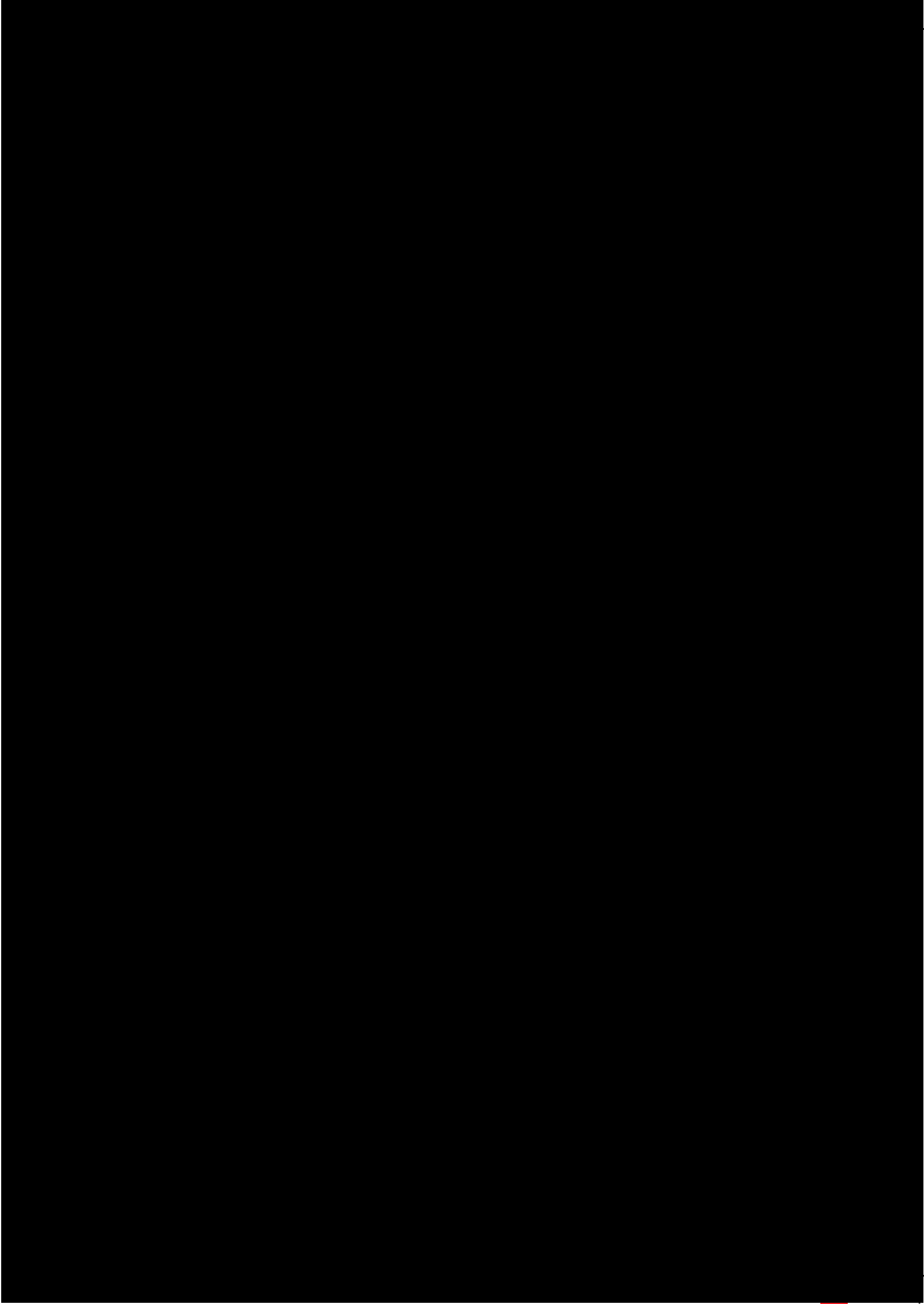
“A football player kicks a football to another player of his team who kicks the football towards the goal. The goalkeeper of the opposite team collects the football and kicks it towards a player of his own team”.

Also identify the agent supplying the force in each case.

3. Explain why some of the leaves may get detached from a tree if we vigorously shake its branch.
4. Why do you fall in the forward direction when a moving bus brakes to a stop and fall backwards when it accelerates from rest?

9.4 Second Law of Motion

The first law of motion indicates that when an unbalanced external force acts on an



motion gives us a method to measure the force acting on an object as a product of its mass and acceleration.

The second law of motion is often seen in action in our everyday life. Have you noticed that while catching a fast moving cricket ball, a fielder in the ground gradually pulls his hands backwards with the moving ball? In doing so, the fielder increases the time during which the high velocity of the moving ball decreases to zero. Thus, the acceleration of the ball is decreased and therefore the impact of catching the fast moving ball (Fig. 9.8) is also reduced. If the ball is stopped suddenly then its high velocity decreases to zero in a very short interval of time. Thus, the rate of change of momentum of the ball will be large. Therefore, a large force would have to be applied for holding the catch that may hurt the palm of the fielder. In a high jump athletic event, the athletes are made to fall either on a cushioned bed or on a sand bed. This is to increase the time of the athlete's fall to stop after making the jump. This decreases the rate of change of momentum and hence the force. Try to ponder how a karate player breaks a slab of ice with a single blow.

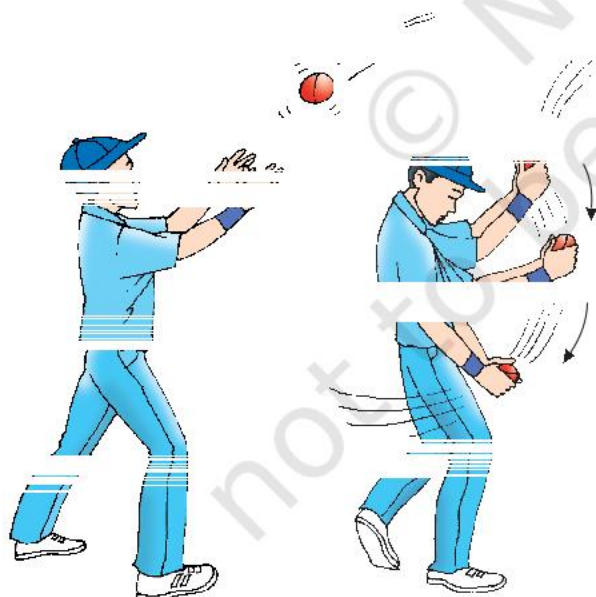


Fig. 9.8: A fielder pulls his hands gradually with the moving ball while holding a catch.

The first law of motion can be mathematically stated from the mathematical expression for the second law of motion. Eq. (9.4) is

$$F = ma$$

$$\text{or } F = \frac{m(v-u)}{t} \quad (9.5)$$

$$\text{or } Ft = mv - mu$$

That is, when $F = 0$, $v = u$ for whatever time, t is taken. This means that the object will continue moving with uniform velocity, u throughout the time, t . If u is zero then v will also be zero. That is, the object will remain at rest.

Example 9.1 A constant force acts on an object of mass 5 kg for a duration of 2 s. It increases the object's velocity from 3 m s^{-1} to 7 m s^{-1} . Find the magnitude of the applied force. Now, if the force was applied for a duration of 5 s, what would be the final velocity of the object?

Solution:

We have been given that $u = 3 \text{ m s}^{-1}$ and $v = 7 \text{ m s}^{-1}$, $t = 2 \text{ s}$ and $m = 5 \text{ kg}$. From Eq. (9.5) we have,

$$F = \frac{m(v-u)}{t}$$

Substitution of values in this relation gives

$$F = 5 \text{ kg } (7 \text{ m s}^{-1} - 3 \text{ m s}^{-1}) / 2 \text{ s} = 10 \text{ N}.$$

Now, if this force is applied for a duration of 5 s ($t = 5 \text{ s}$), then the final velocity can be calculated by rewriting Eq. (9.5) as

$$v = u + \frac{Ft}{m}$$

On substituting the values of u , F , m and t , we get the final velocity,

$$v = 13 \text{ m s}^{-1}.$$

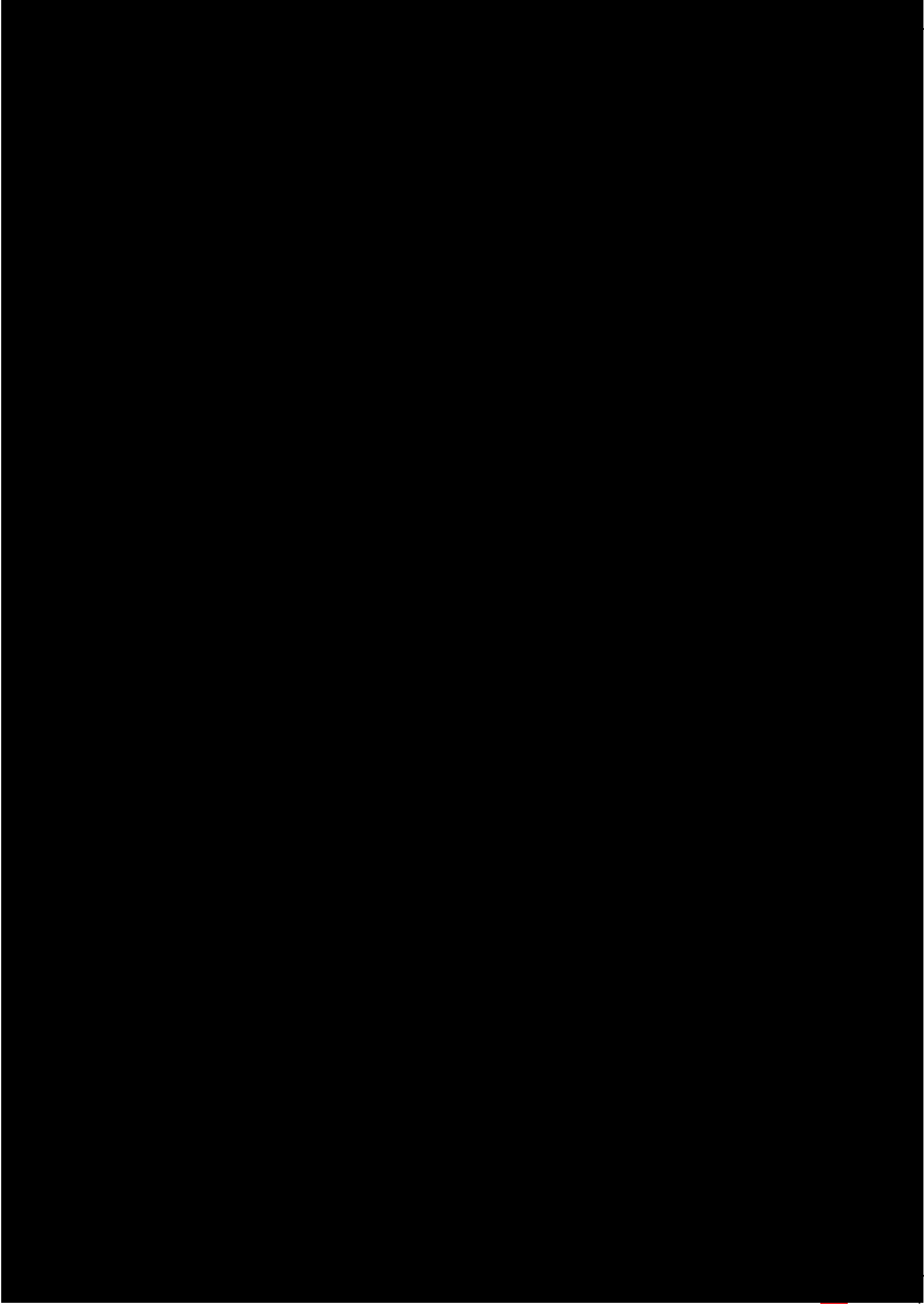




Fig. 9.12: As the sailor jumps in forward direction, the boat moves backwards.

Activity 9.4

- Request two children to stand on two separate carts as shown in Fig. 9.13.
- Give them a bag full of sand or some other heavy object. Ask them to play a game of catch with the bag.
- Does each of them experience an instantaneous force as a result of throwing the sand bag?
- You can paint a white line on cartwheels to observe the motion of the two carts when the children throw the bag towards each other.

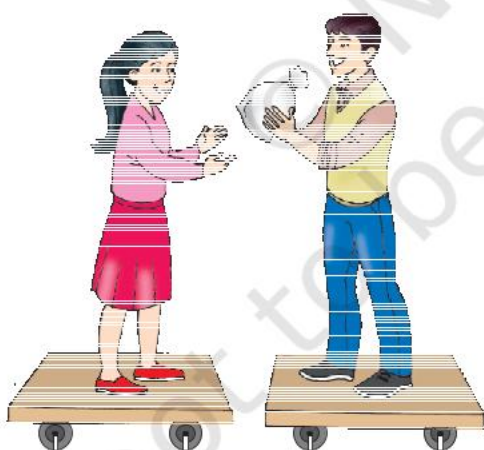


Fig. 9.13

Now, place two children on one cart and one on another cart. The second law of motion can be seen, as this arrangement would show different accelerations for the same force.

The cart shown in this activity can be constructed by using a 12 mm or 18 mm thick plywood board of about 50 cm × 100 cm with two pairs of hard ball-bearing wheels (skate wheels are good to use). Skateboards are not as effective because it is difficult to maintain straight-line motion.

9.6 Conservation of Momentum

Suppose two objects (two balls A and B, say) of masses m_A and m_B are travelling in the same direction along a straight line at different velocities u_A and u_B , respectively [Fig. 9.14(a)]. And there are no other external unbalanced forces acting on them. Let $u_A > u_B$ and the two balls collide with each other as shown in Fig. 9.14(b). During collision which lasts for a time t , the ball A exerts a force F_{AB} on ball B and the ball B exerts a force F_{BA} on ball A. Suppose v_A and v_B are the velocities of the two balls A and B after the collision, respectively [Fig. 9.14(c)].

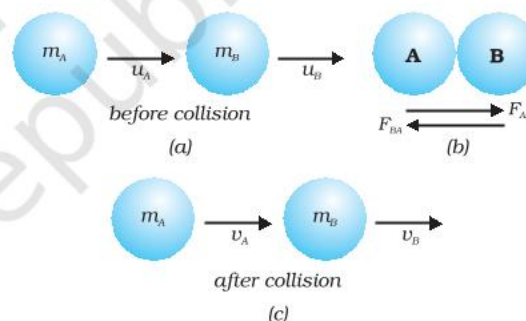


Fig. 9.14: Conservation of momentum in collision of two balls.

From Eq. (9.1), the momenta (plural of momentum) of ball A before and after the collision are $m_A u_A$ and $m_A v_A$, respectively. The rate of change of its momentum (or F_{AB}) during the collision will be $m_A \frac{(v_A - u_A)}{t}$.

Similarly, the rate of change of momentum of ball B ($= F_{BA}$) during the collision will be $m_B \frac{(v_B - u_B)}{t}$.

According to the third law of motion, the force F_{AB} exerted by ball A on ball B

and the force F_{BA} exerted by the ball B on ball A must be equal and opposite to each other. Therefore,

$$F_{AB} = -F_{BA} \quad (9.6)$$

$$\text{or} \quad m_A \frac{(v_A - u_A)}{t} = -m_B \frac{(v_B - u_B)}{t}.$$

This gives,

$$m_A u_A + m_B u_B = m_A v_A + m_B v_B \quad (9.7)$$

Since $(m_A u_A + m_B u_B)$ is the total momentum of the two balls A and B before the collision and $(m_A v_A + m_B v_B)$ is their total momentum after the collision, from Eq. (9.7) we observe that the total momentum of the two balls remains unchanged or conserved provided no other external force acts.

As a result of this ideal collision experiment, we say that the sum of momenta of the two objects before collision is equal to the sum of momenta after the collision provided there is no external unbalanced force acting on them. This is known as the law of conservation of momentum. This statement can alternatively be given as the total momentum of the two objects is unchanged or conserved by the collision.

Activity 9.5

- Take a big rubber balloon and inflate it fully. Tie its neck using a thread. Also using adhesive tape, fix a straw on the surface of this balloon.
- Pass a thread through the straw and hold one end of the thread in your hand or fix it on the wall.
- Ask your friend to hold the other end of the thread or fix it on a wall at some distance. This arrangement is shown in Fig. 9.15.
- Now remove the thread tied on the neck of balloon. Let the air escape from the mouth of the balloon.
- Observe the direction in which the straw moves.

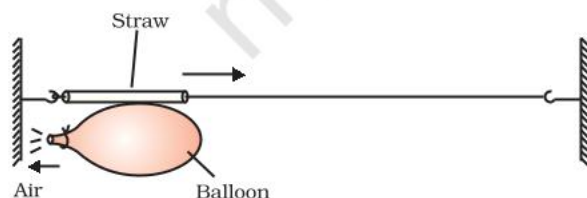


Fig. 9.15

Activity 9.6

- Take a test tube of good quality glass material and put a small amount of water in it. Place a stop cork at the mouth of it.
- Now suspend the test tube horizontally by two strings or wires as shown in Fig. 9.16.
- Heat the test tube with a burner until water vaporises and the cork blows out.
- Observe that the test tube recoils in the direction opposite to the direction of the cork.

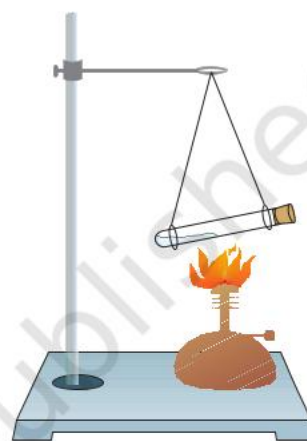


Fig. 9.16

- Also, observe the difference in the velocity the cork appears to have and that of the recoiling test tube.

Example 9.6 A bullet of mass 20 g is horizontally fired with a velocity 150 m s^{-1} from a pistol of mass 2 kg. What is the recoil velocity of the pistol?

Solution:

We have the mass of bullet, $m_1 = 20 \text{ g} (= 0.02 \text{ kg})$ and the mass of the pistol, $m_2 = 2 \text{ kg}$; initial velocities of the bullet (u_1) and pistol (u_2) = 0, respectively. The final velocity of the bullet, $v_1 = +150 \text{ m s}^{-1}$. The direction of bullet is taken from left to right (positive, by convention, Fig. 9.17). Let v be the recoil velocity of the pistol.

Total momenta of the pistol and bullet before the fire, when the gun is at rest
 $= (2 + 0.02) \text{ kg} \times 0 \text{ m s}^{-1}$
 $= 0 \text{ kg m s}^{-1}$

Total momenta of the pistol and bullet after it is fired
 $= 0.02 \text{ kg} \times (+ 150 \text{ m s}^{-1})$
 $+ 2 \text{ kg} \times v \text{ m s}^{-1}$
 $= (3 + 2v) \text{ kg m s}^{-1}$

According to the law of conservation of momentum

Total momenta after the fire = Total momenta before the fire
 $3 + 2v = 0$
 $\Rightarrow v = - 1.5 \text{ m s}^{-1}$.

Negative sign indicates that the direction in which the pistol would recoil is opposite to that of bullet, that is, right to left.

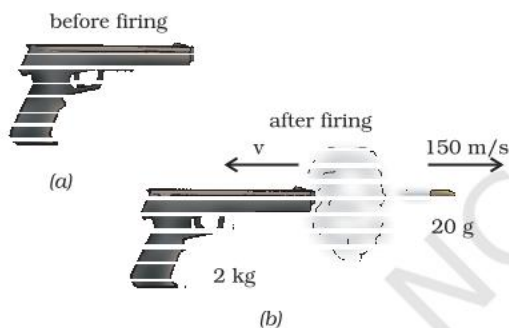


Fig. 9.17: Recoil of a pistol

Example 9.7 A girl of mass 40 kg jumps with a horizontal velocity of 5 m s^{-1} onto a stationary cart with frictionless wheels. The mass of the cart is 3 kg. What is her velocity as the cart starts moving? Assume that there is no external unbalanced force working in the horizontal direction.

Solution:

Let v be the velocity of the girl on the cart as the cart starts moving.

The total momenta of the girl and cart before the interaction

$$= 40 \text{ kg} \times 5 \text{ m s}^{-1} + 3 \text{ kg} \times 0 \text{ m s}^{-1}$$

$$= 200 \text{ kg m s}^{-1}.$$

Total momenta after the interaction

$$= (40 + 3) \text{ kg} \times v \text{ m s}^{-1}$$

$$= 43 v \text{ kg m s}^{-1}.$$

According to the law of conservation of momentum, the total momentum is conserved during the interaction. That is,

$$43 v = 200$$

$$\Rightarrow v = 200/43 = + 4.65 \text{ m s}^{-1}.$$

The girl on cart would move with a velocity of 4.65 m s^{-1} in the direction in which the girl jumped (Fig. 9.18).

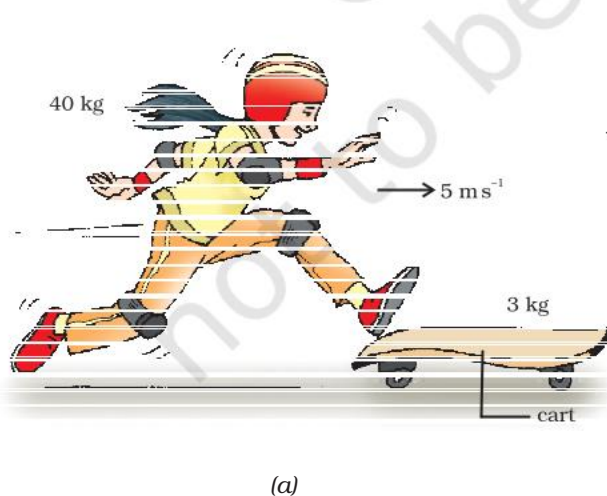
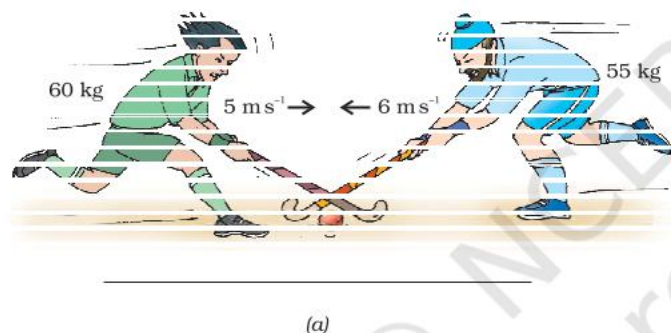


Fig. 9.18: The girl jumps onto the cart.

Example 9.8 Two hockey players of opposite teams, while trying to hit a hockey ball on the ground collide and immediately become entangled. One has a mass of 60 kg and was moving with a velocity 5.0 m s^{-1} while the other has a mass of 55 kg and was moving faster with a velocity 6.0 m s^{-1} towards the first player. In which direction and with what velocity will they move after they become entangled? Assume that the frictional force acting between the feet of the two players and ground is negligible.

Solution:



If v is the velocity of the two entangled players after the collision, the total momentum then

$$\begin{aligned} &= (m_1 + m_2) \times v \\ &= (60 + 55) \text{ kg} \times v \text{ m s}^{-1} \\ &= 115 \times v \text{ kg m s}^{-1}. \end{aligned}$$

Equating the momenta of the system before and after collision, in accordance with the law of conservation of momentum, we get

$$\begin{aligned} v &= -30/115 \\ &= -0.26 \text{ m s}^{-1}. \end{aligned}$$

Thus, the two entangled players would move with velocity 0.26 m s^{-1} from right to left, that is, in the direction the second player was moving before the collision.



Fig. 9.19: A collision of two hockey players: (a) before collision and (b) after collision.

Let the first player be moving from left to right. By convention left to right is taken as the positive direction and thus right to left is the negative direction (Fig. 9.19). If symbols m and u represent the mass and initial velocity of the two players, respectively. Subscripts 1 and 2 in these physical quantities refer to the two hockey players. Thus,

$$m_1 = 60 \text{ kg}; u_1 = +5 \text{ m s}^{-1}; \text{ and}$$

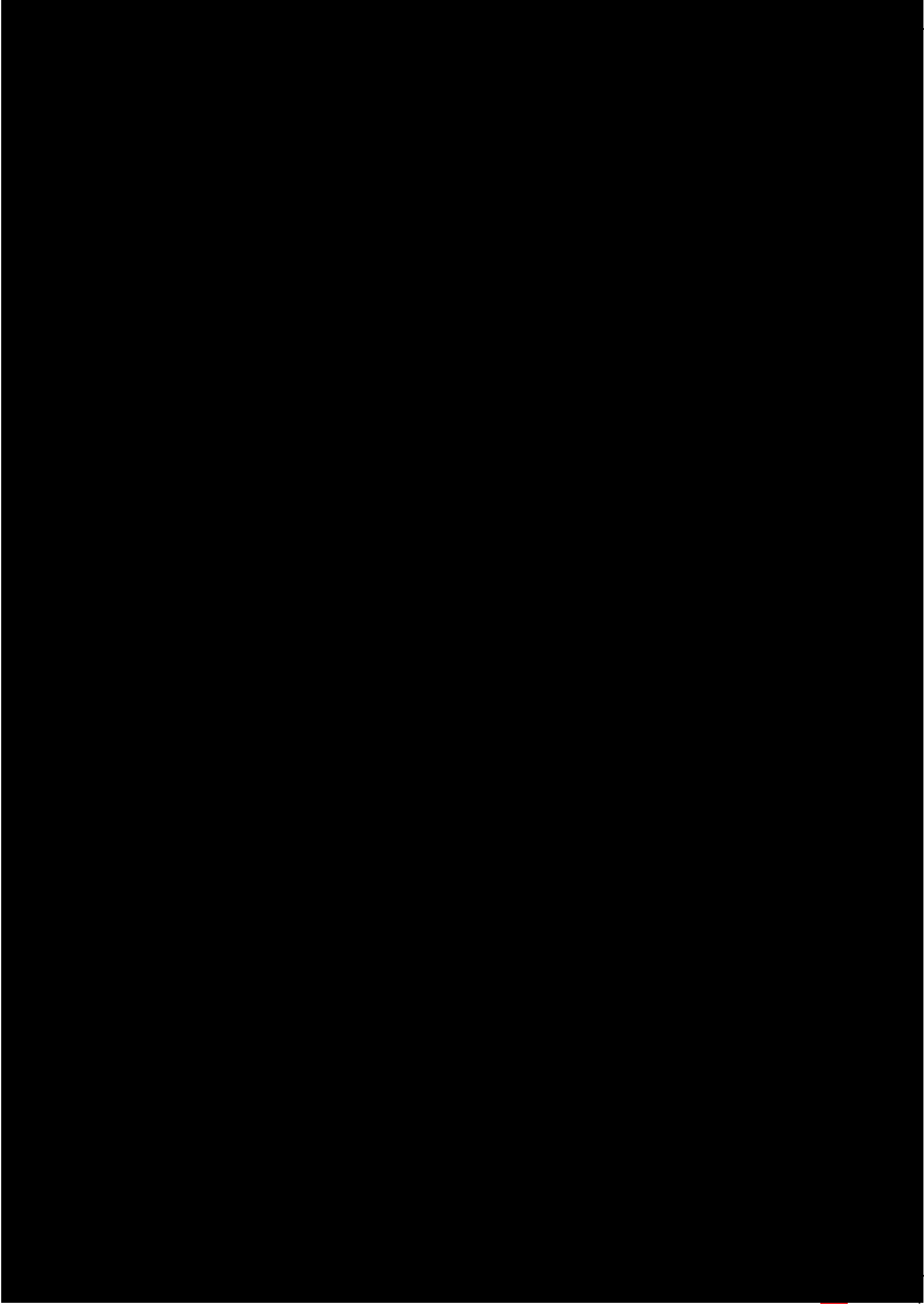
$$m_2 = 55 \text{ kg}; u_2 = -6 \text{ m s}^{-1}.$$

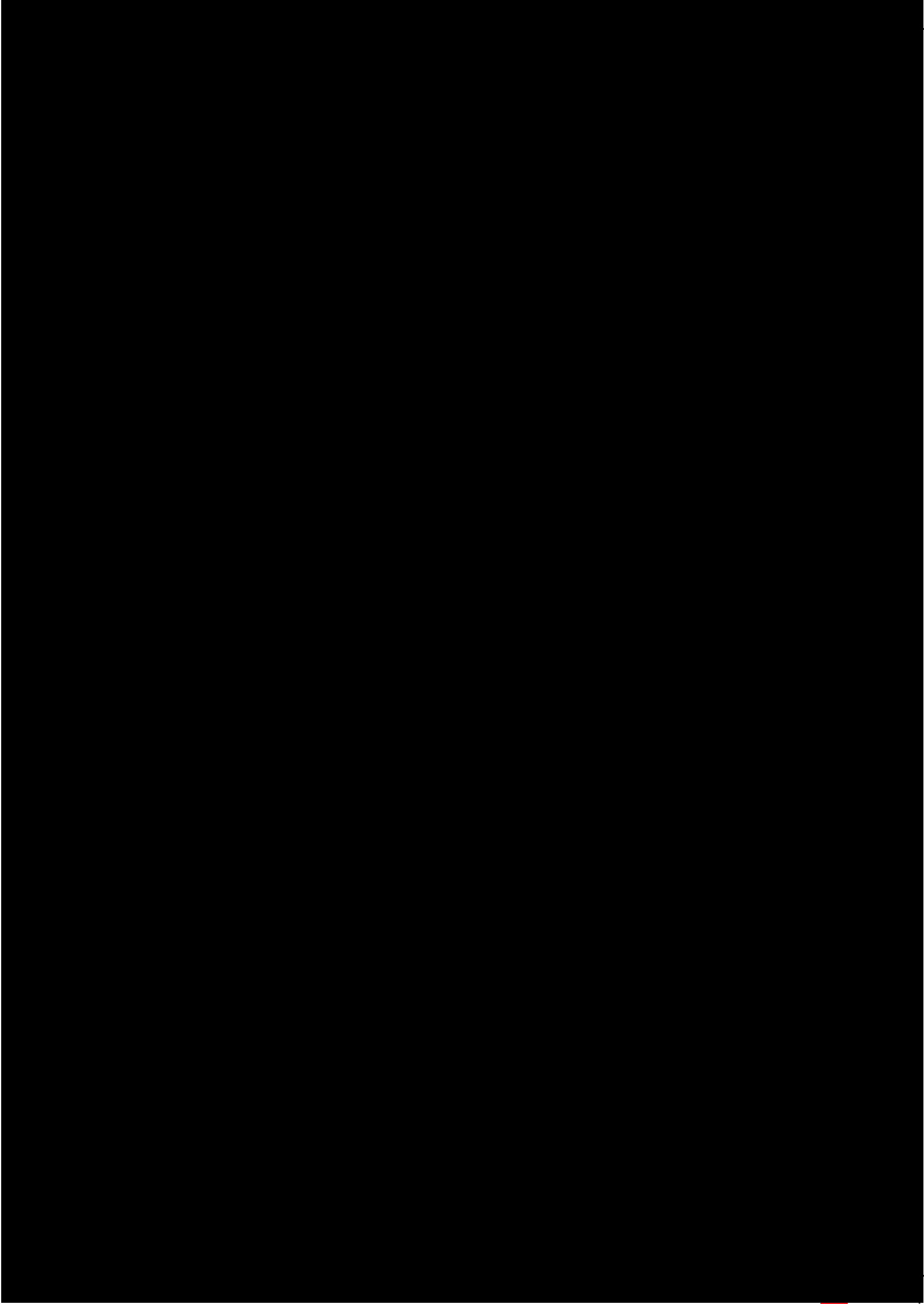
The total momentum of the two players before the collision

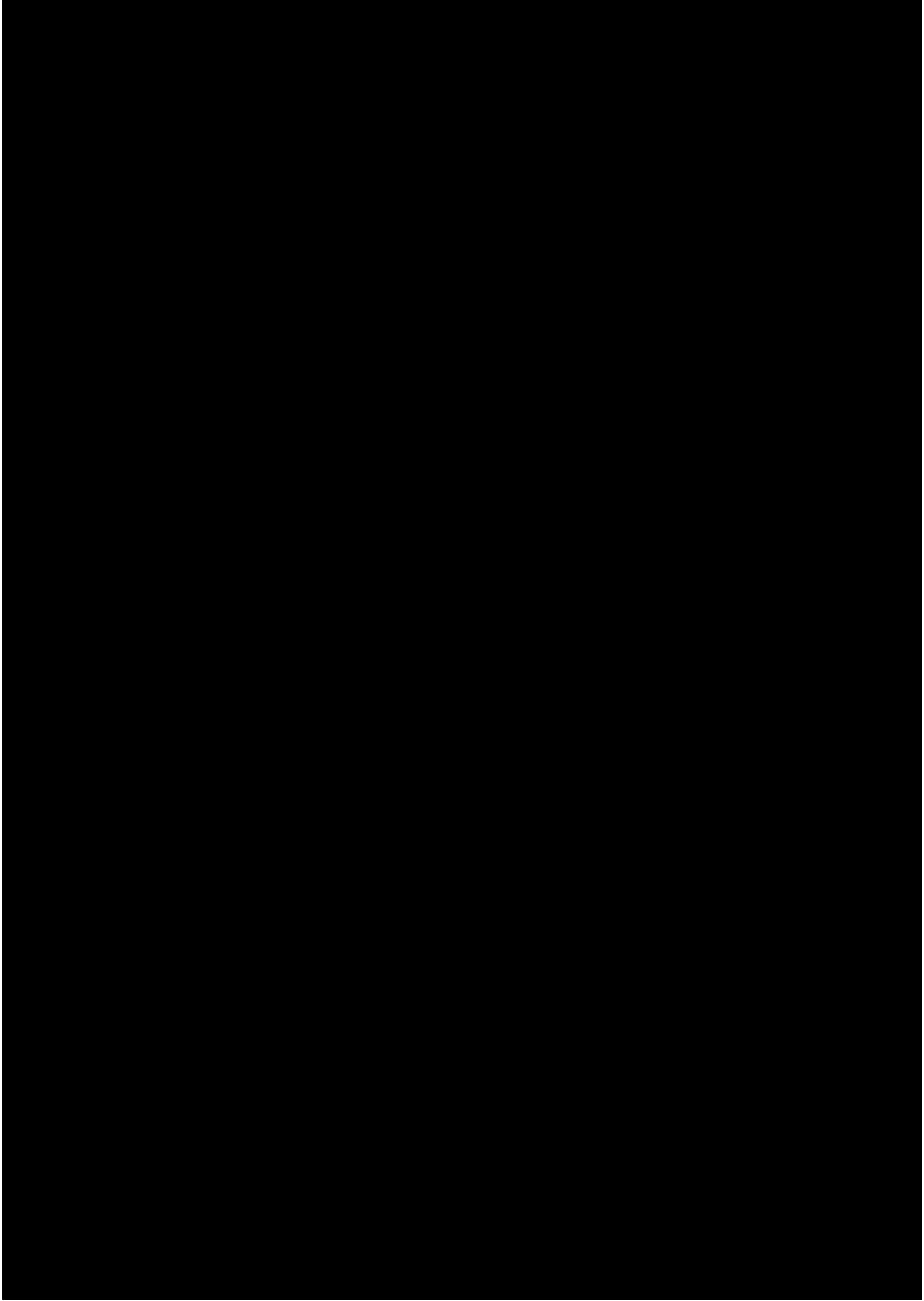
$$\begin{aligned} &= 60 \text{ kg} \times (+5 \text{ m s}^{-1}) + \\ &\quad 55 \text{ kg} \times (-6 \text{ m s}^{-1}) \\ &= -30 \text{ kg m s}^{-1} \end{aligned}$$

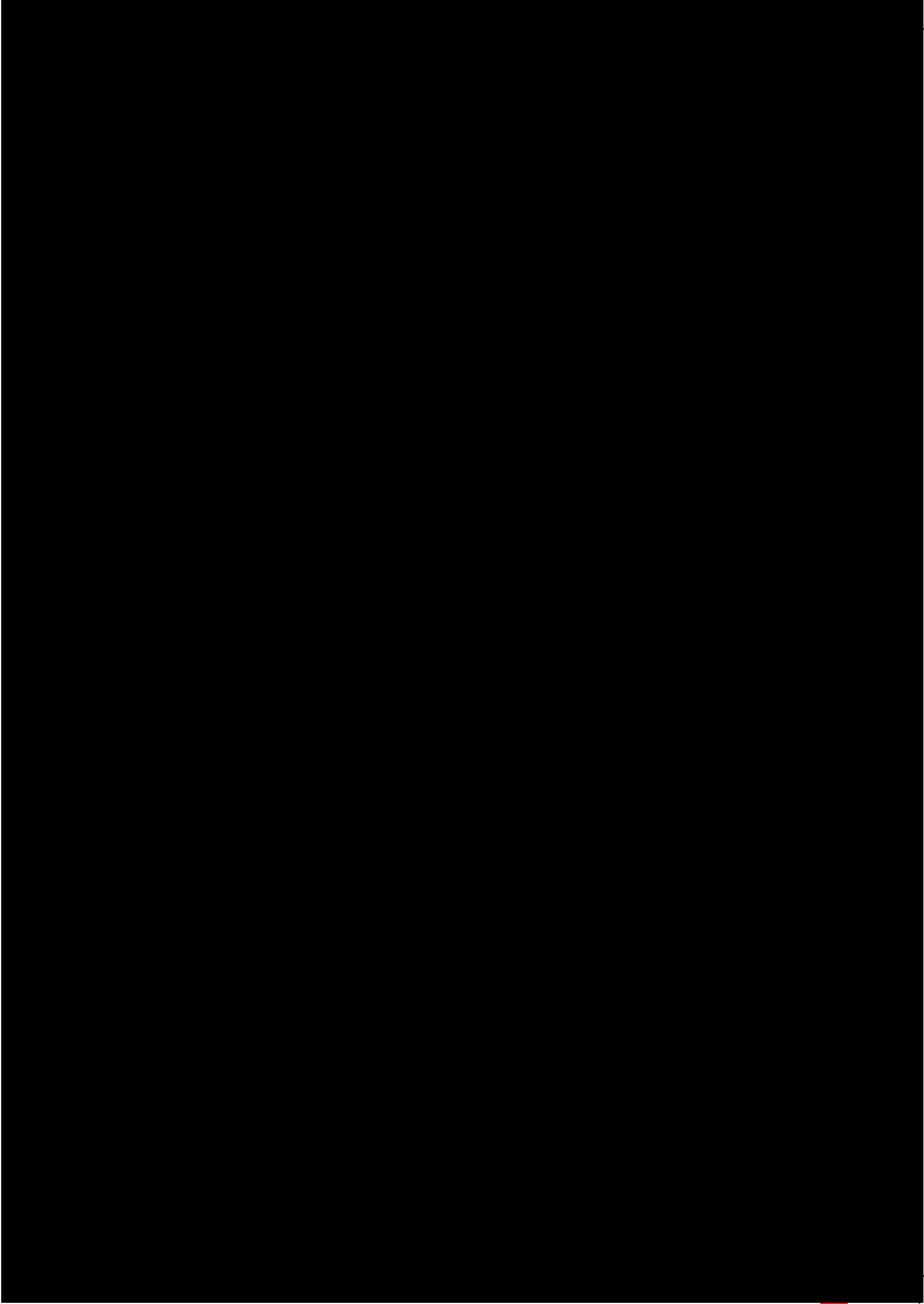
Questions

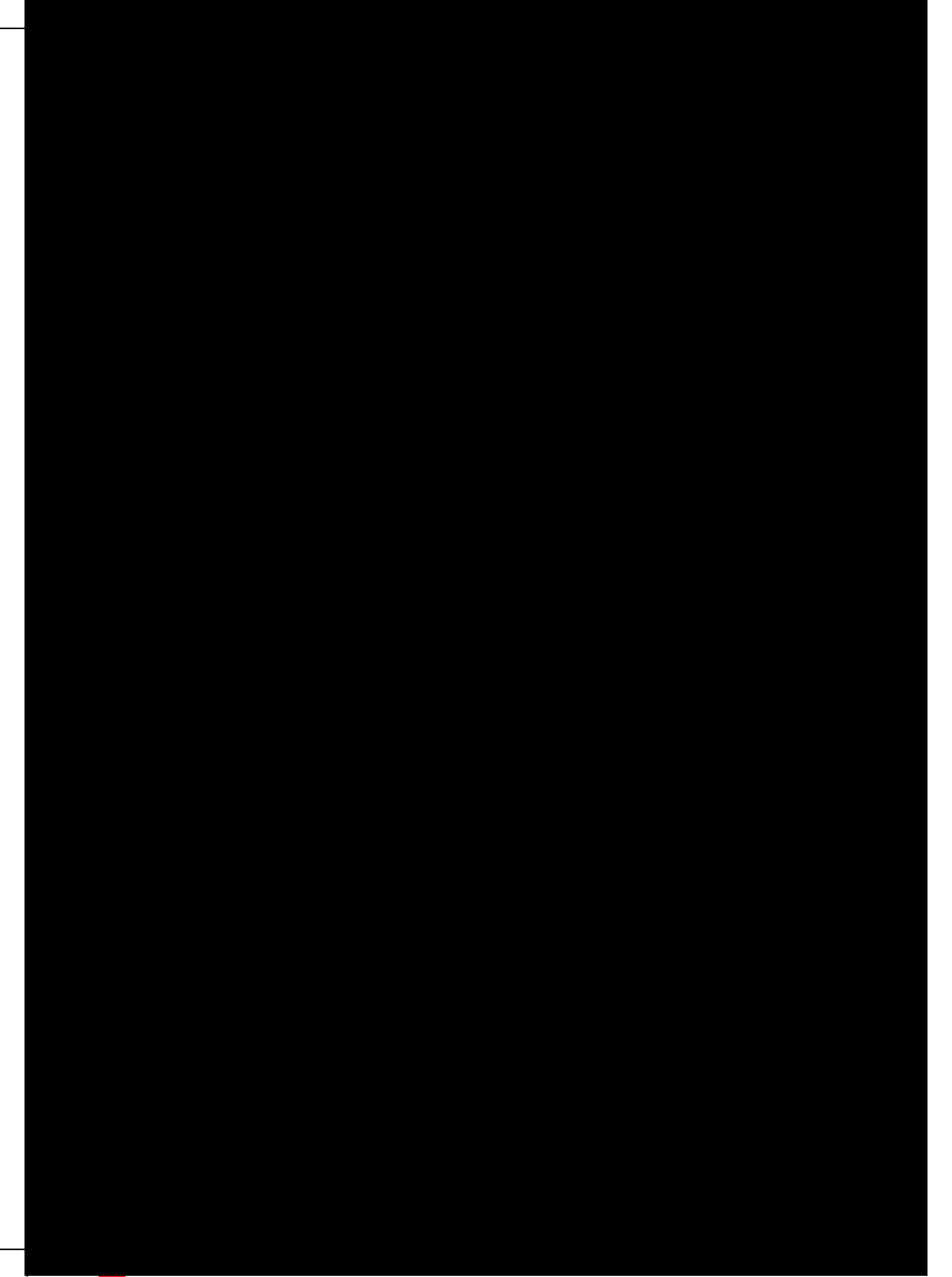
1. If action is always equal to the reaction, explain how a horse can pull a cart.
2. Explain, why is it difficult for a fireman to hold a hose, which ejects large amounts of water at a high velocity.
3. From a rifle of mass 4 kg, a bullet of mass 50 g is fired with an initial velocity of 35 m s^{-1} . Calculate the initial recoil velocity of the rifle.

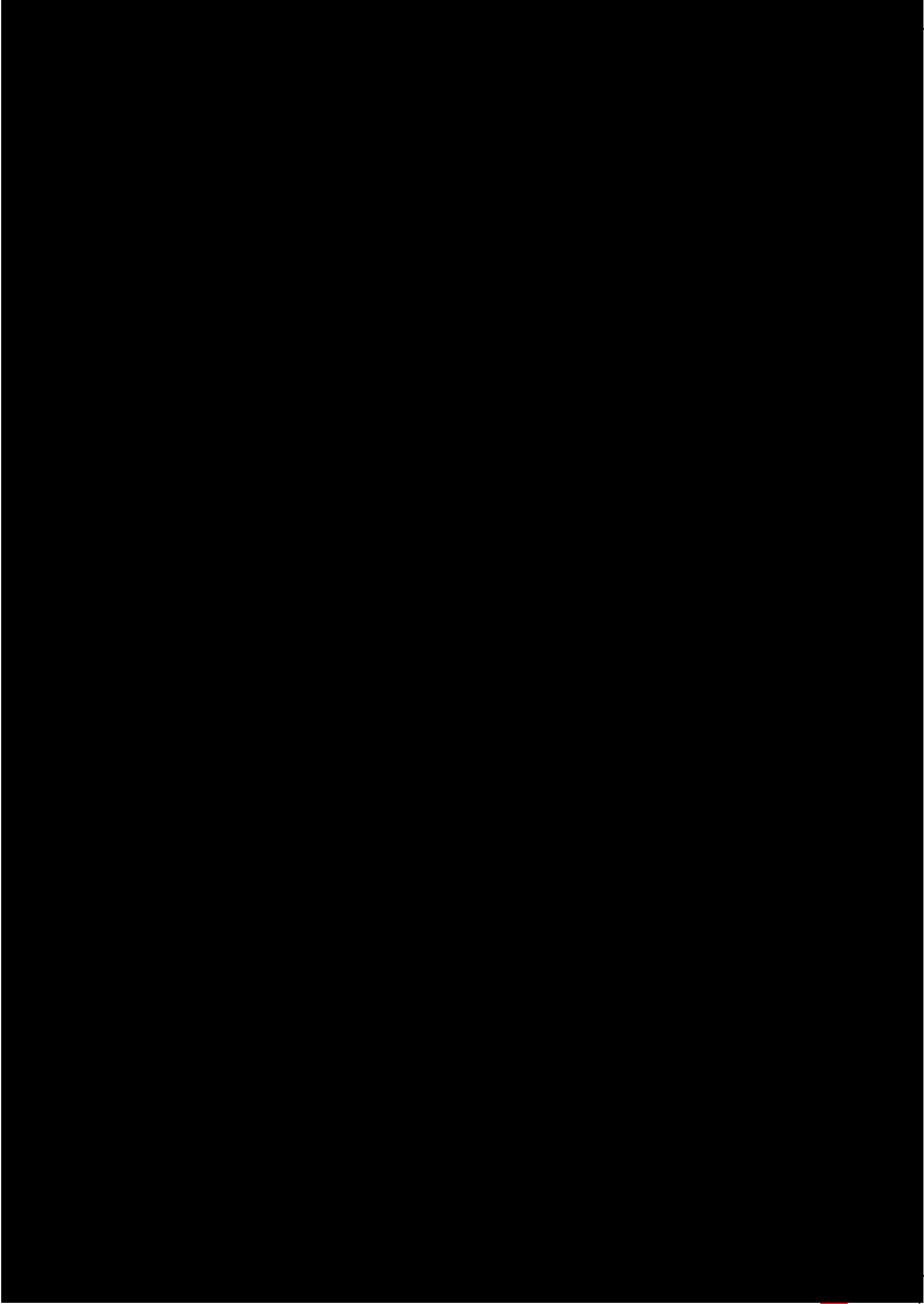


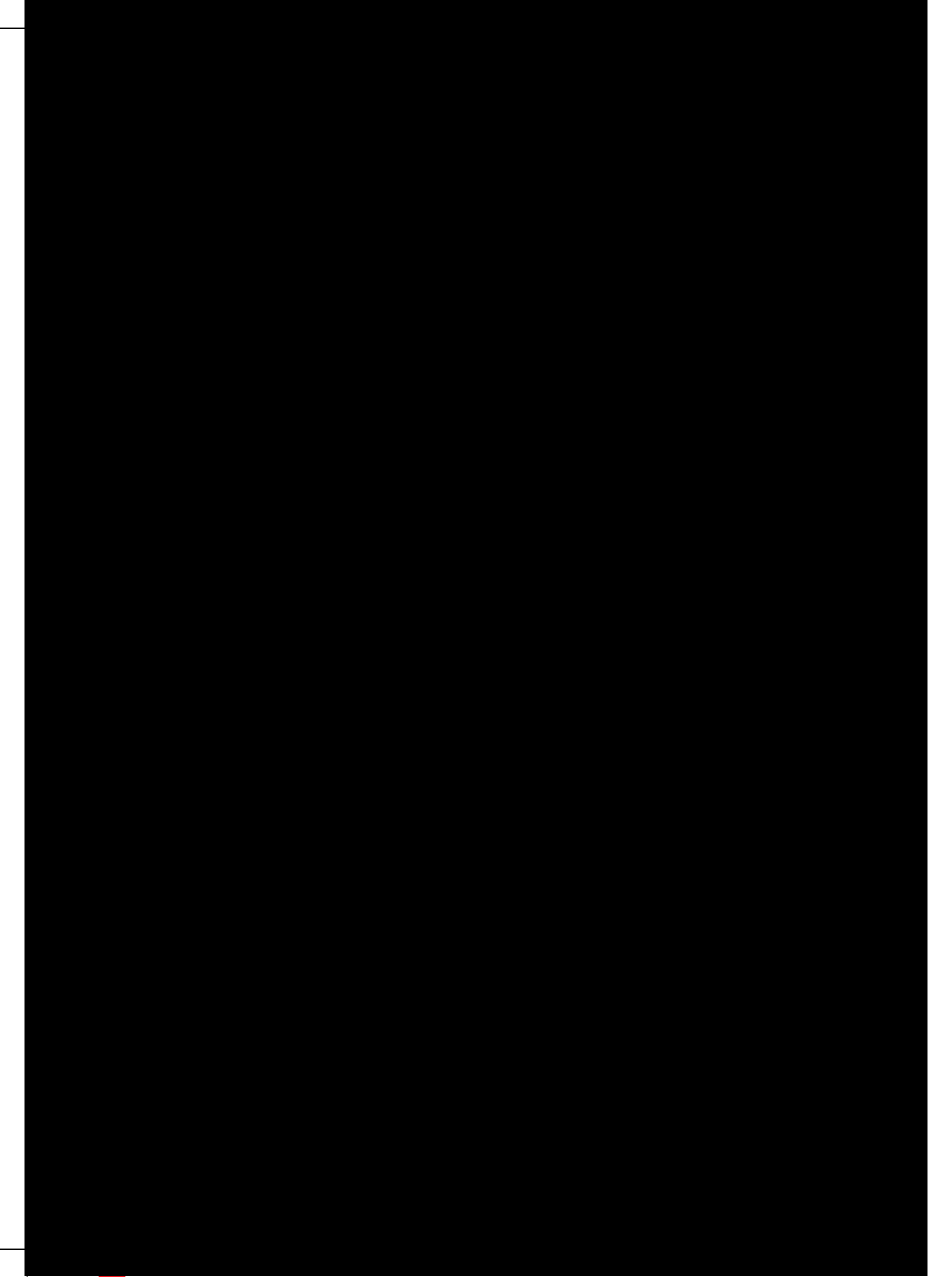


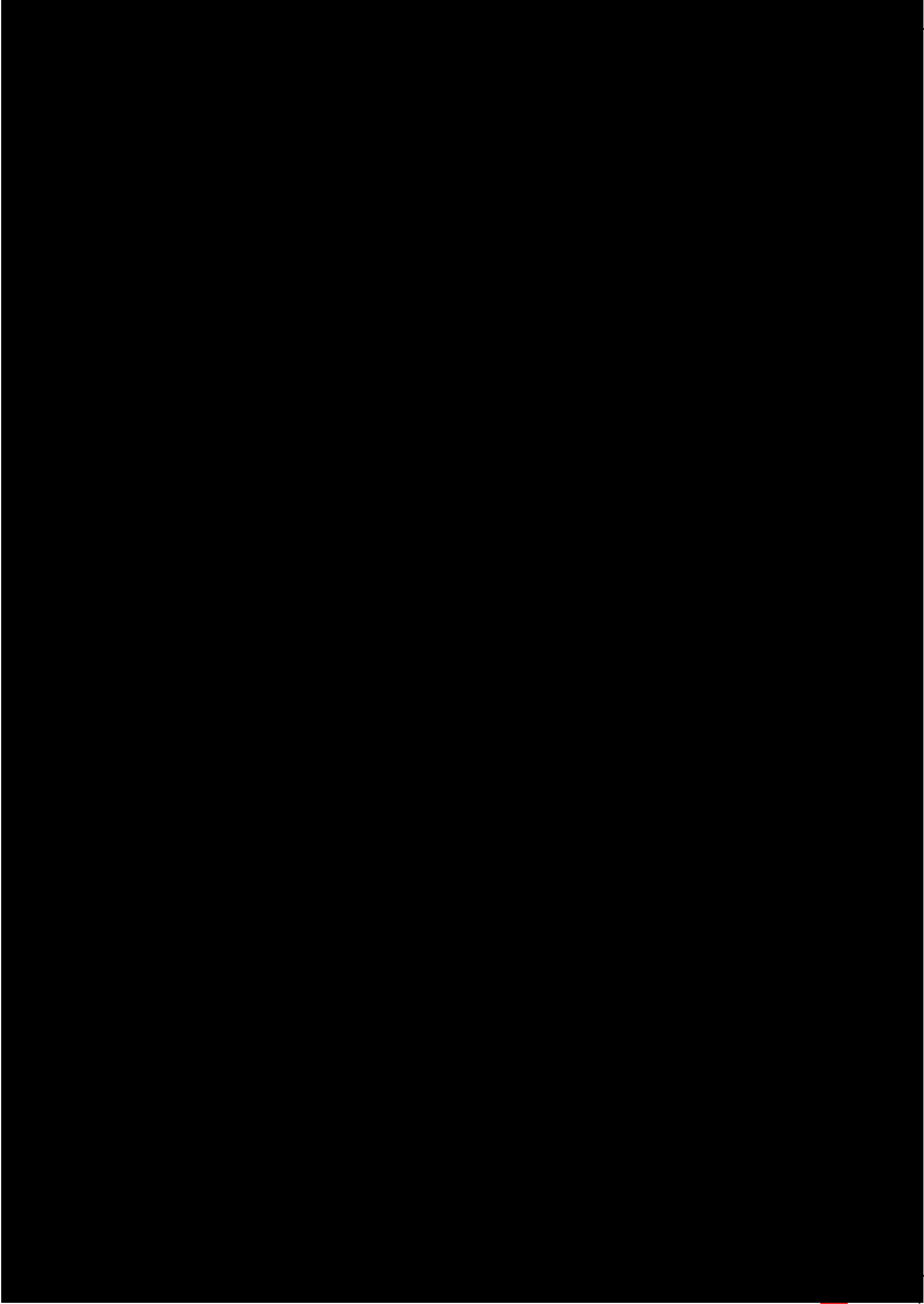


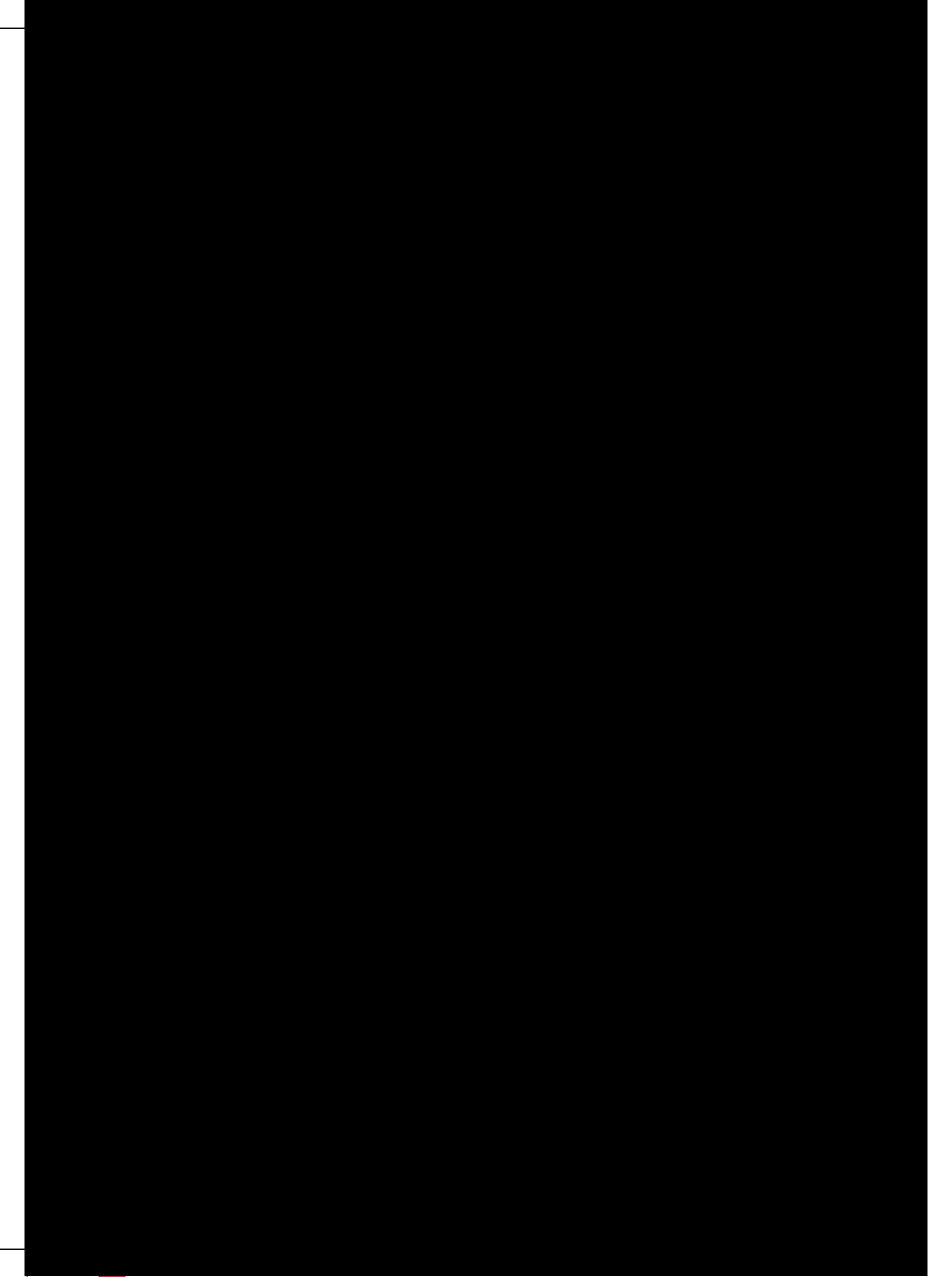


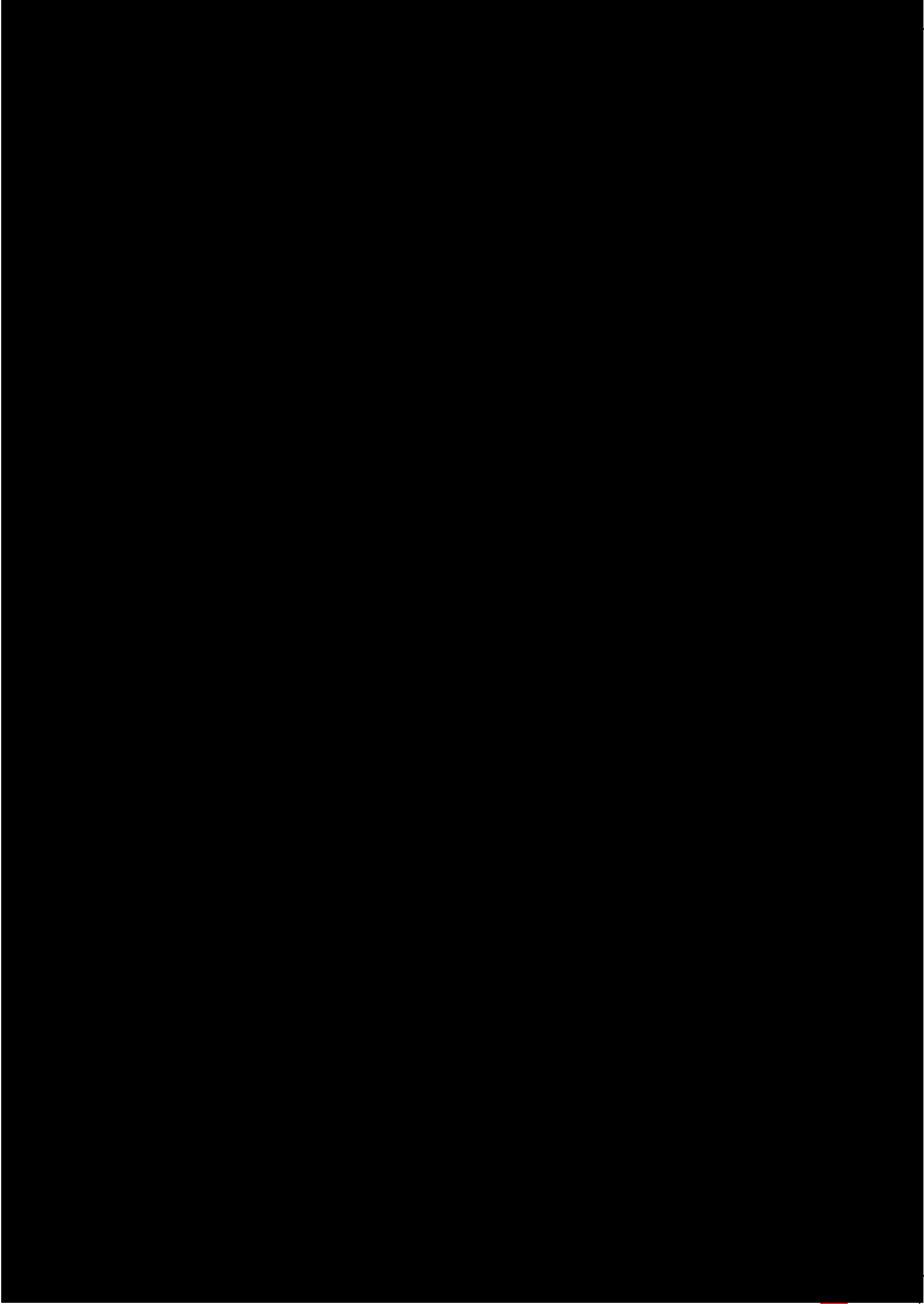


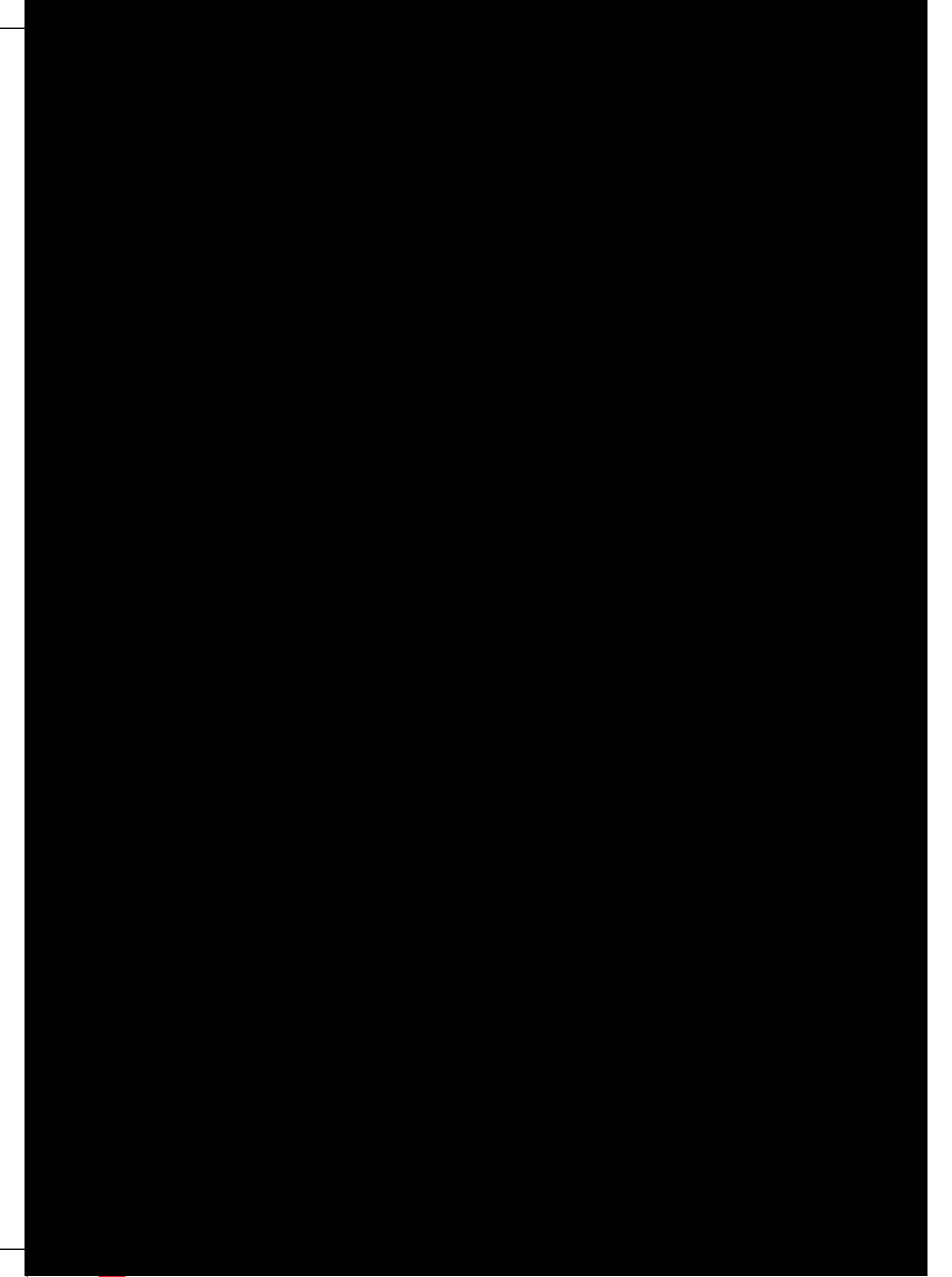


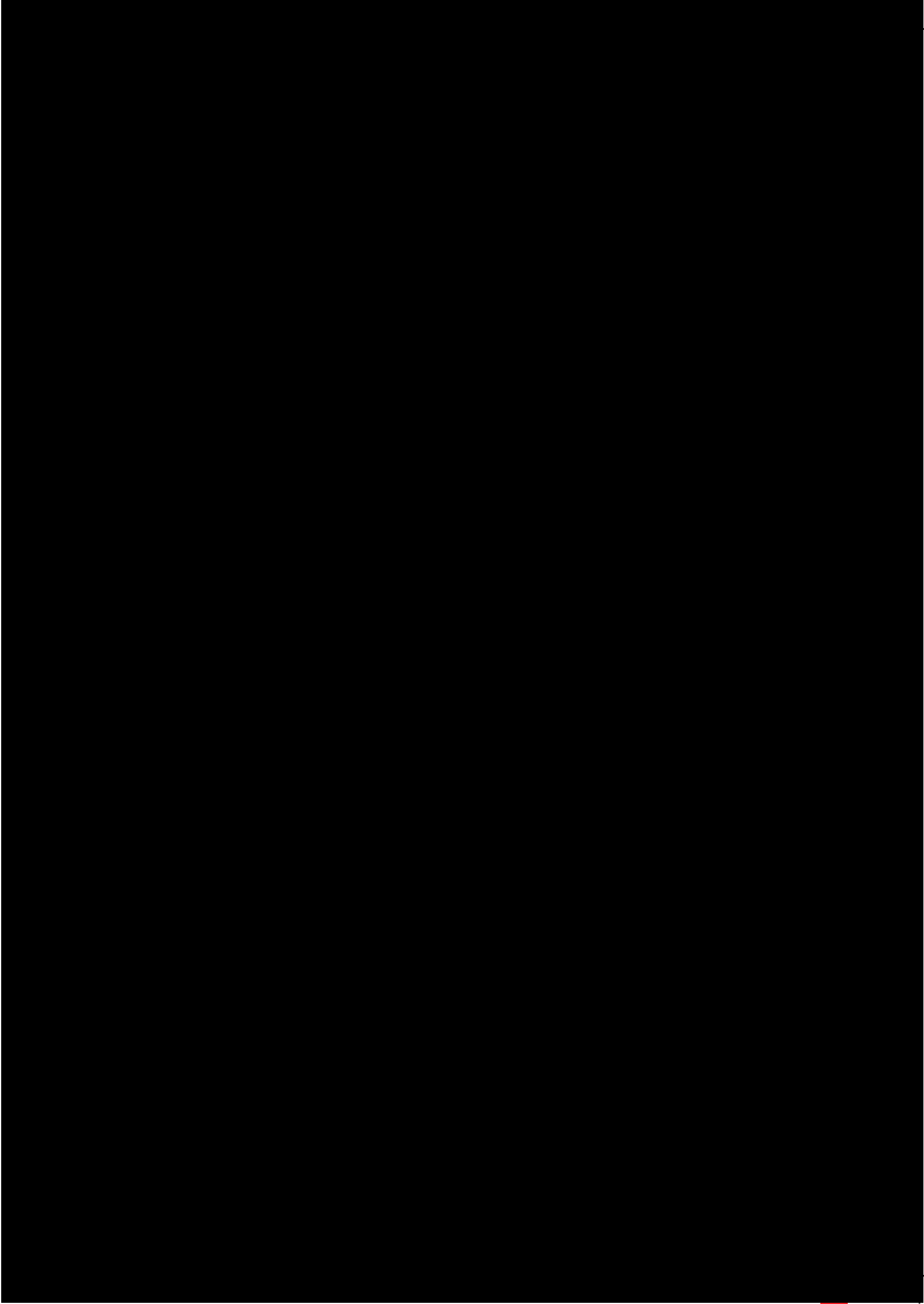


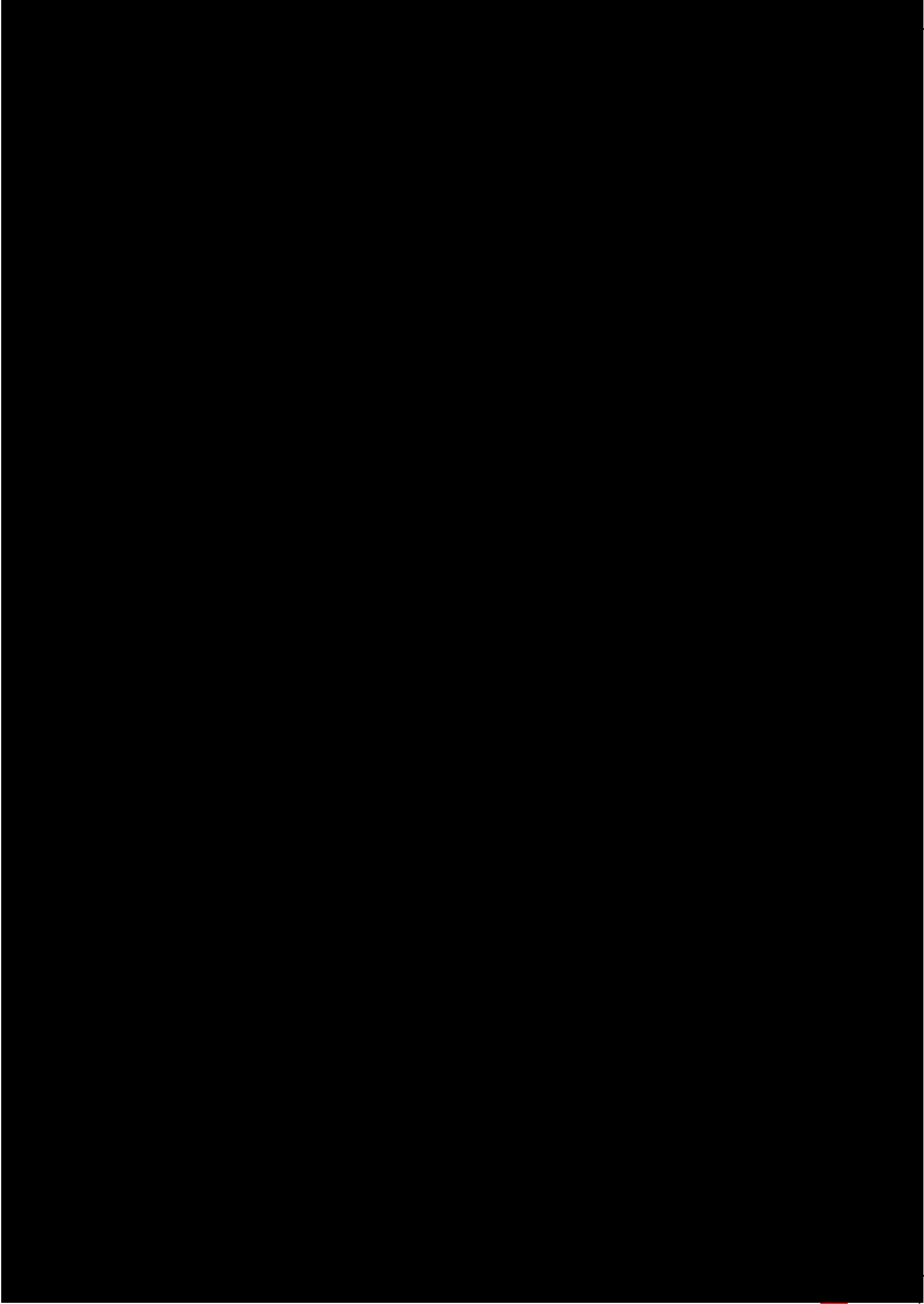


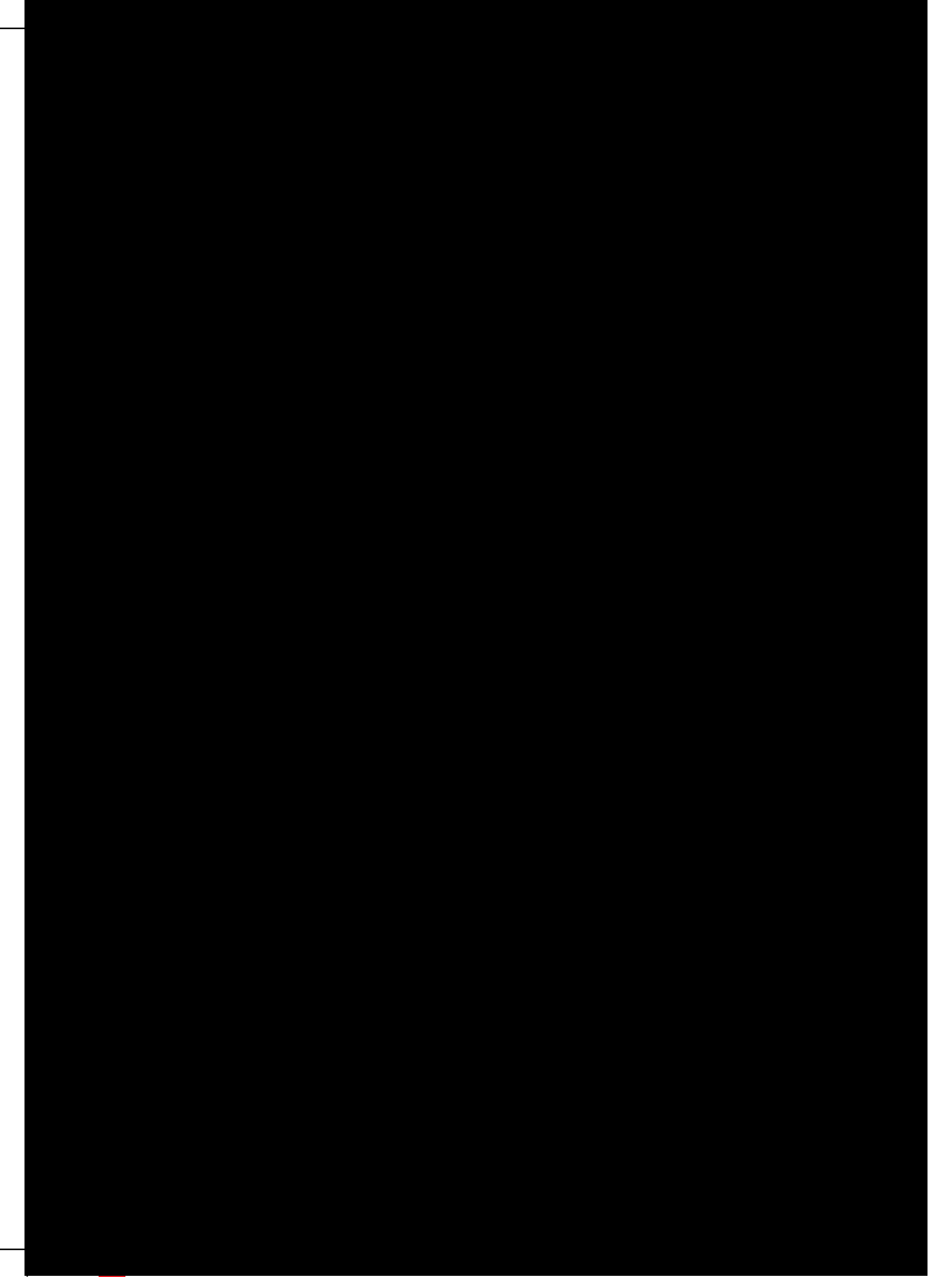


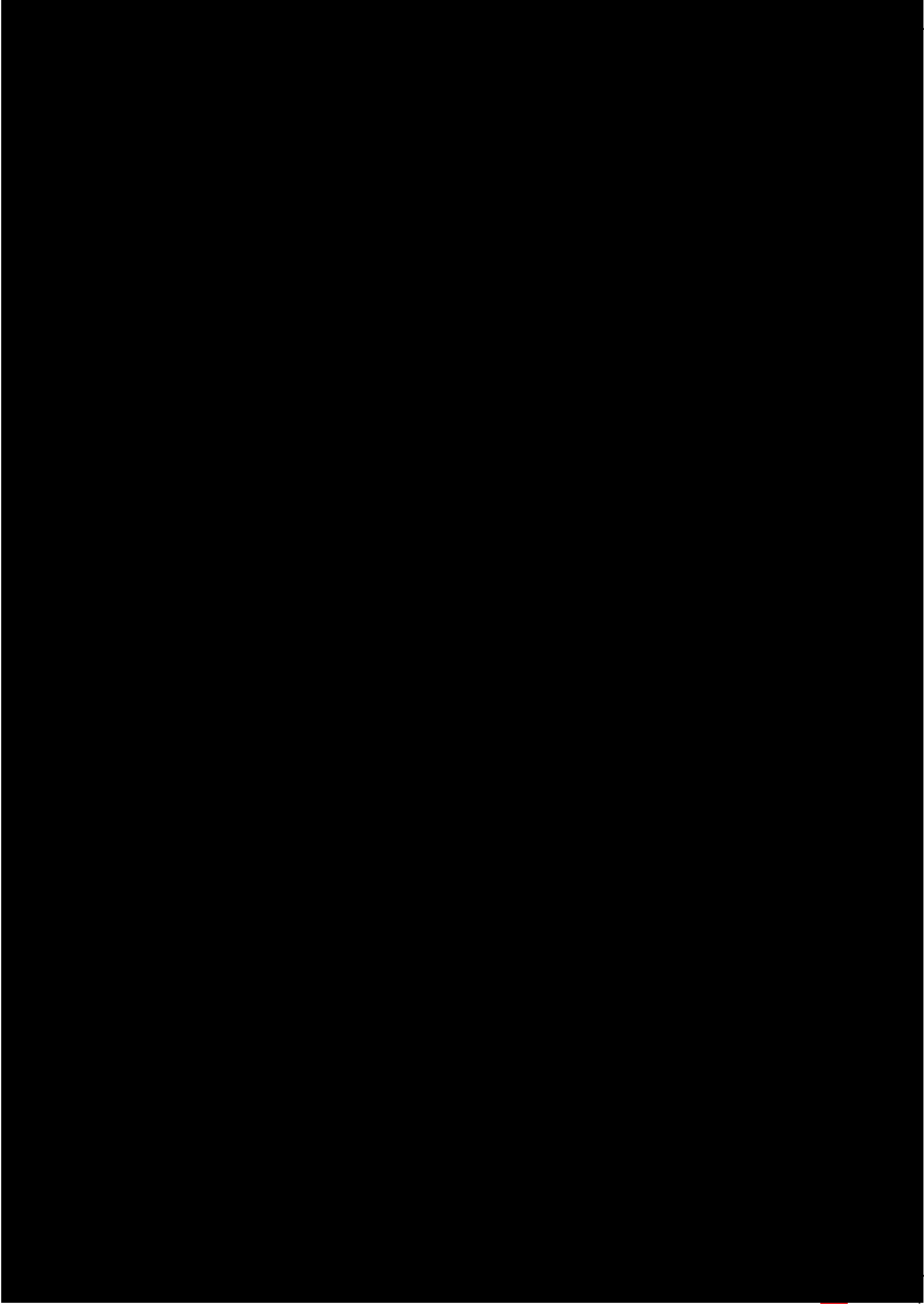


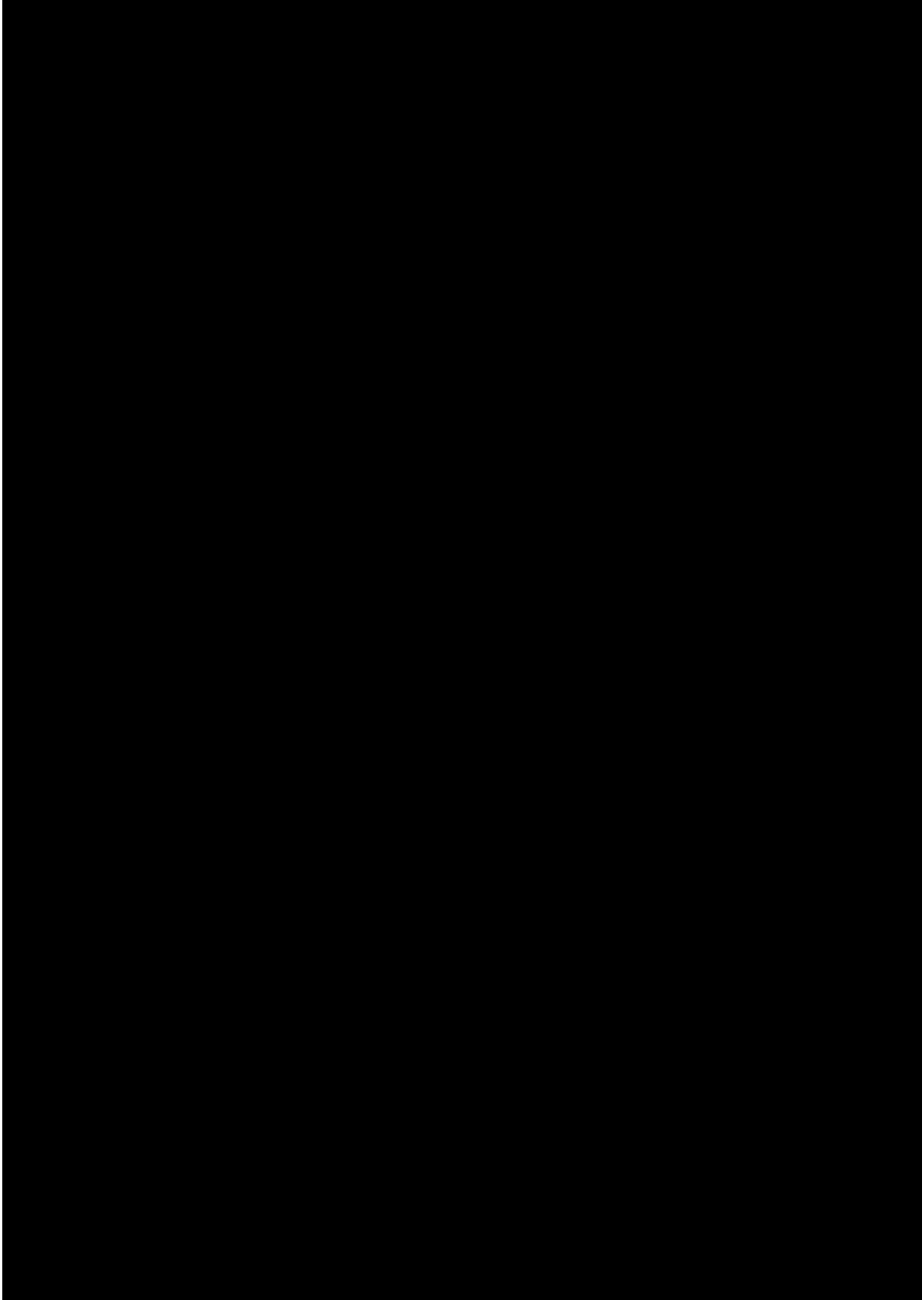


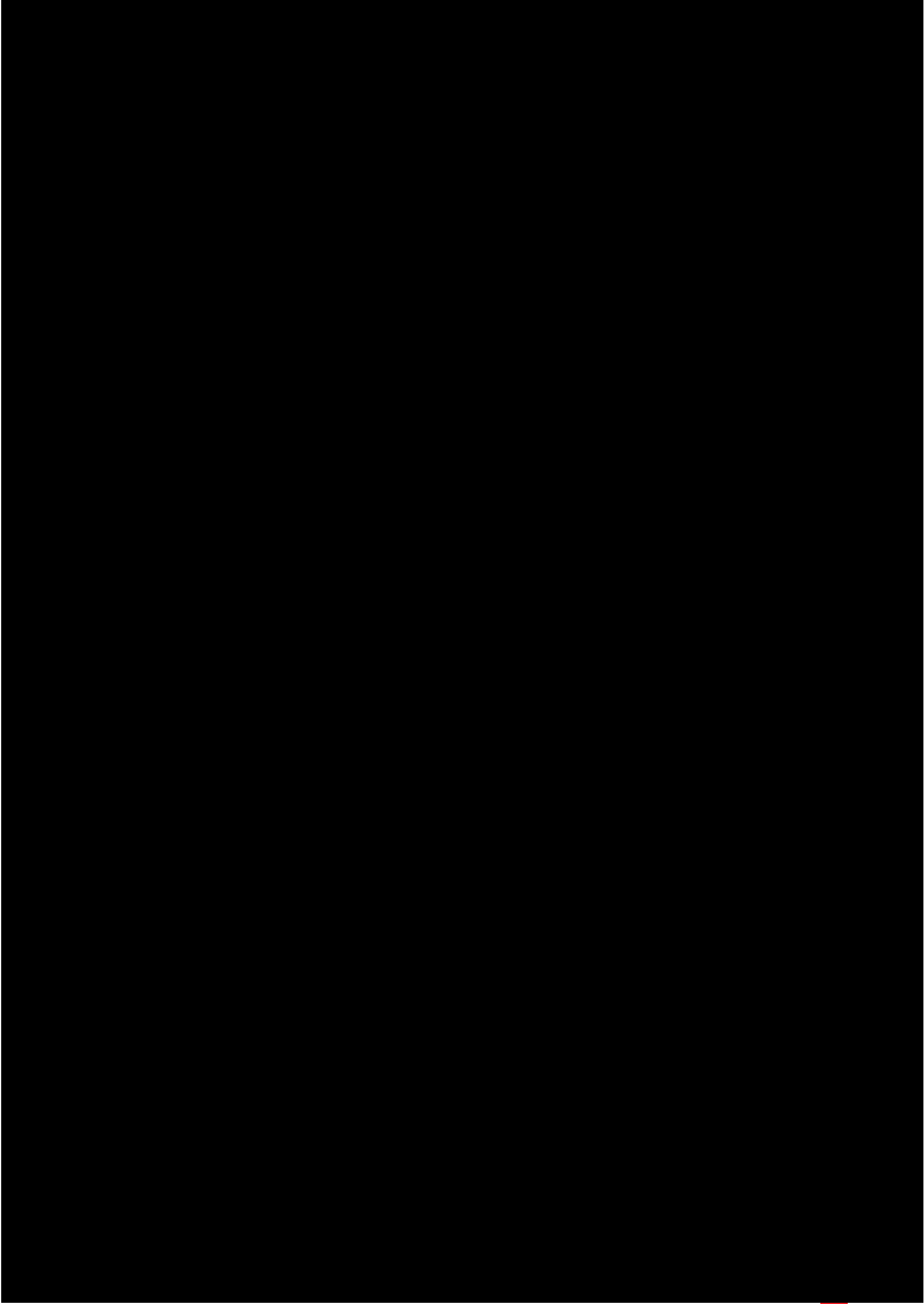


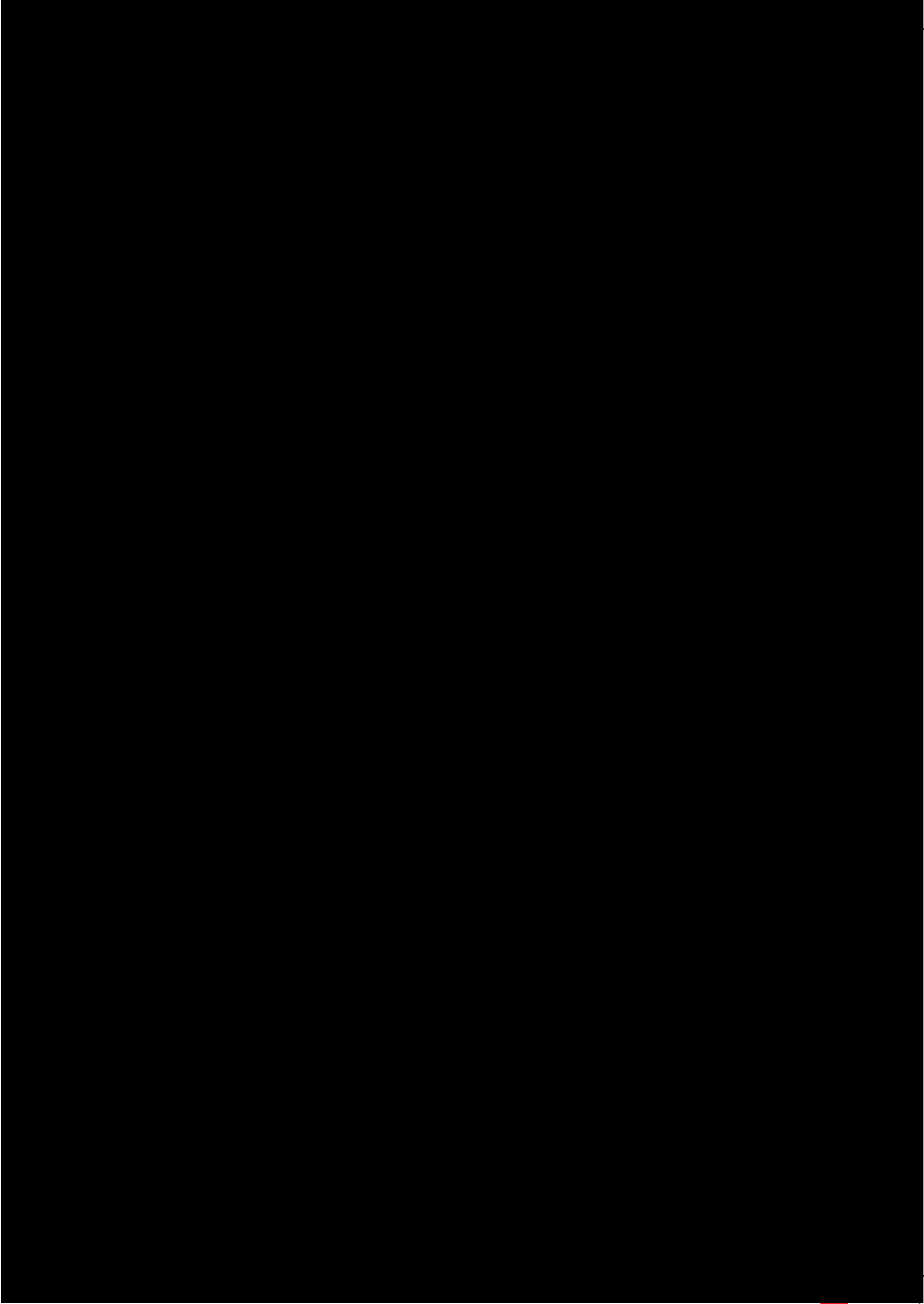


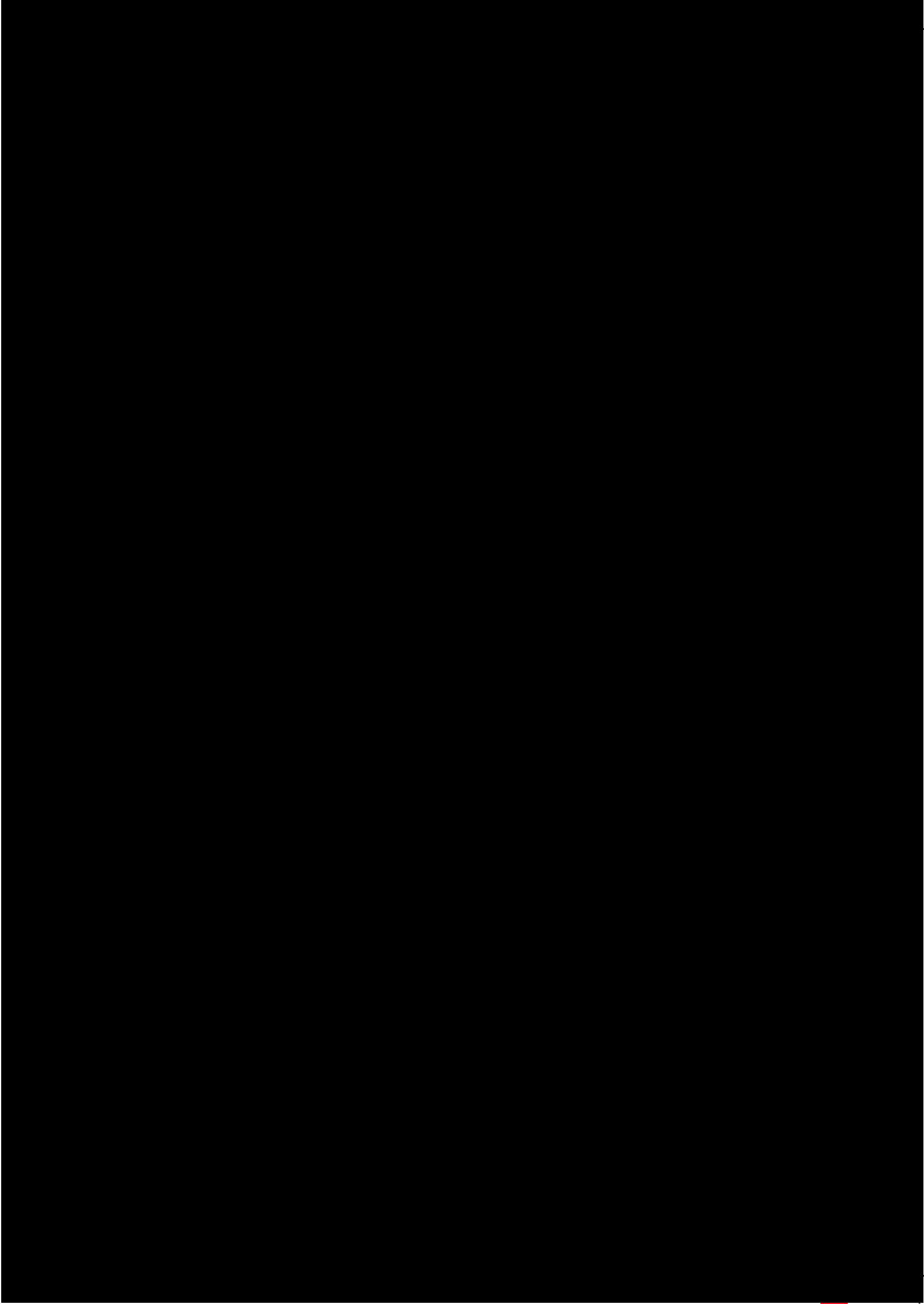


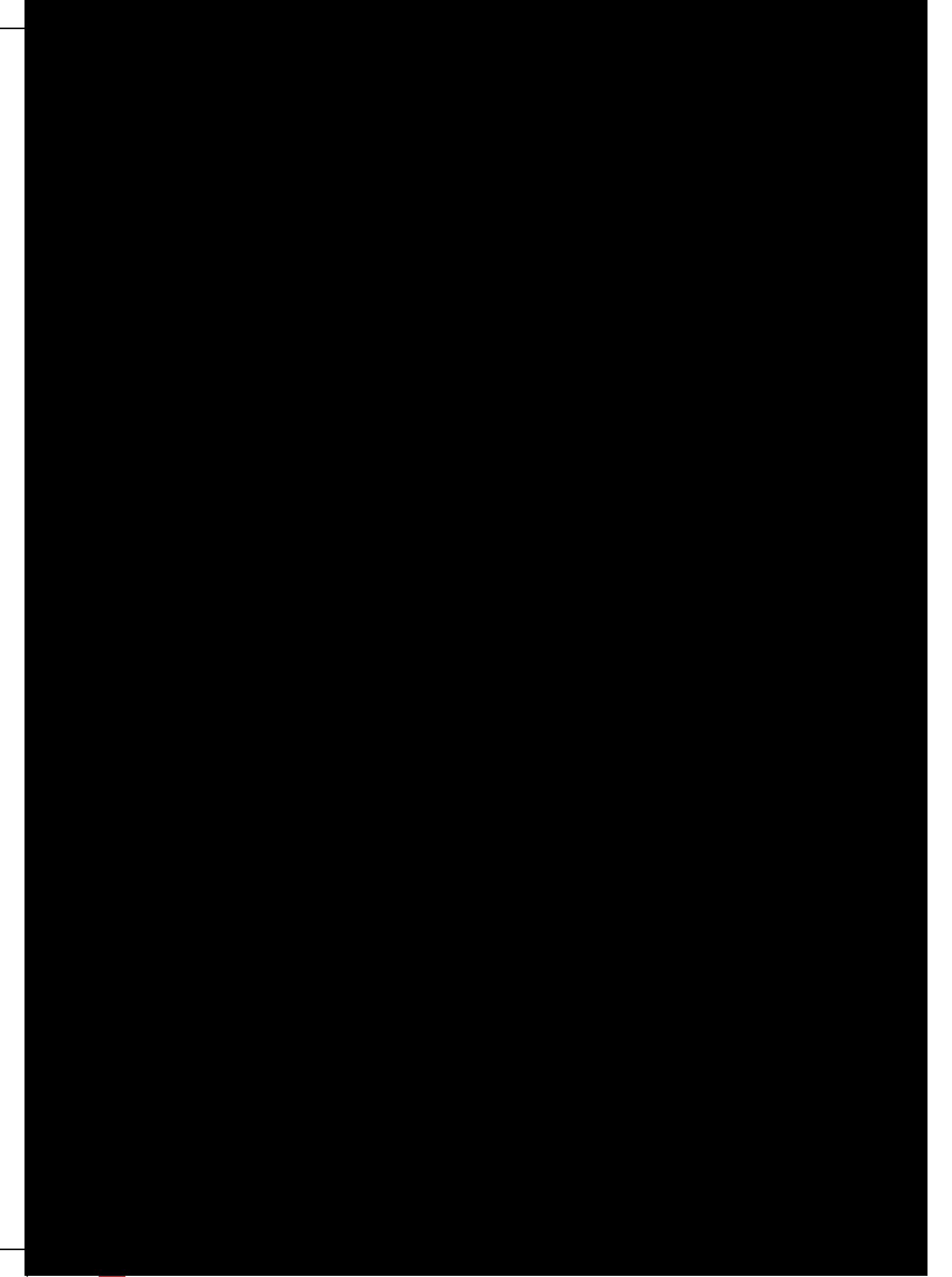


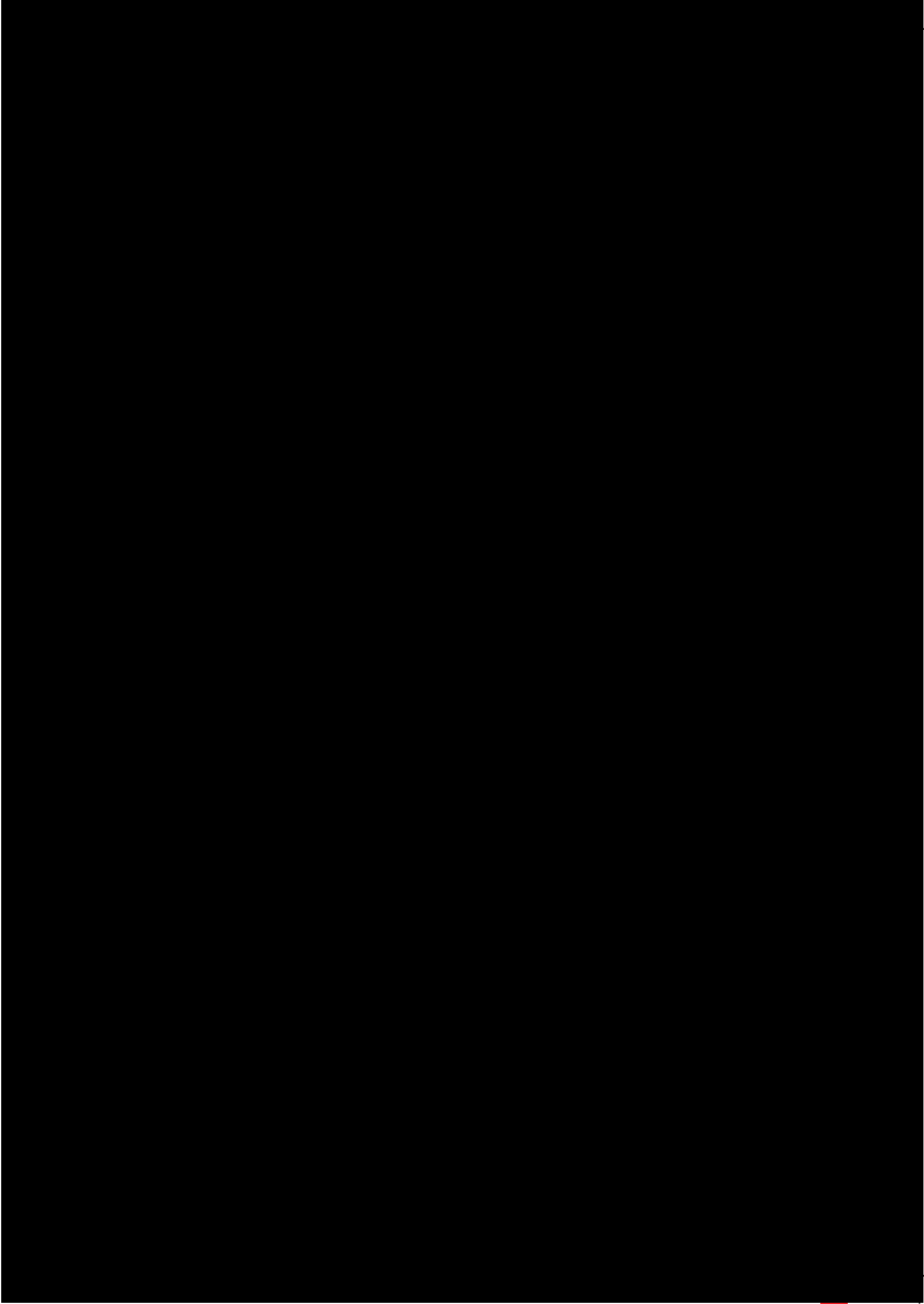


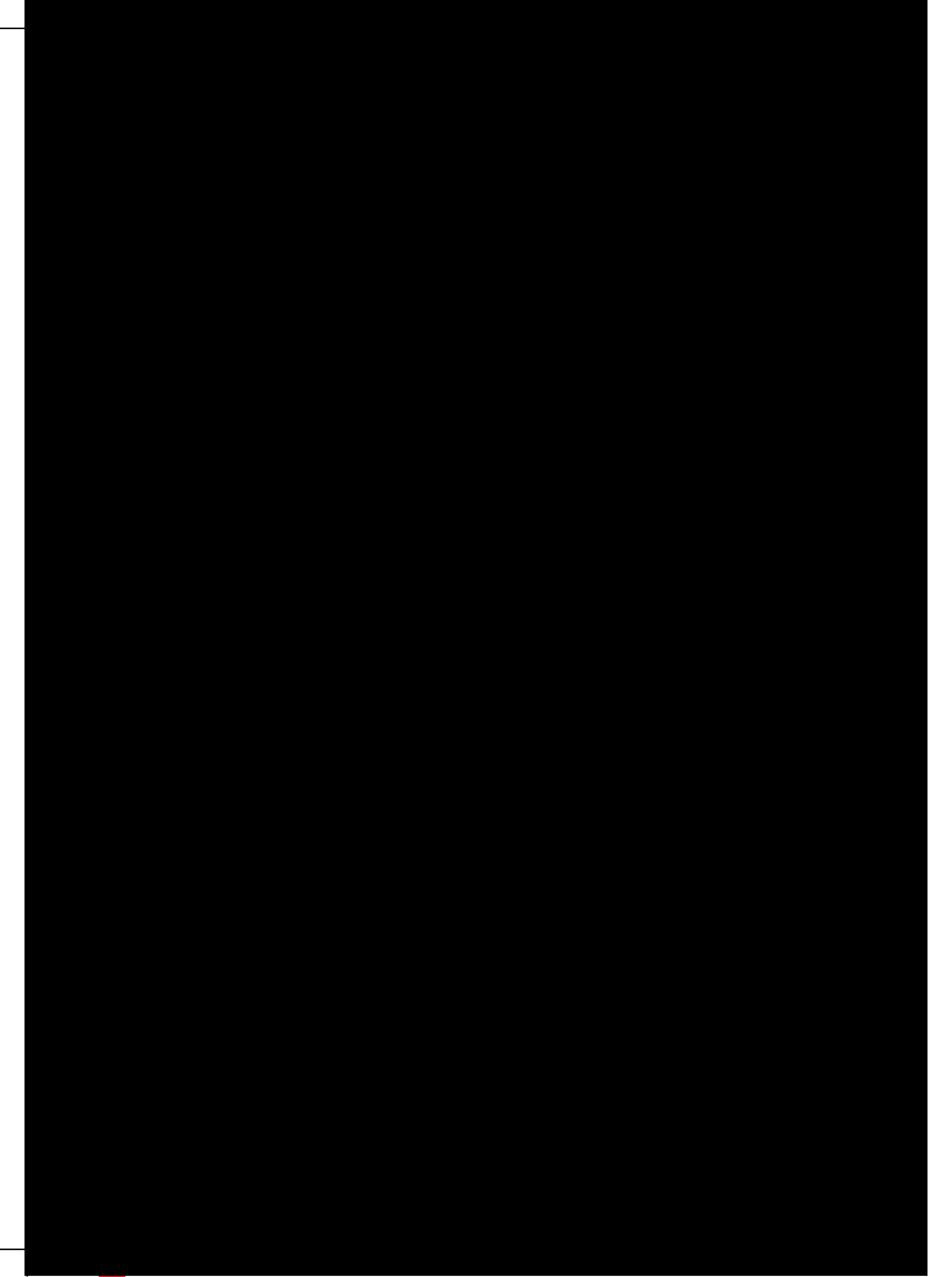


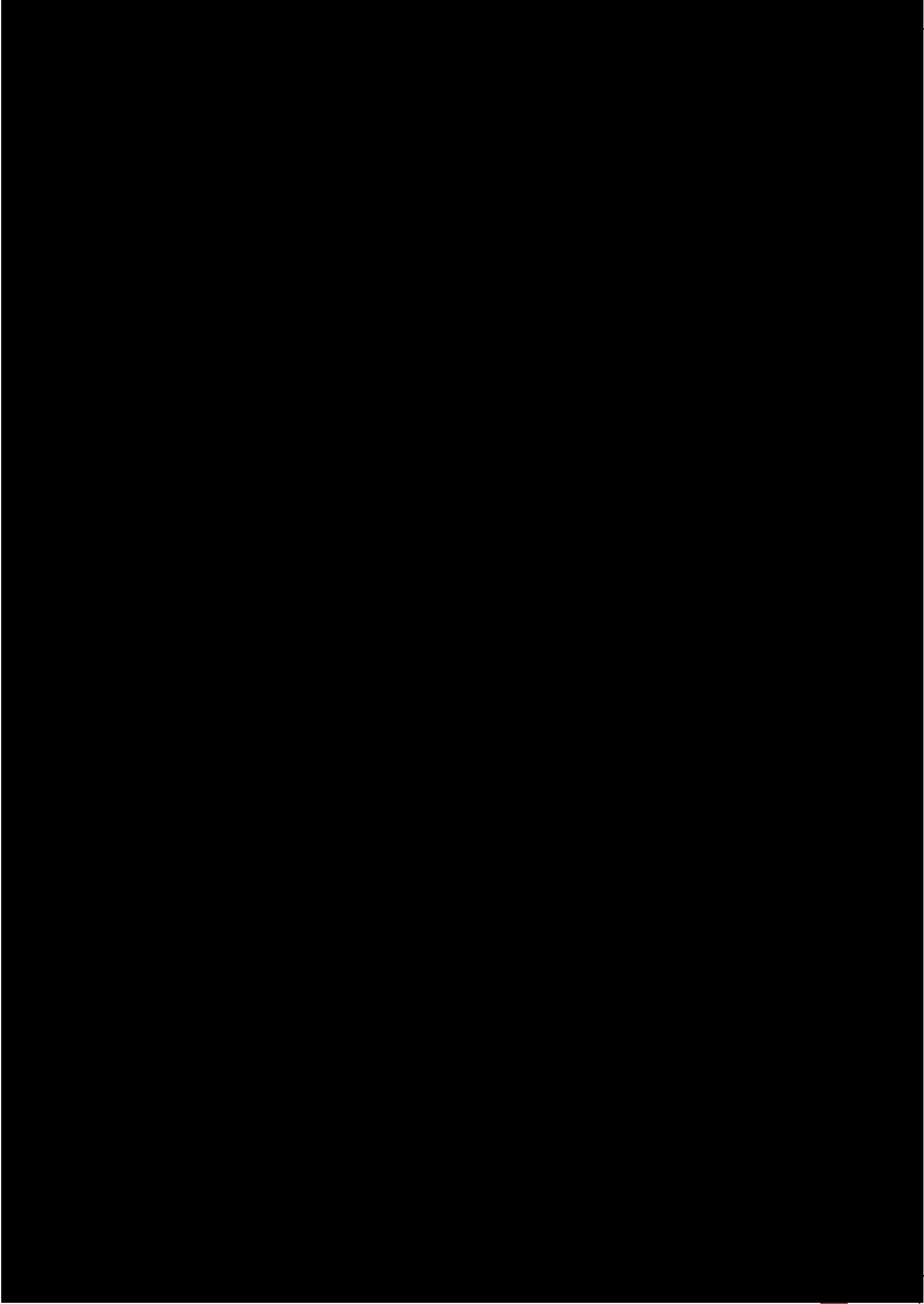


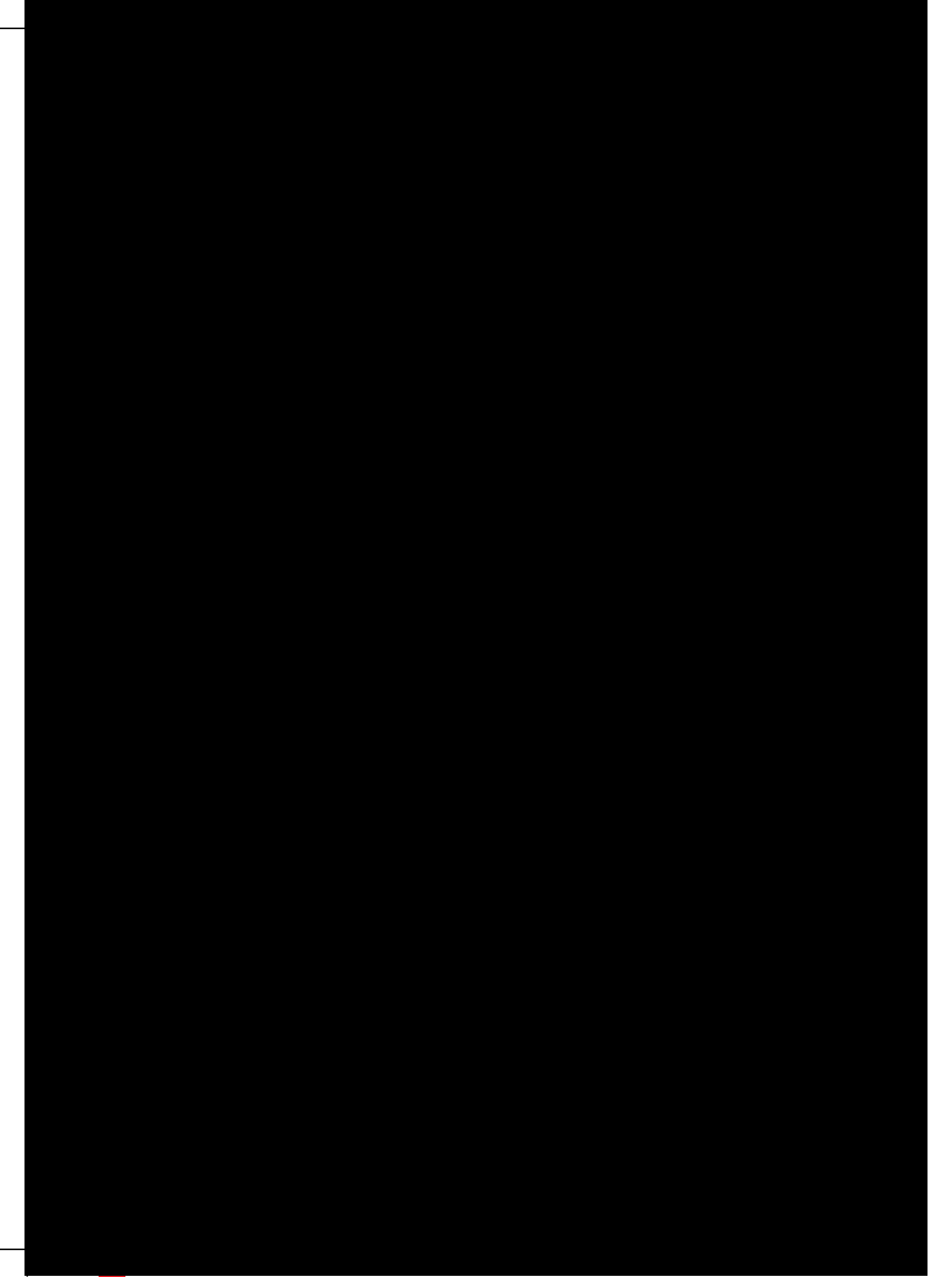


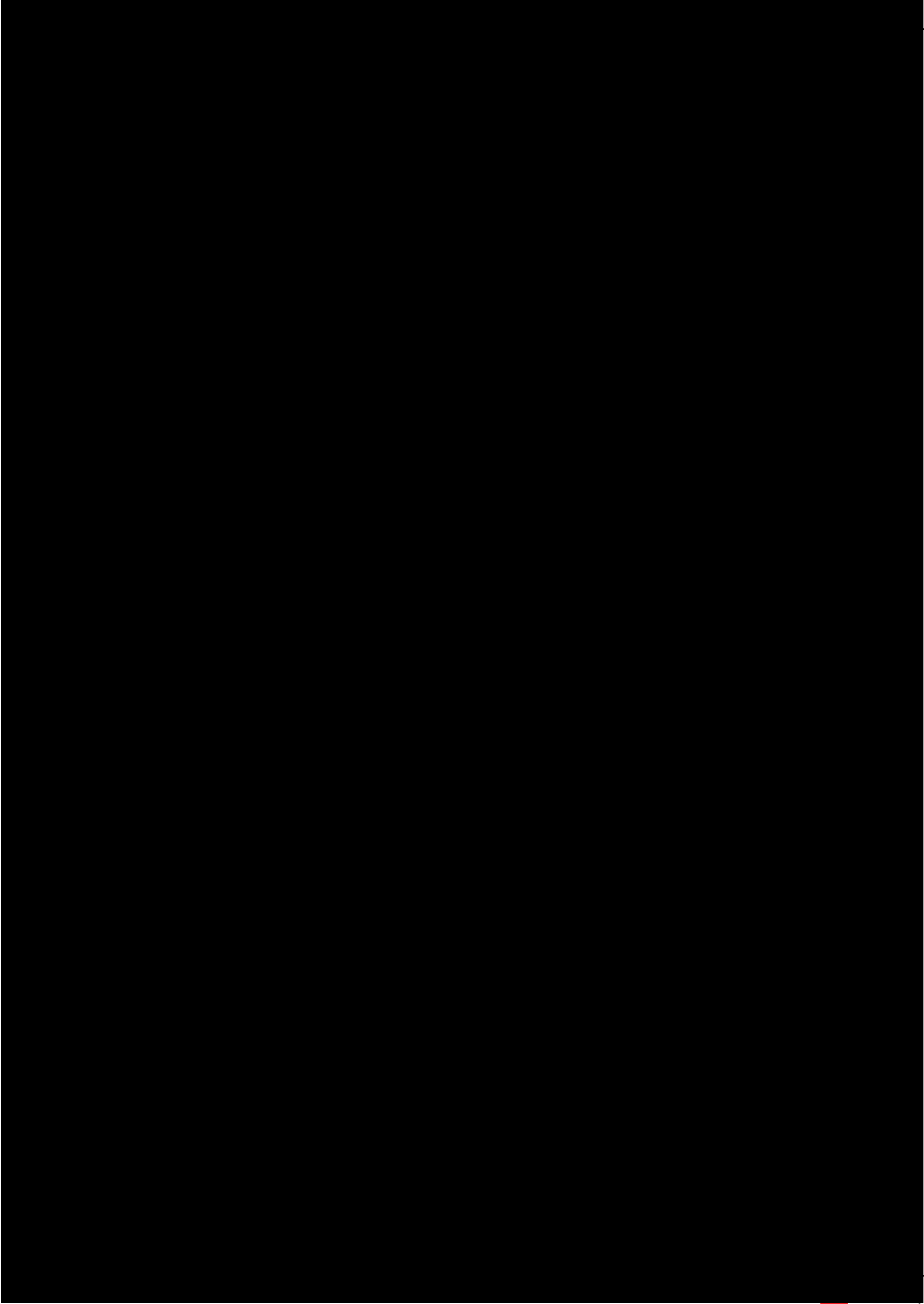


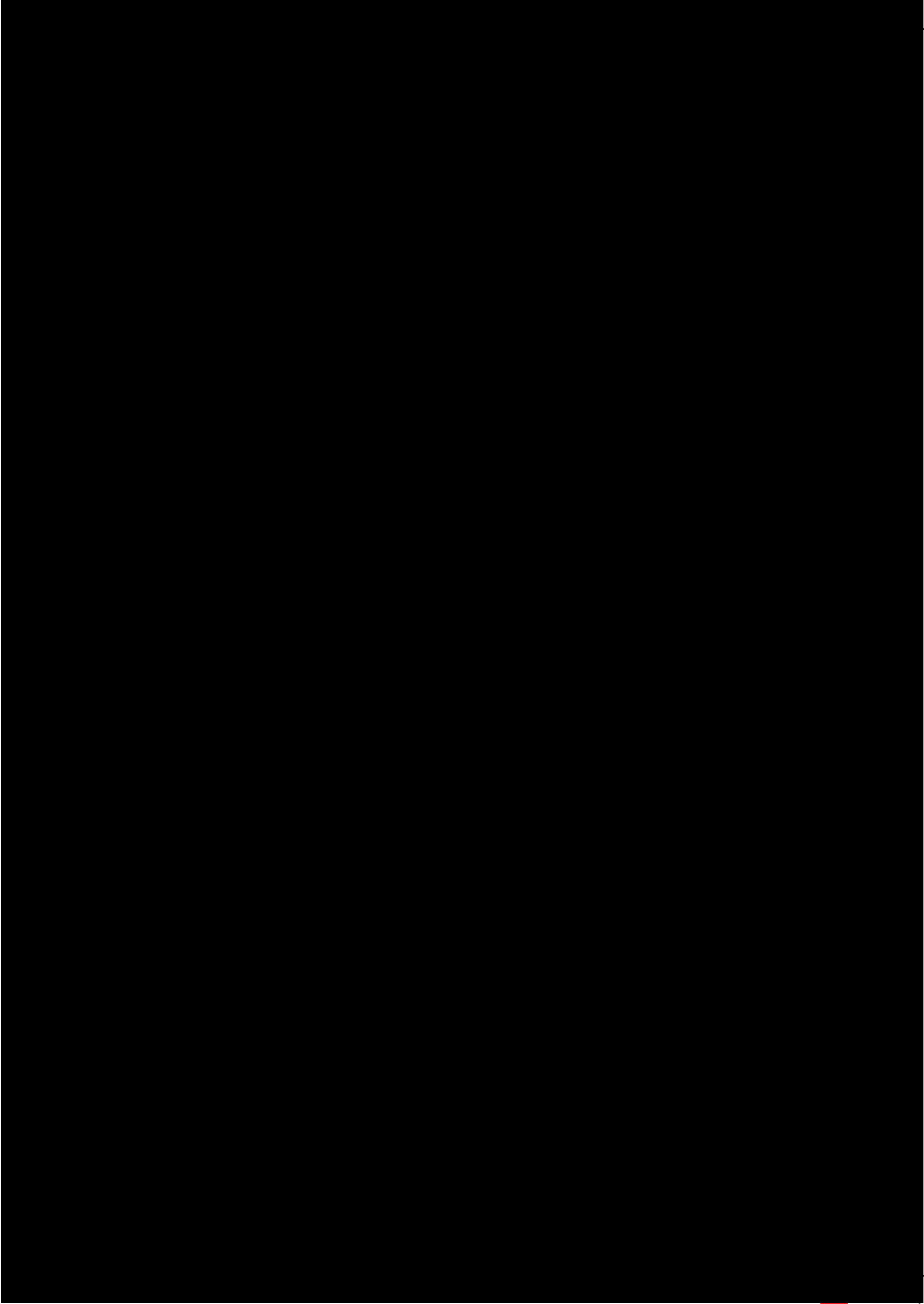


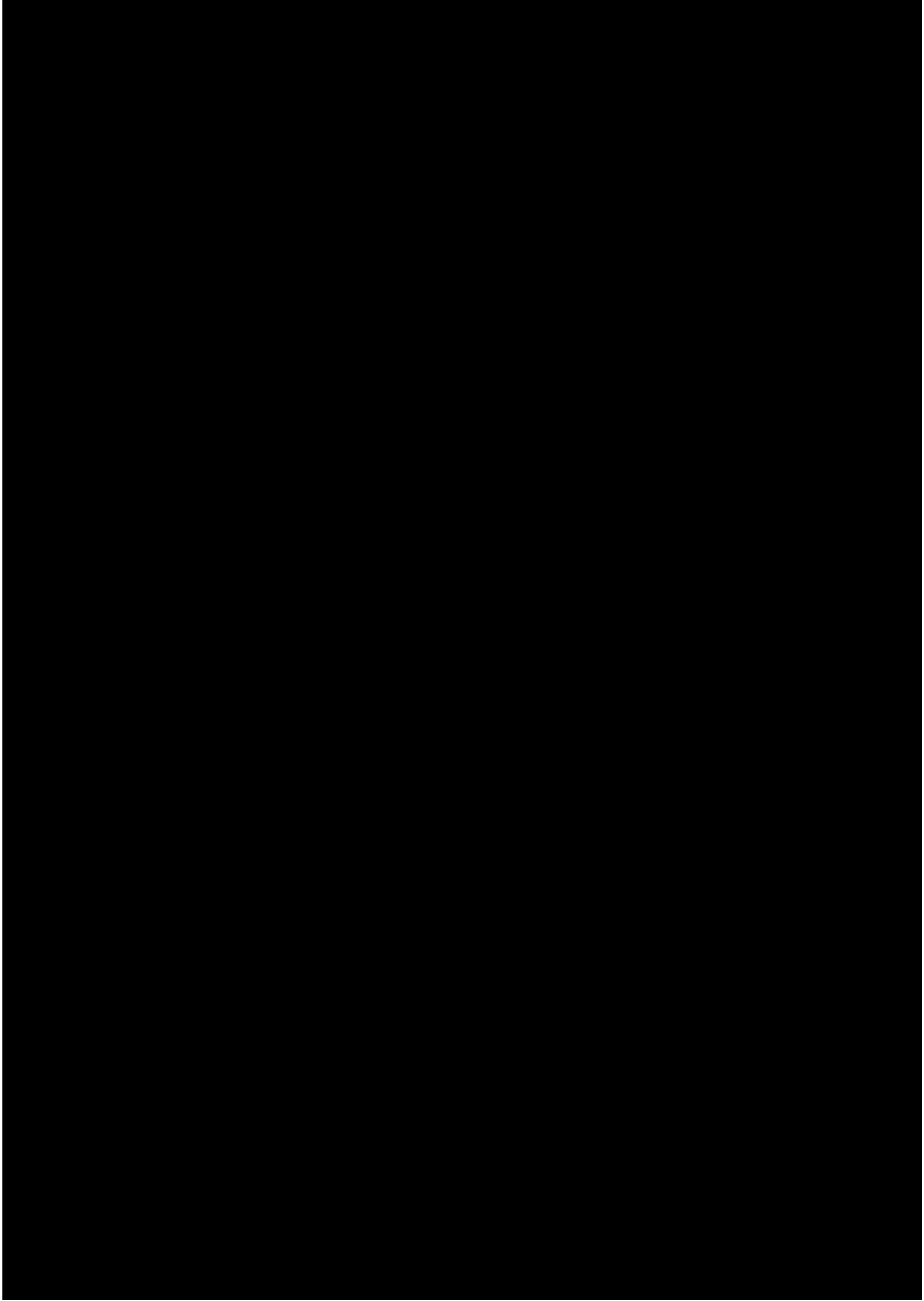


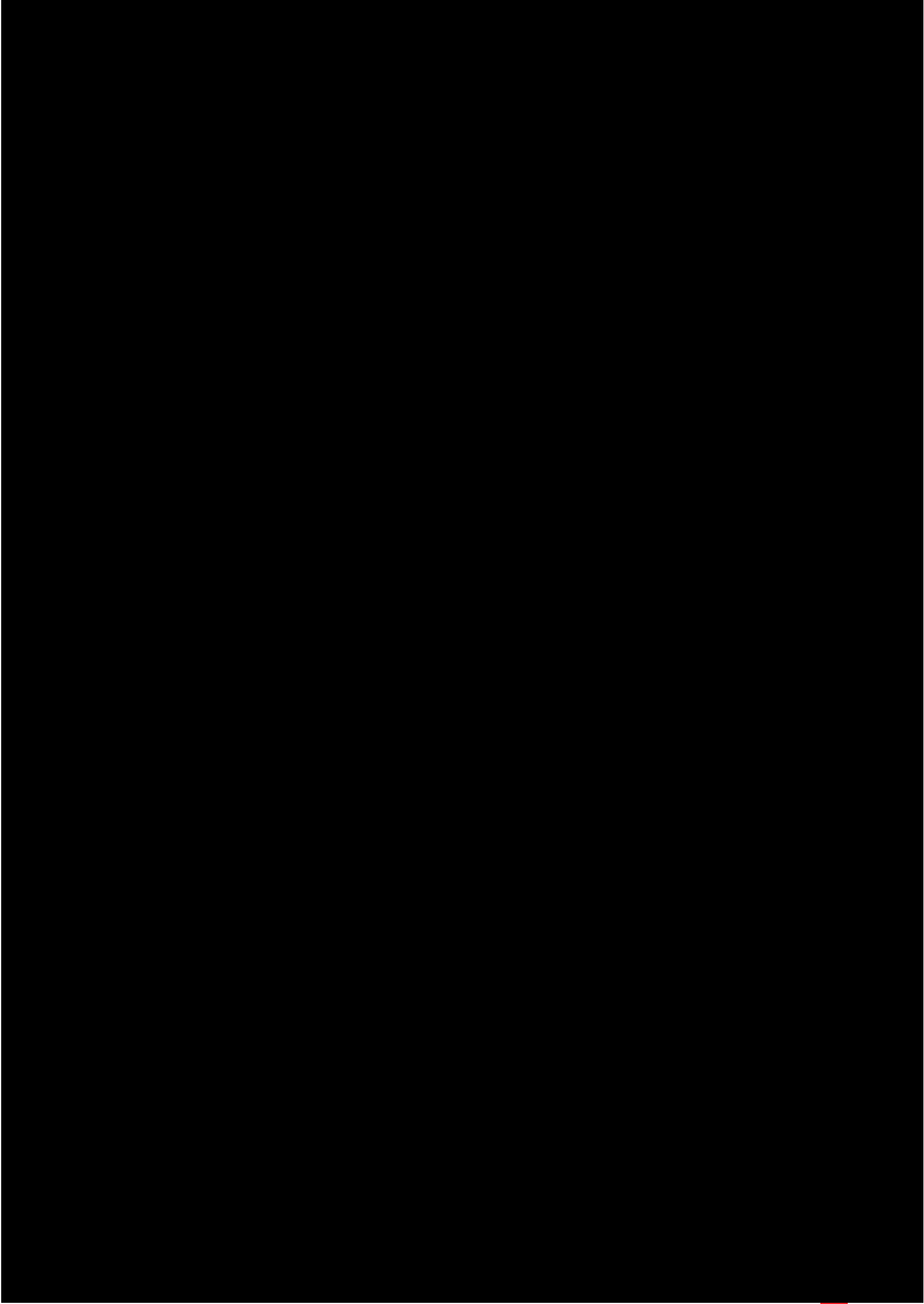


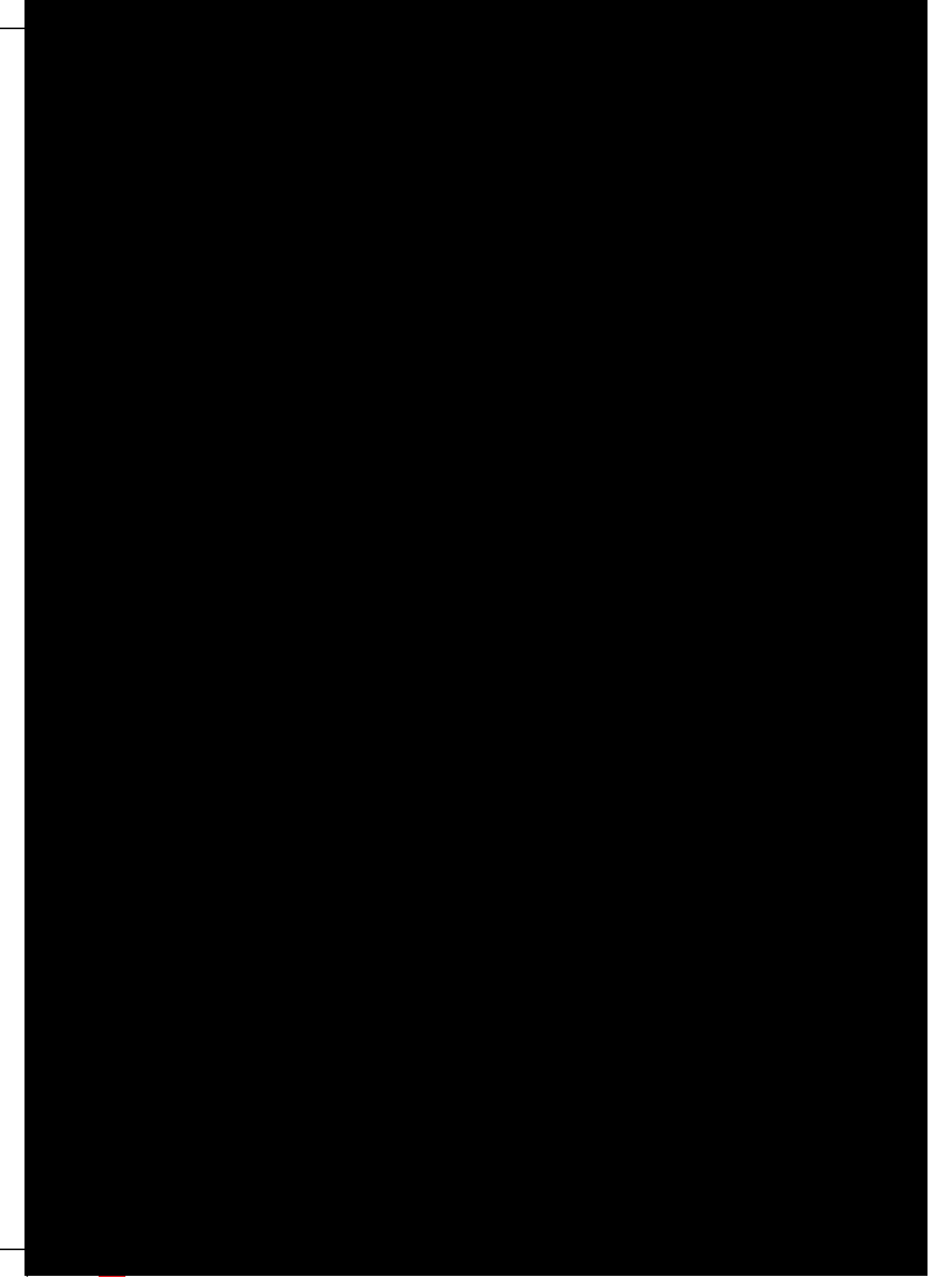


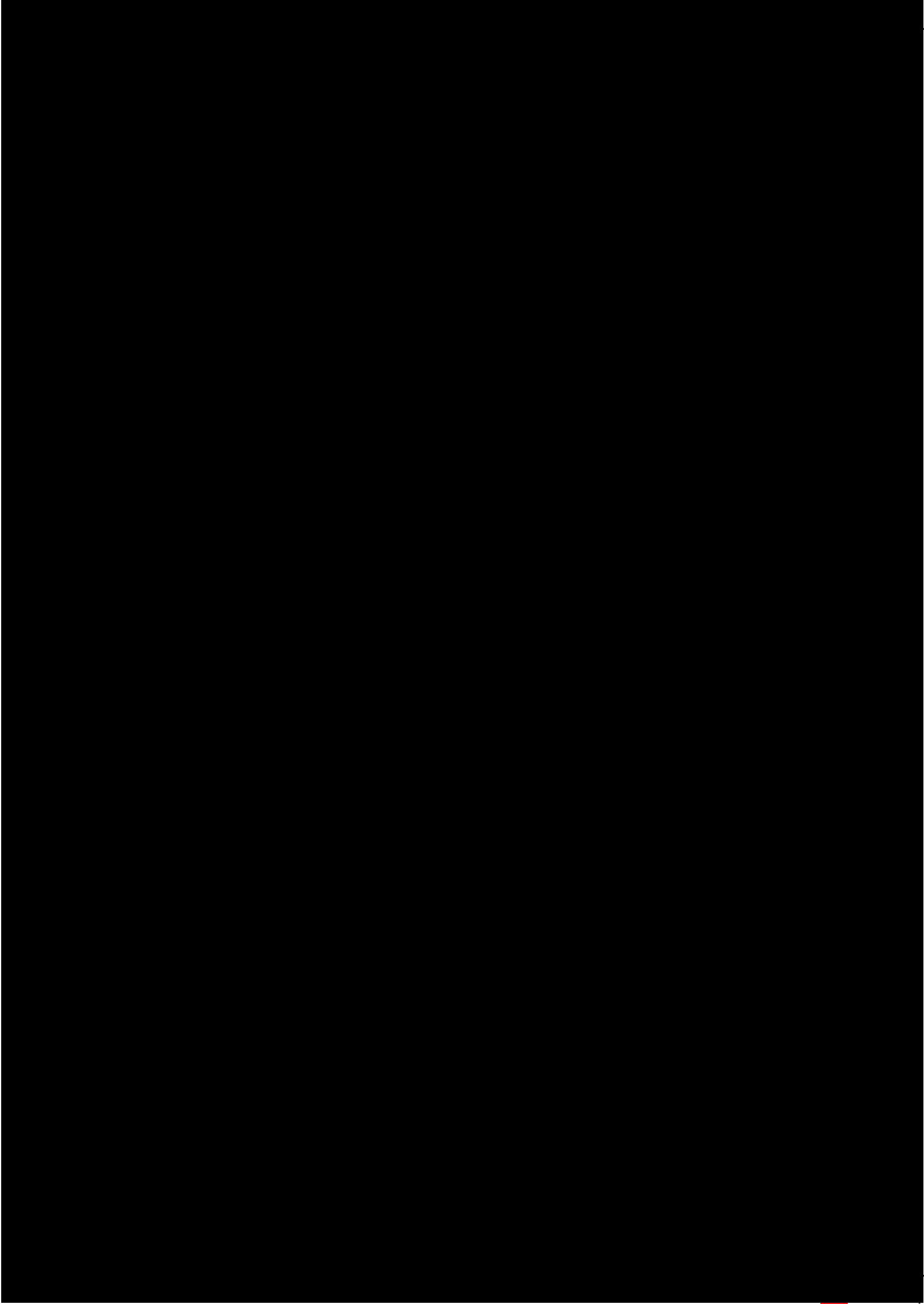


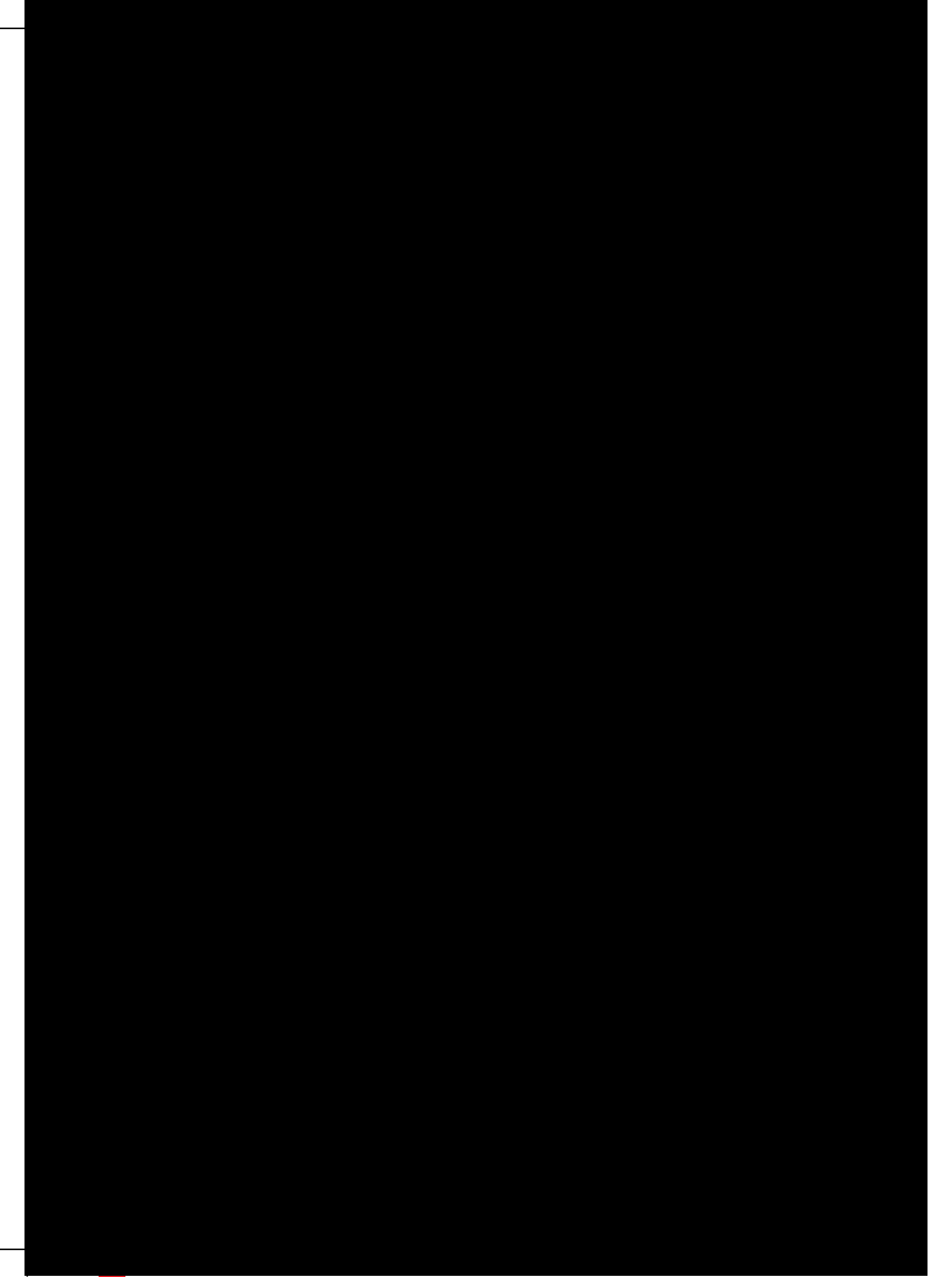


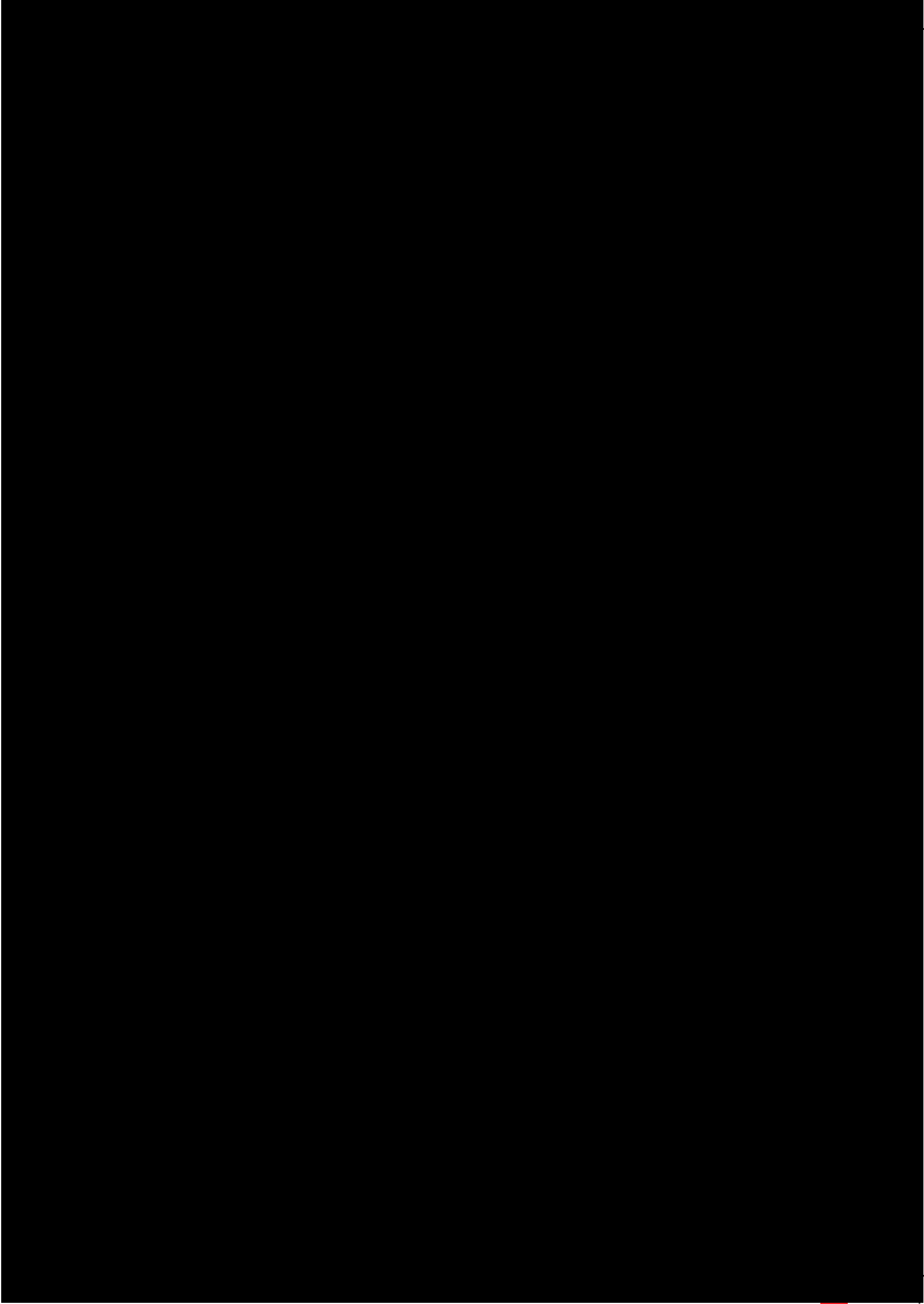


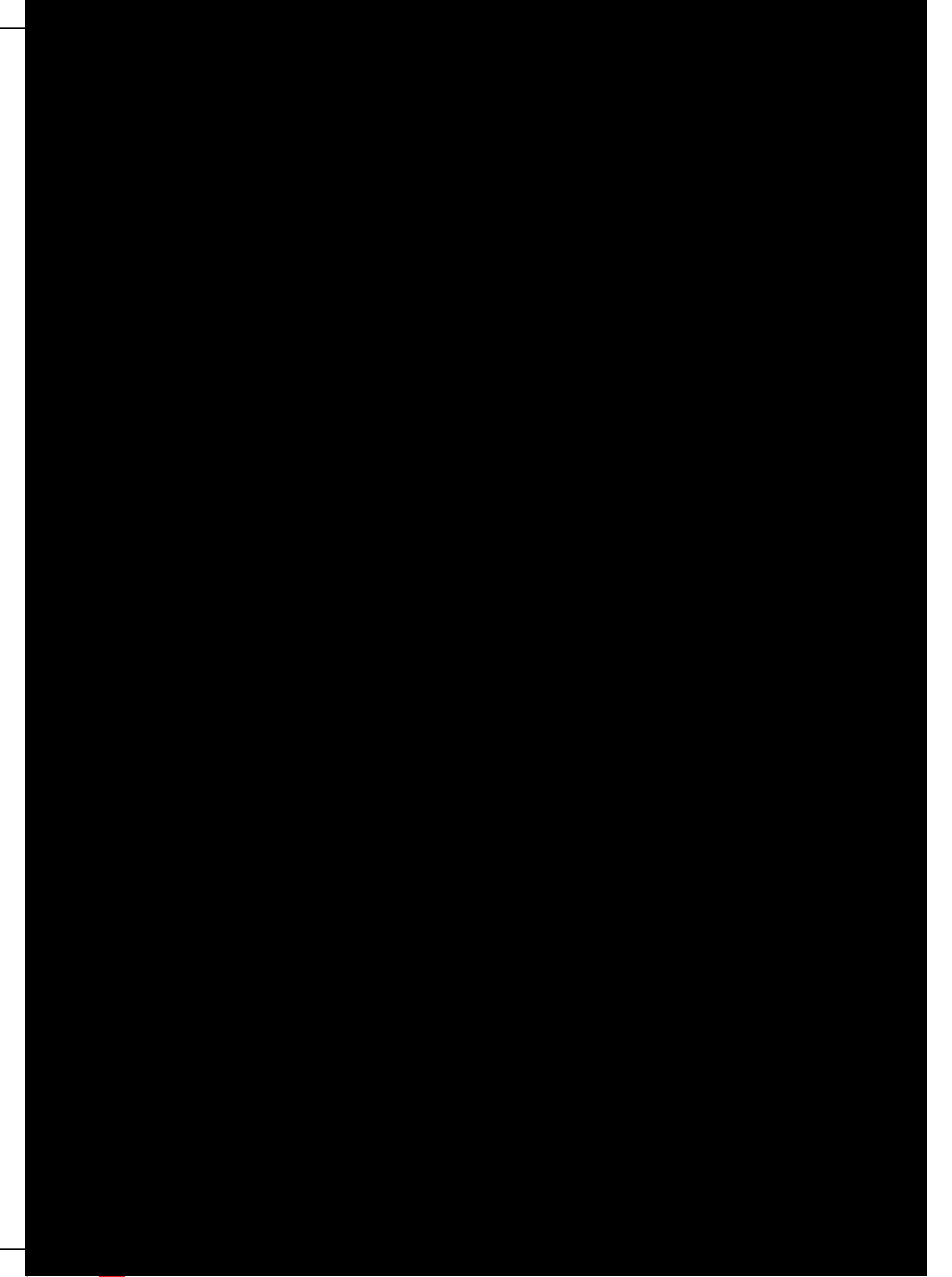


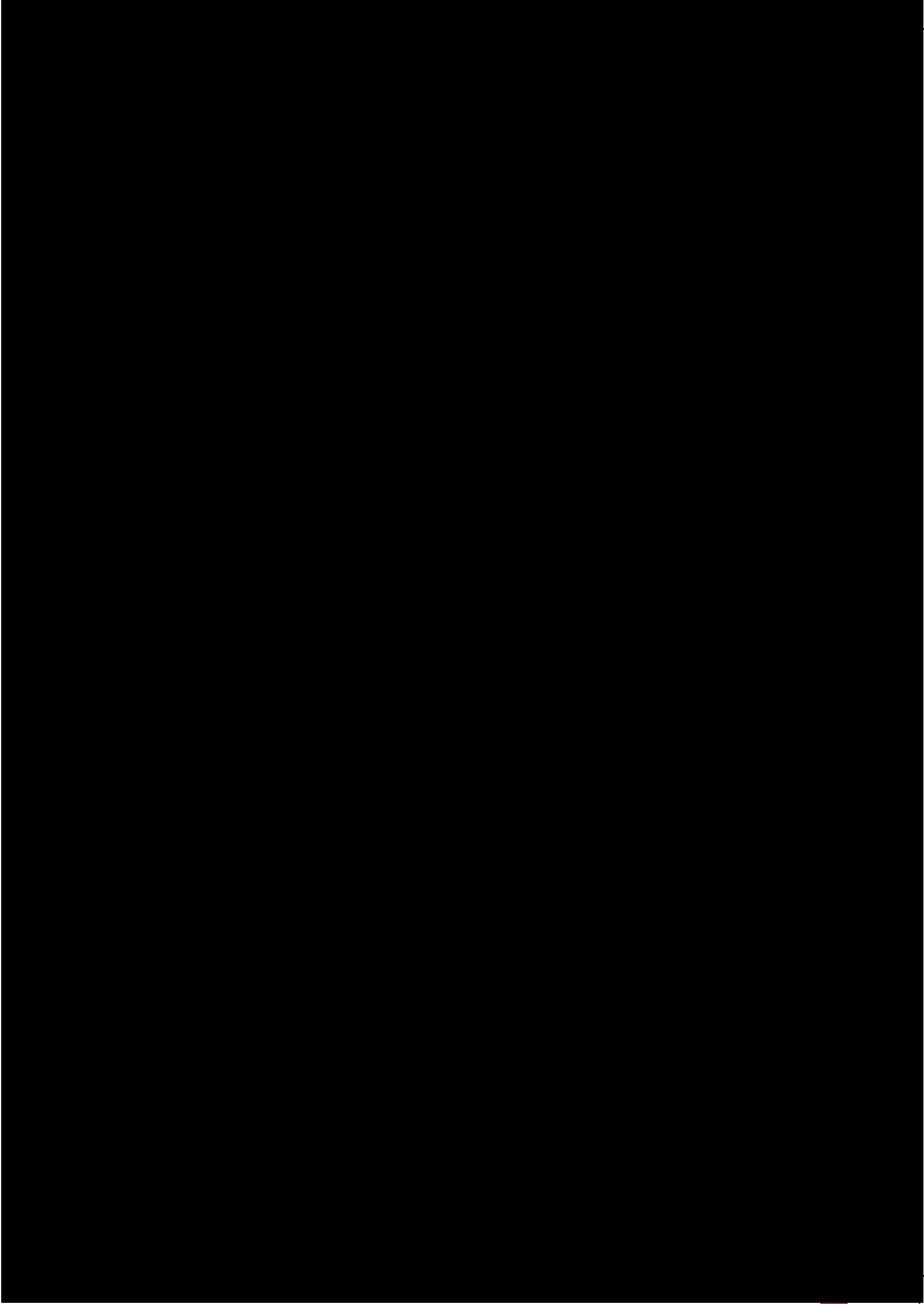






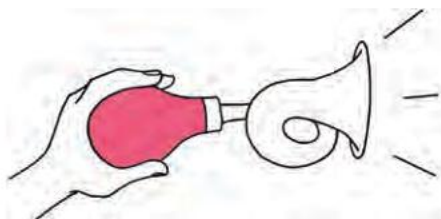








Megaphone



Horn

Fig 12.12: A megaphone and a horn.

In these instruments, a tube followed by a conical opening reflects sound successively to guide most of the sound waves from the source in the forward direction towards the audience.

2. Stethoscope is a medical instrument used for listening to sounds produced within the body, mainly in the heart or lungs. In stethoscopes the sound of the patient's heartbeat reaches the doctor's ears by multiple reflection of sound, as shown in Fig. 12.13.



Fig.12.13: Stethoscope

3. Generally the ceilings of concert halls, conference halls and cinema halls are curved so that sound after reflection reaches all corners of the hall, as shown in Fig 12.14. Sometimes a curved

soundboard may be placed behind the stage so that the sound, after reflecting from the sound board, spreads evenly across the width of the hall (Fig 12.15).

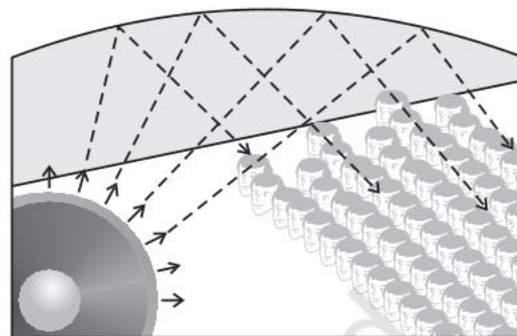


Fig. 12.14: Curved ceiling of a conference hall.

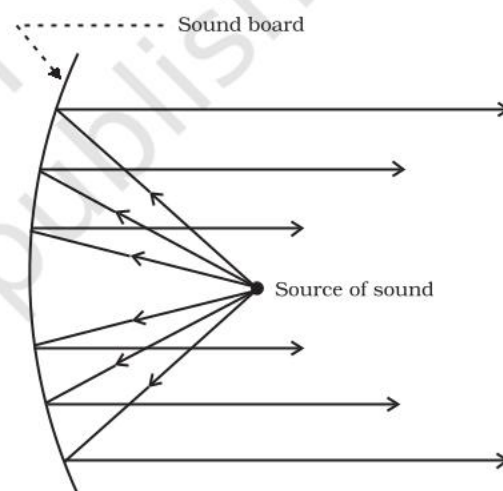


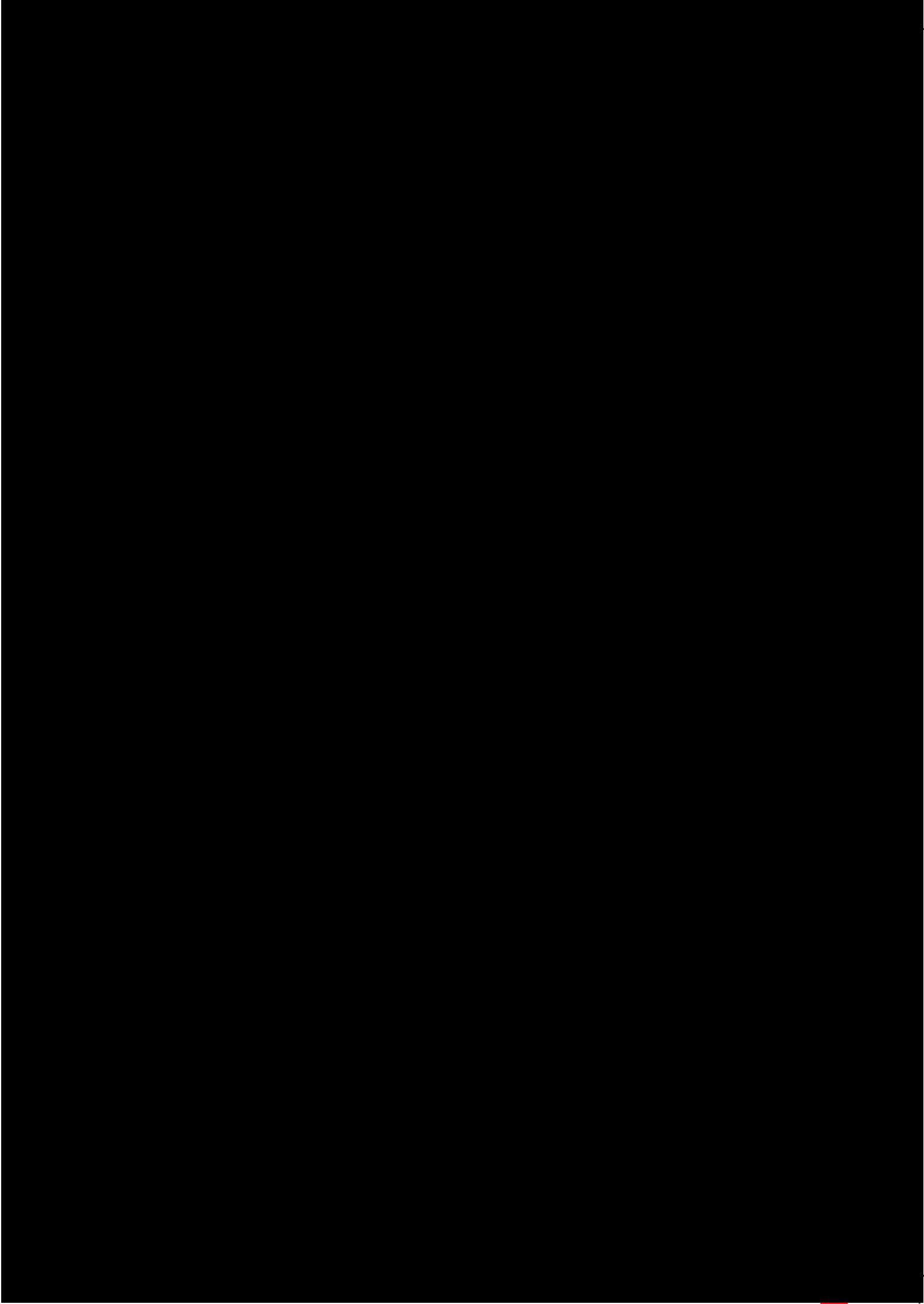
Fig. 12.15: Sound board used in a big hall.

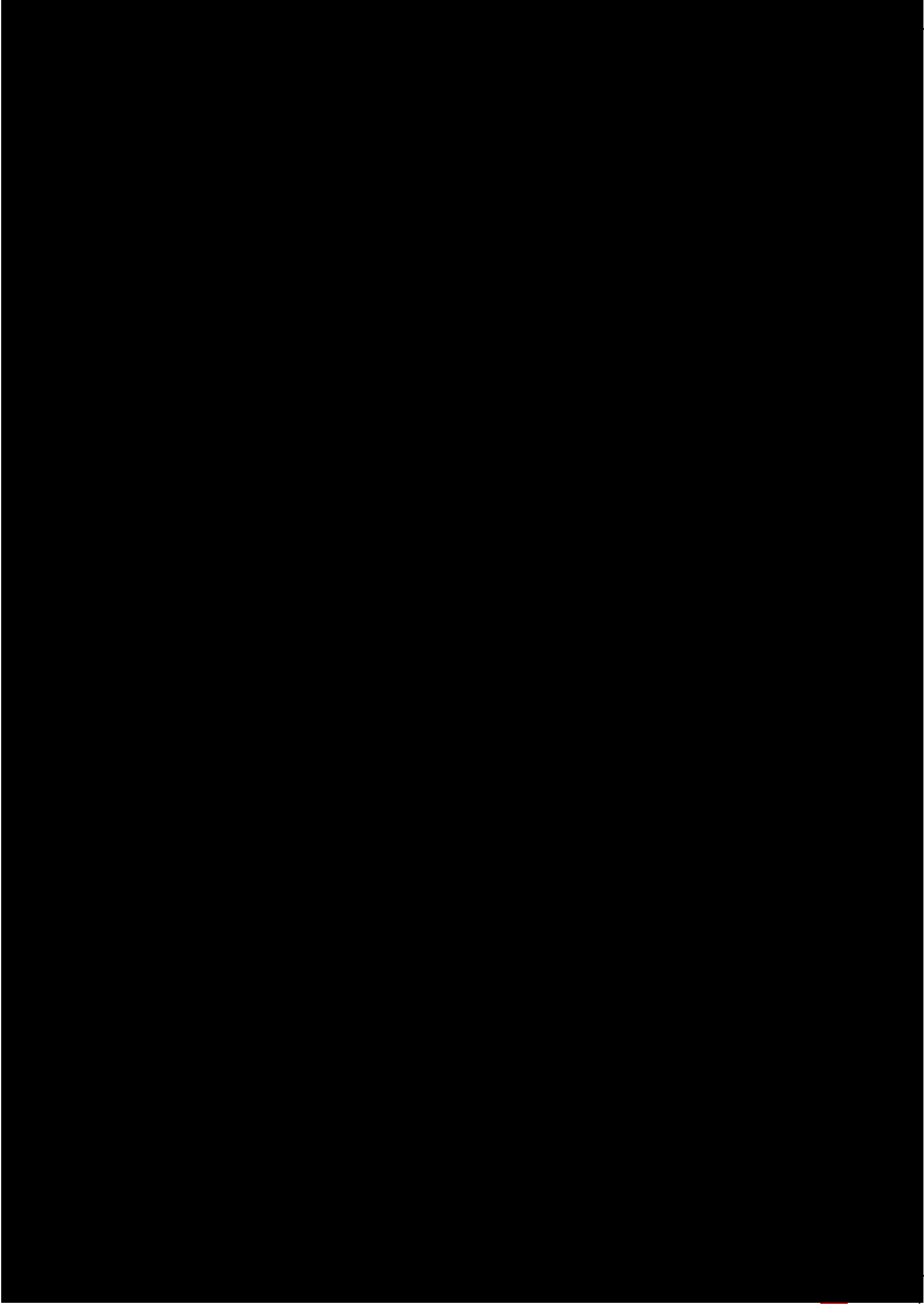
Question

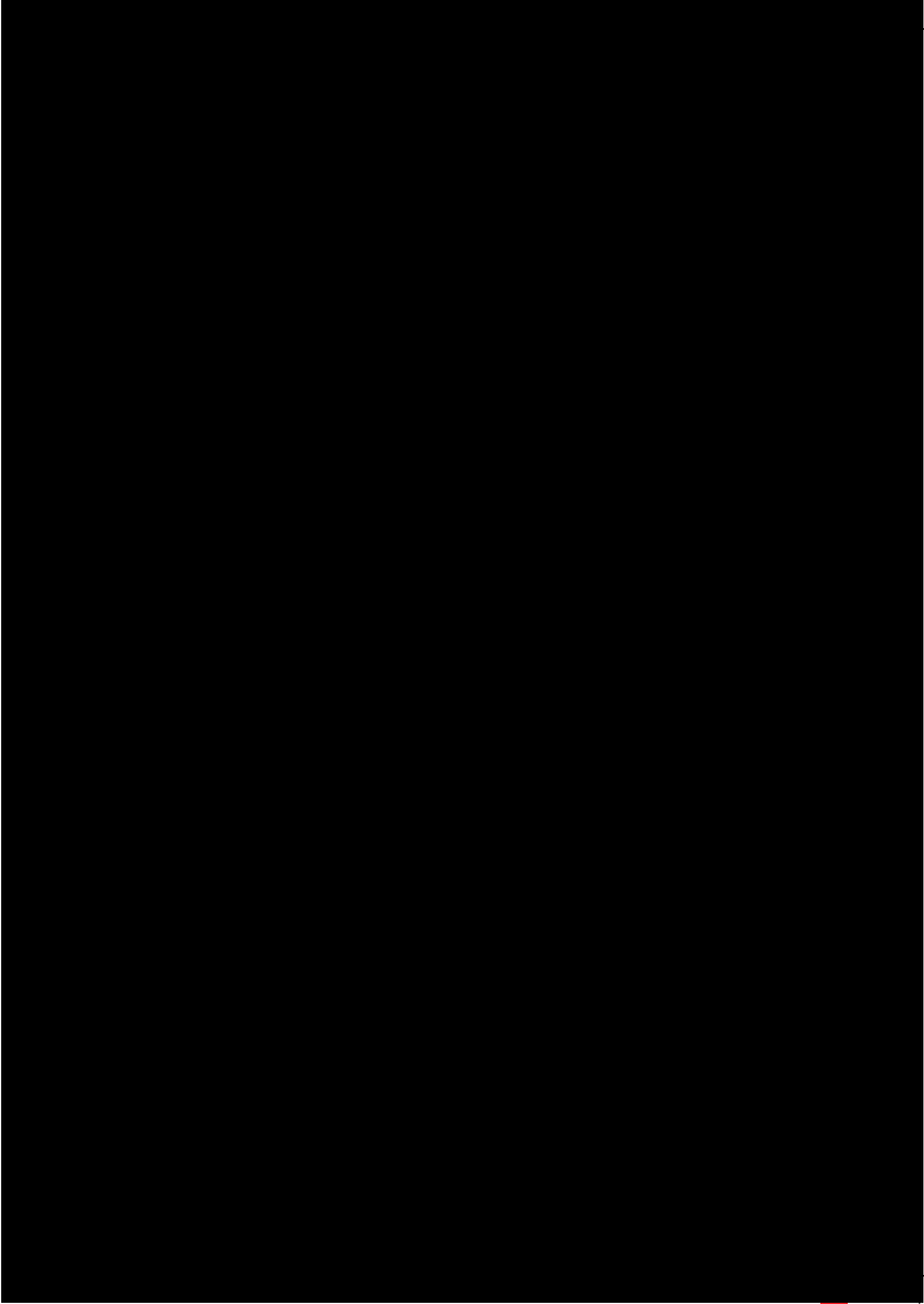
1. Why are the ceilings of concert halls curved?

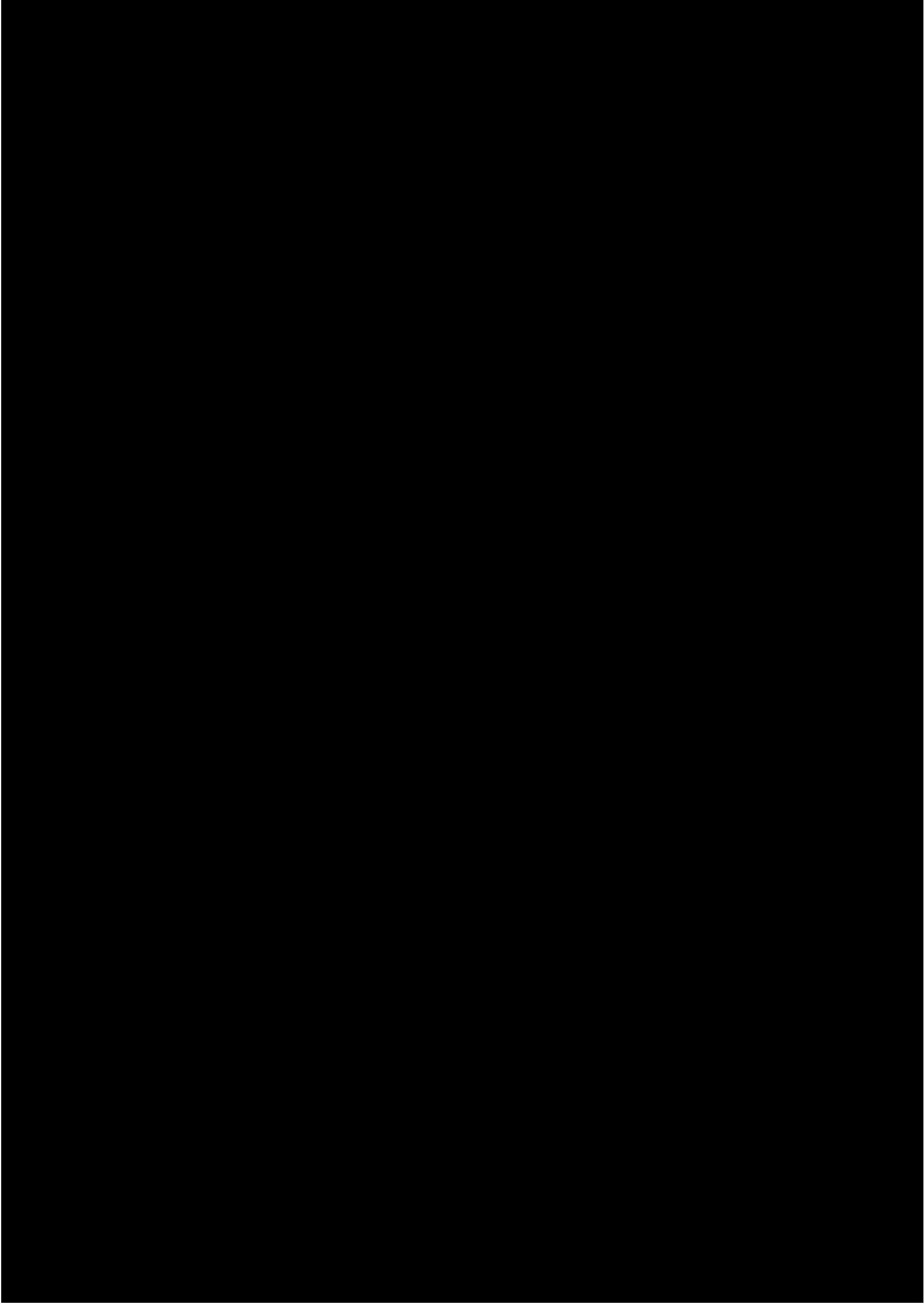
12.4 Range of Hearing

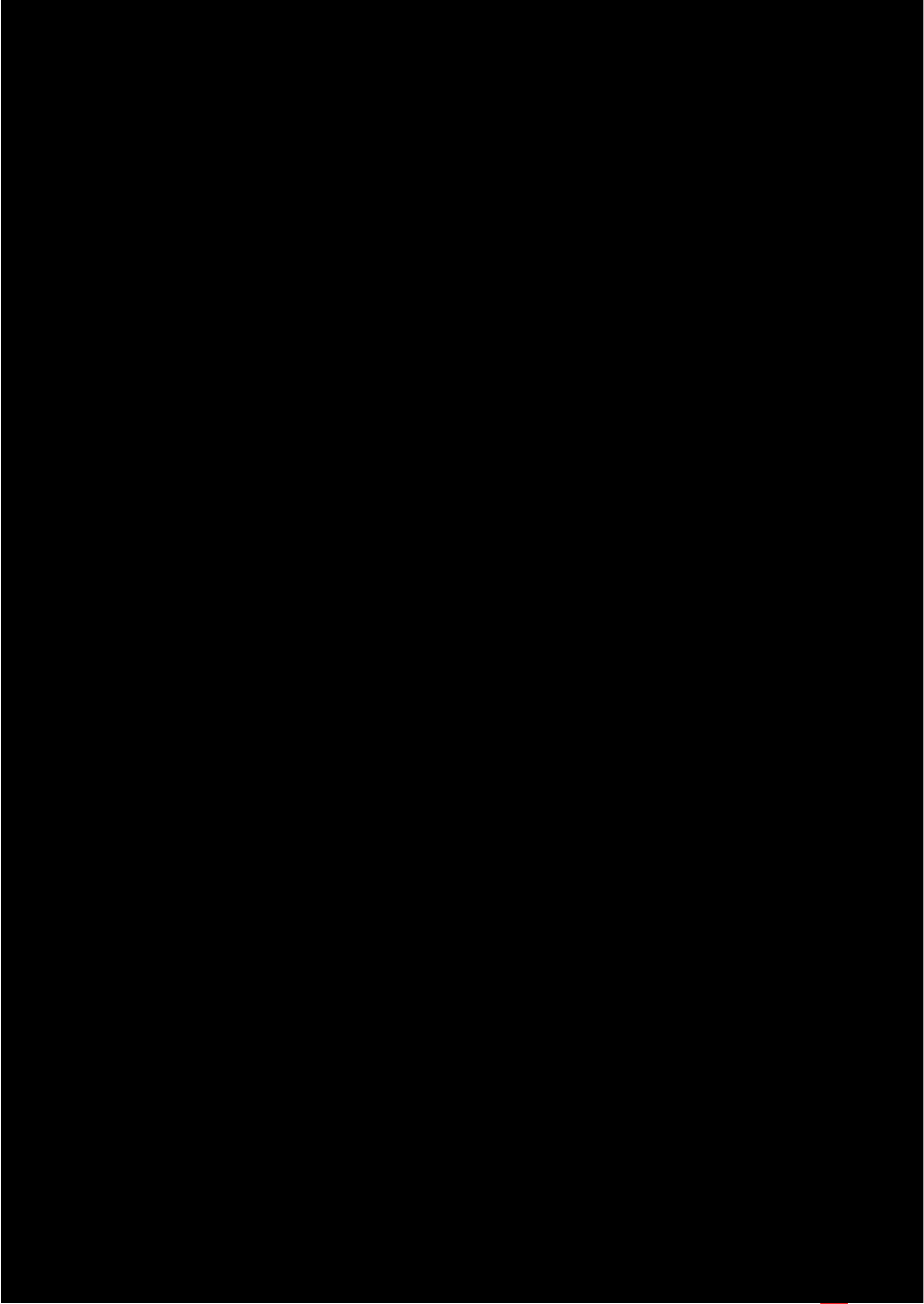
The audible range of sound for human beings extends from about 20 Hz to 20000 Hz (one Hz = one cycle/s). Children under the age of

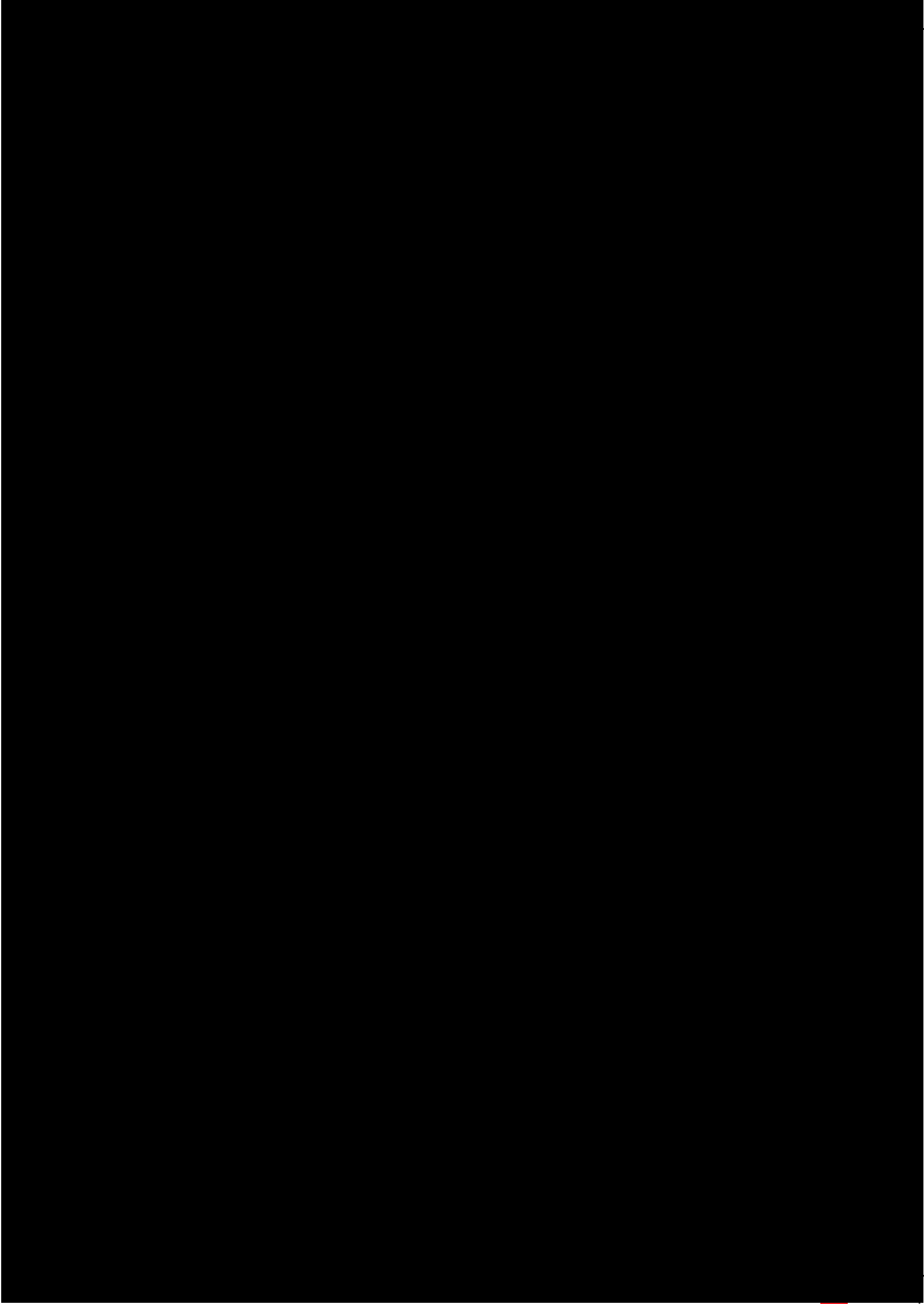


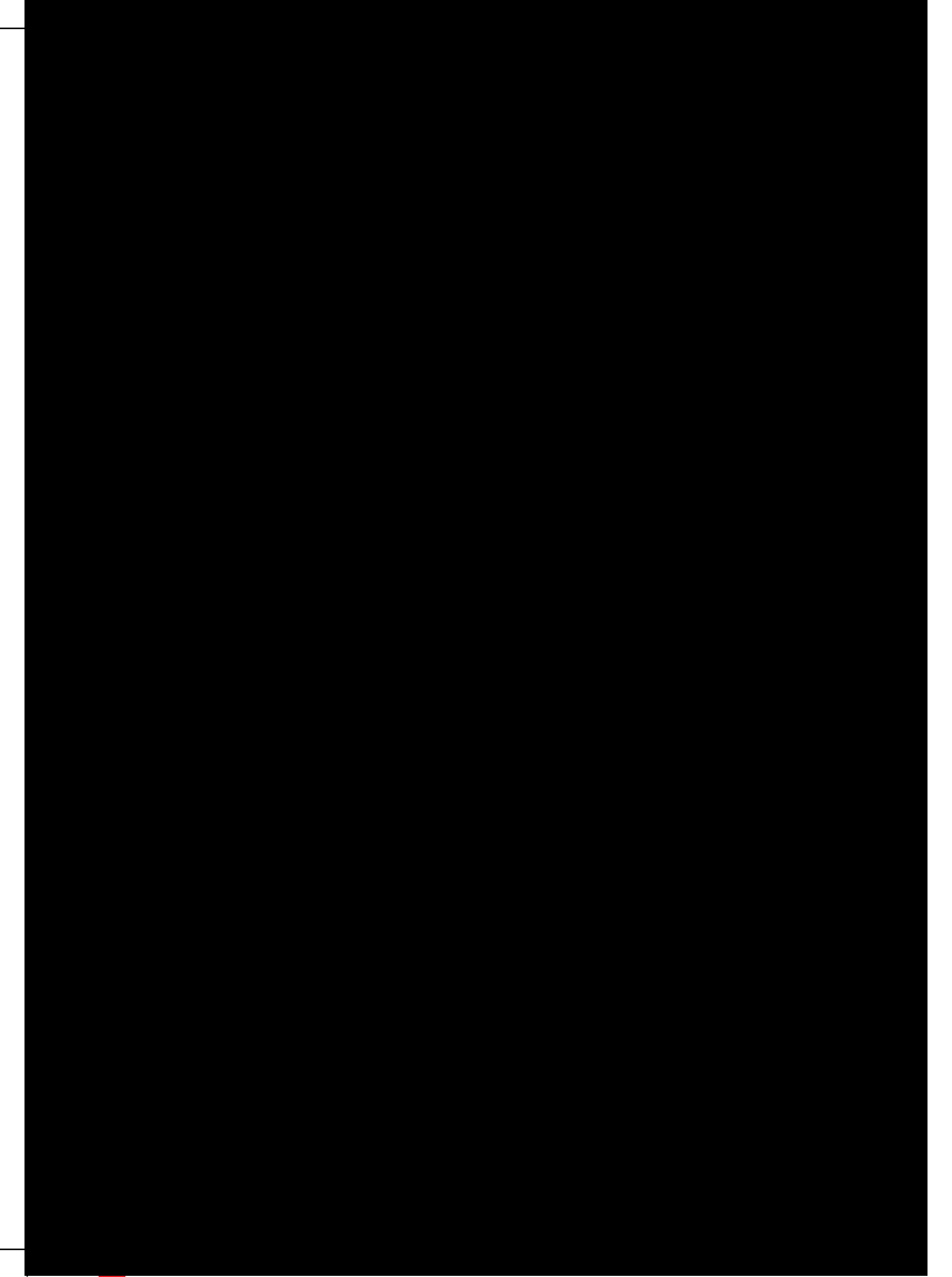


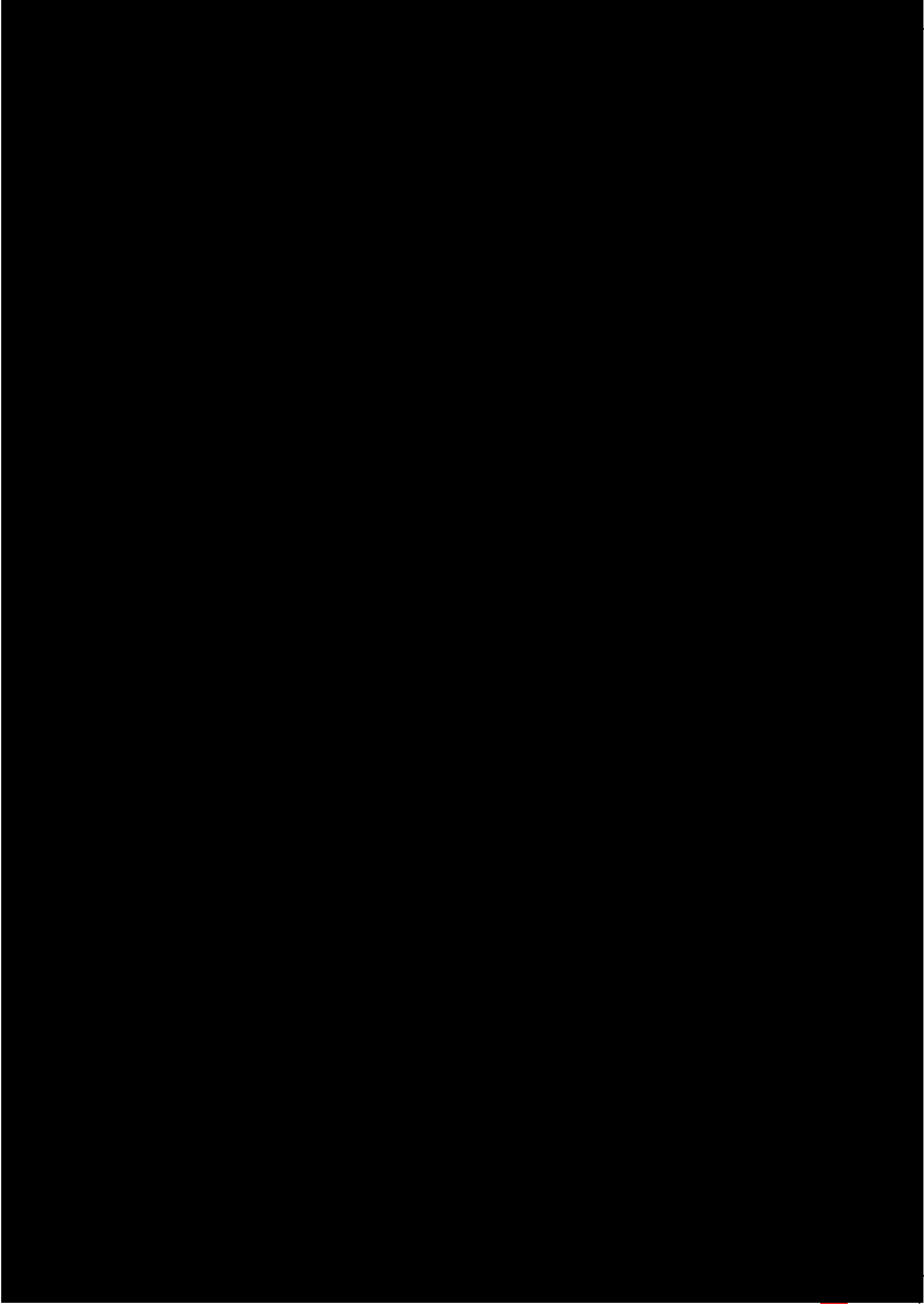


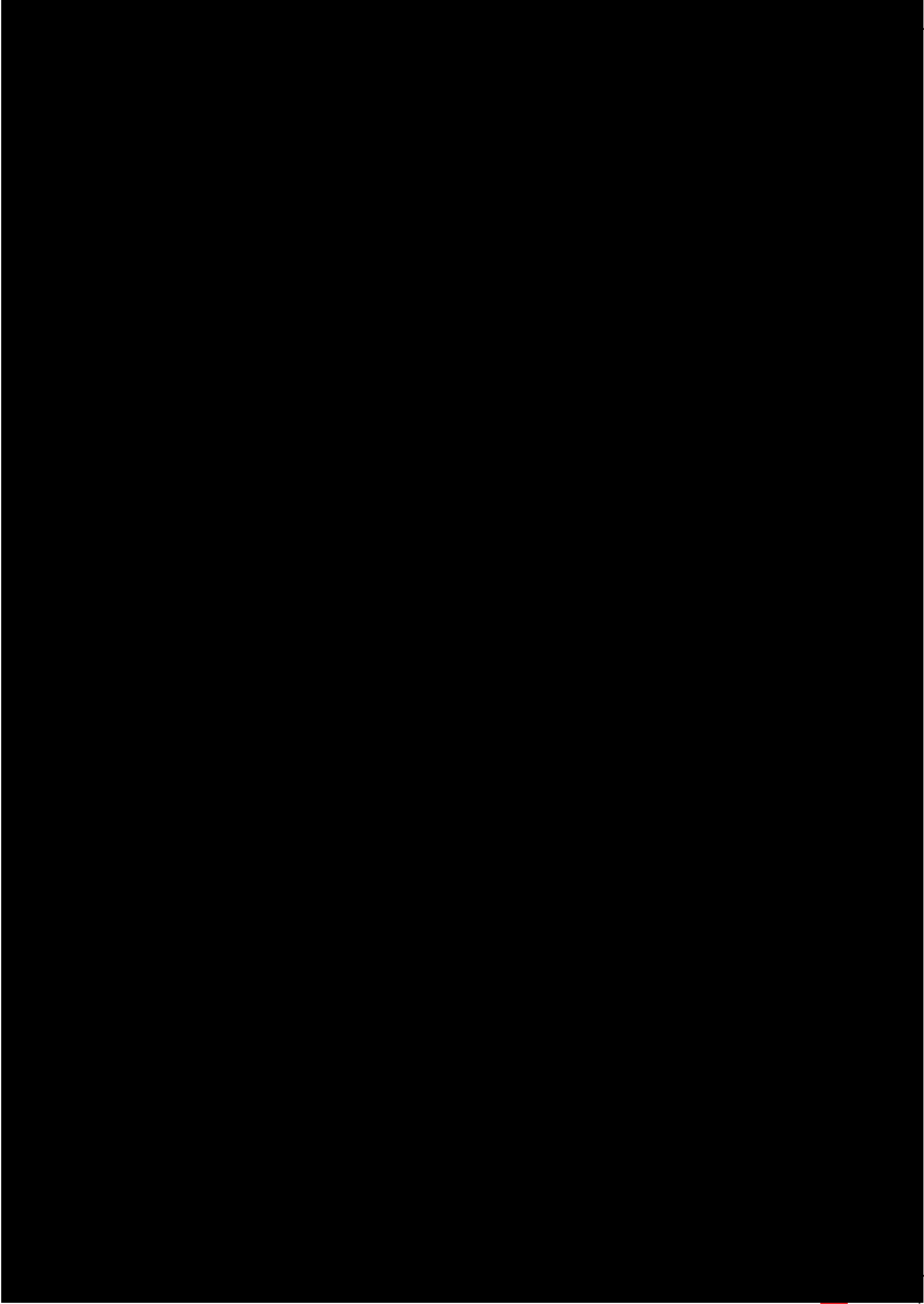


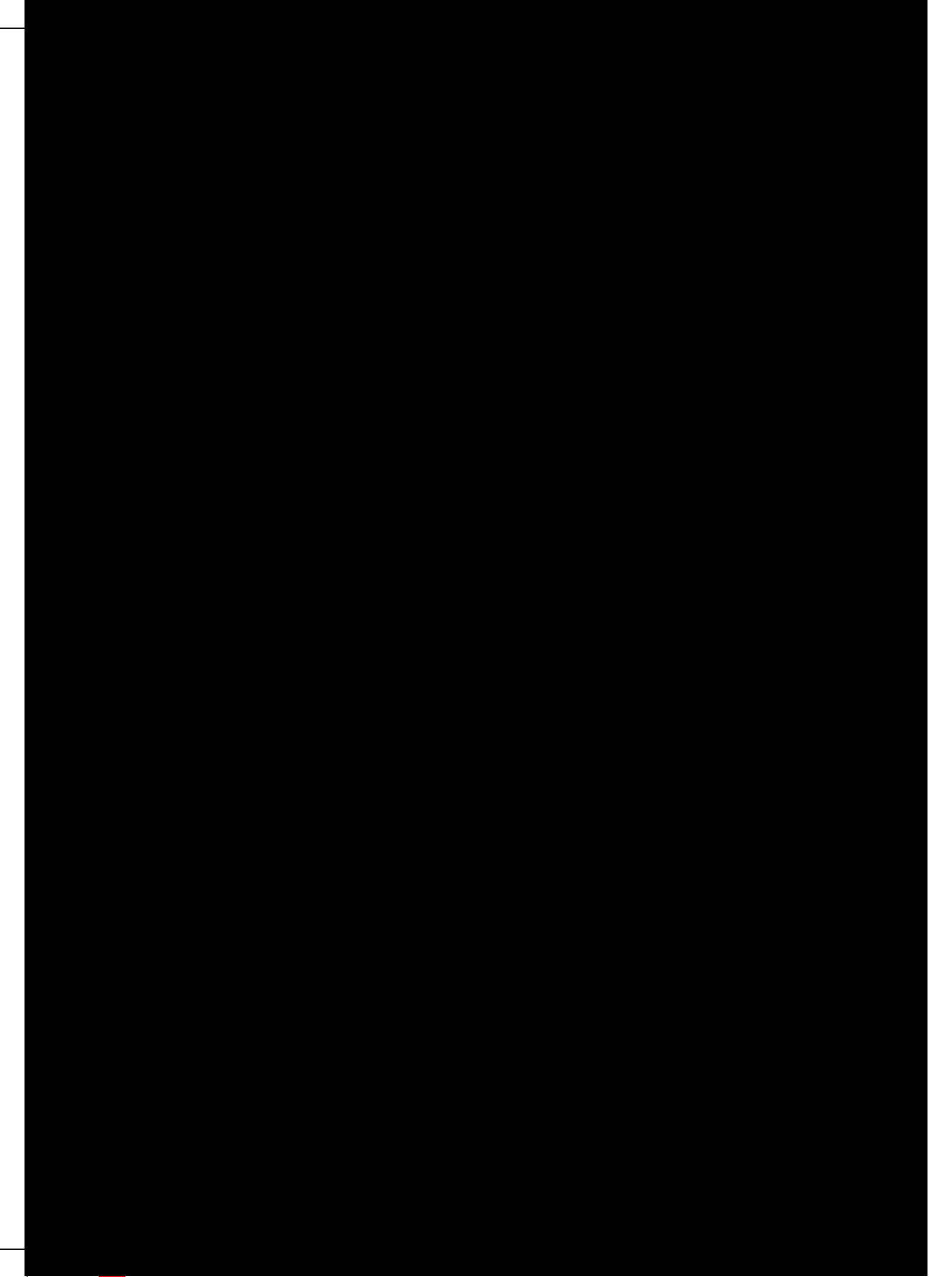


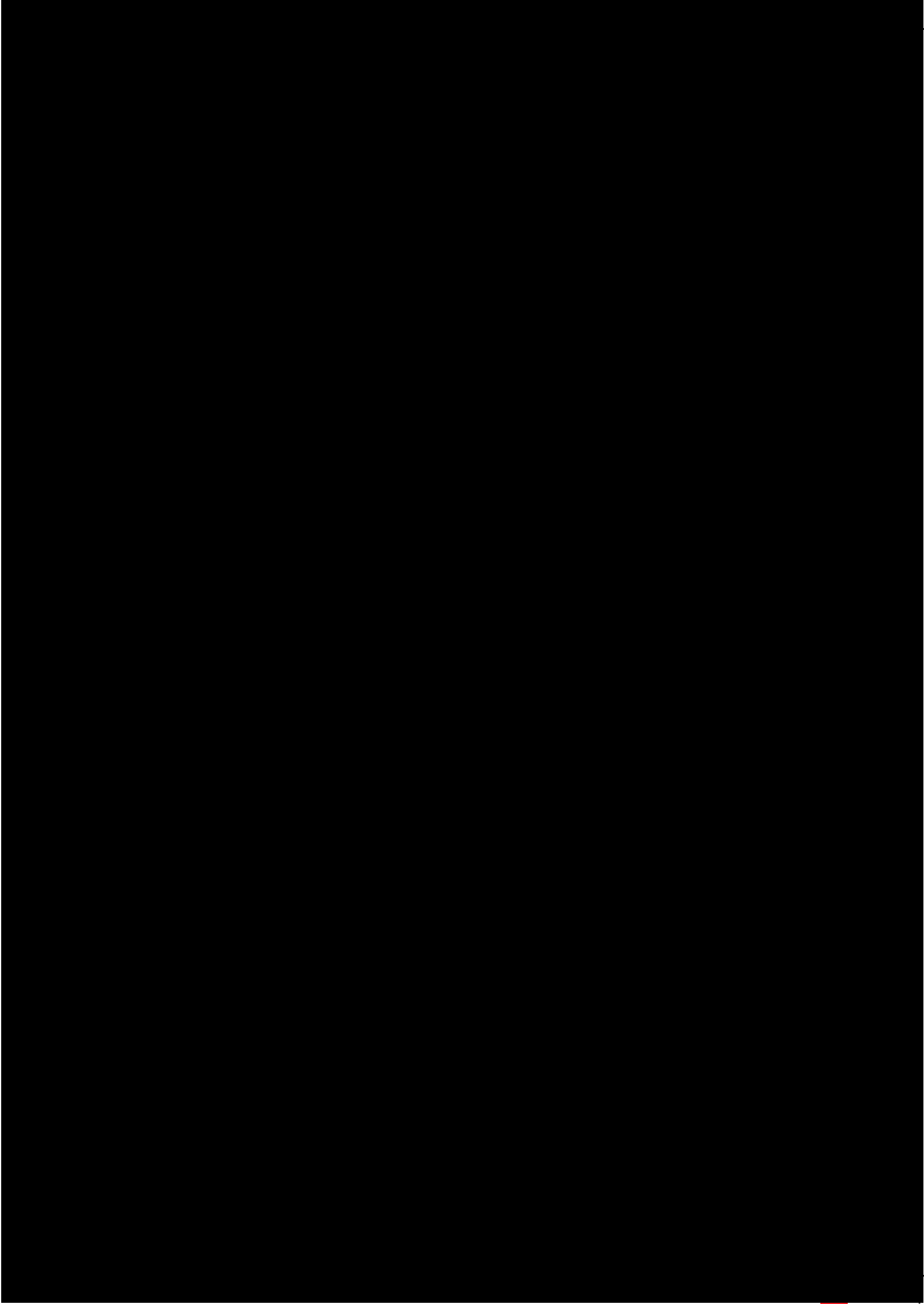


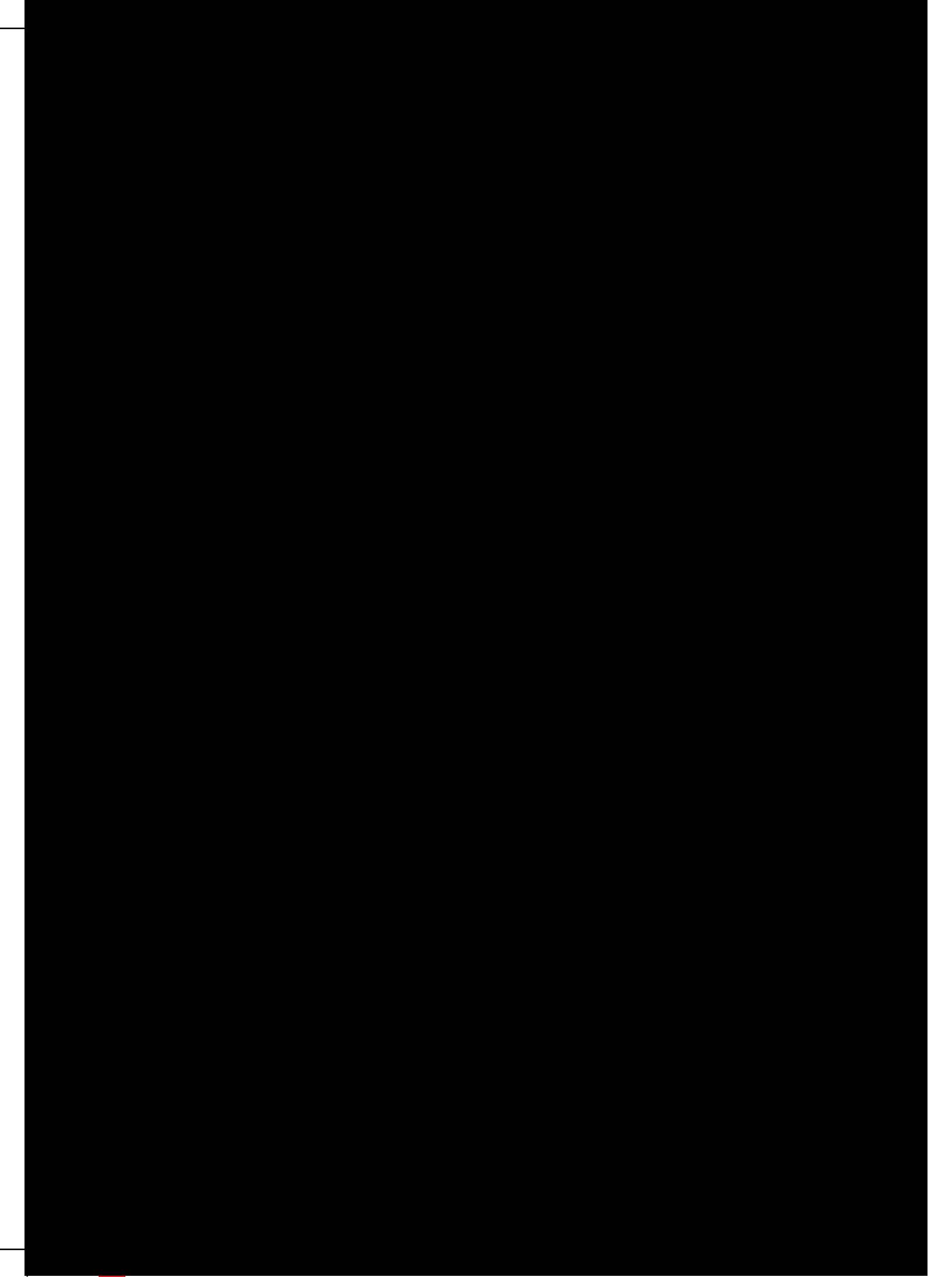


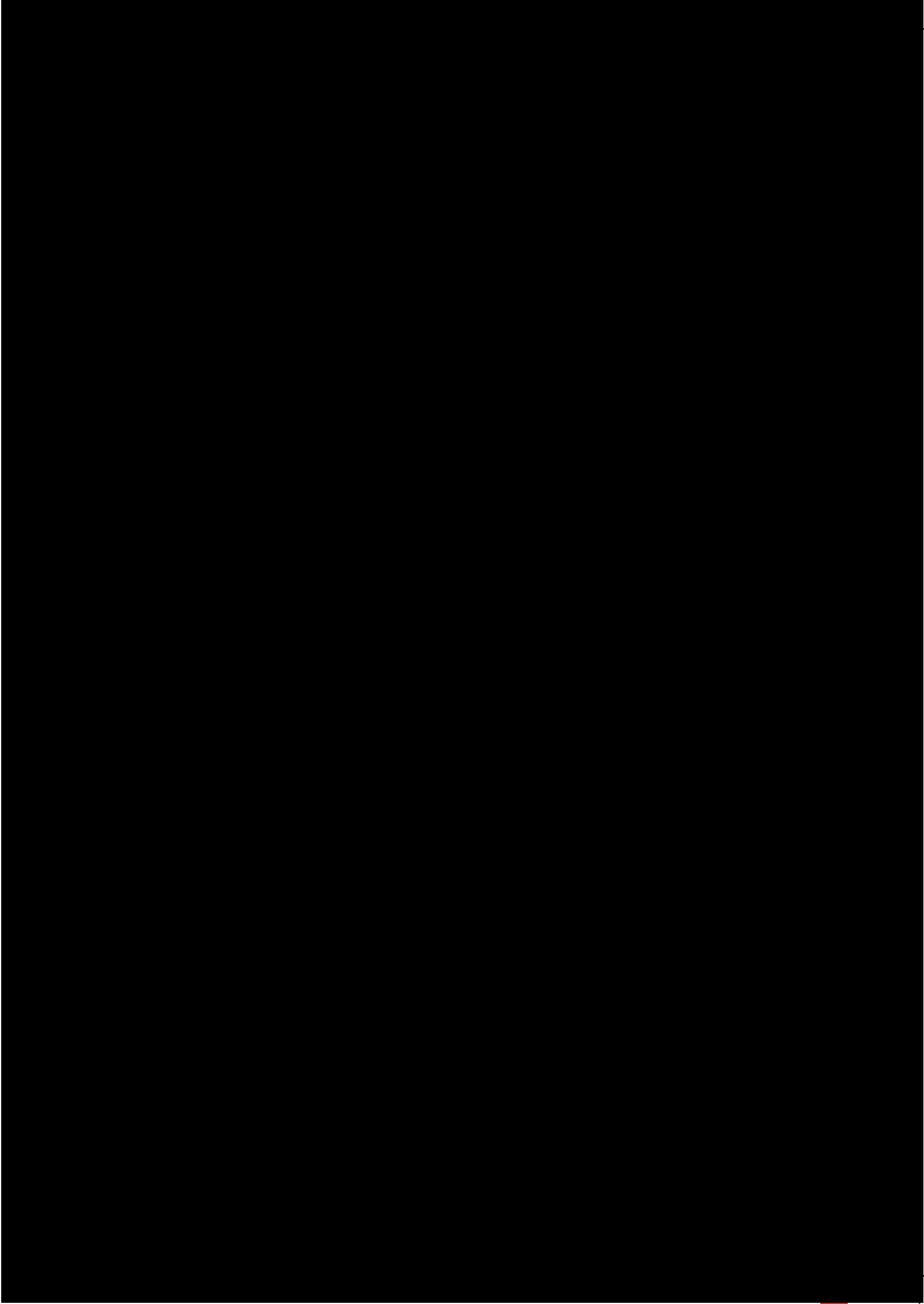


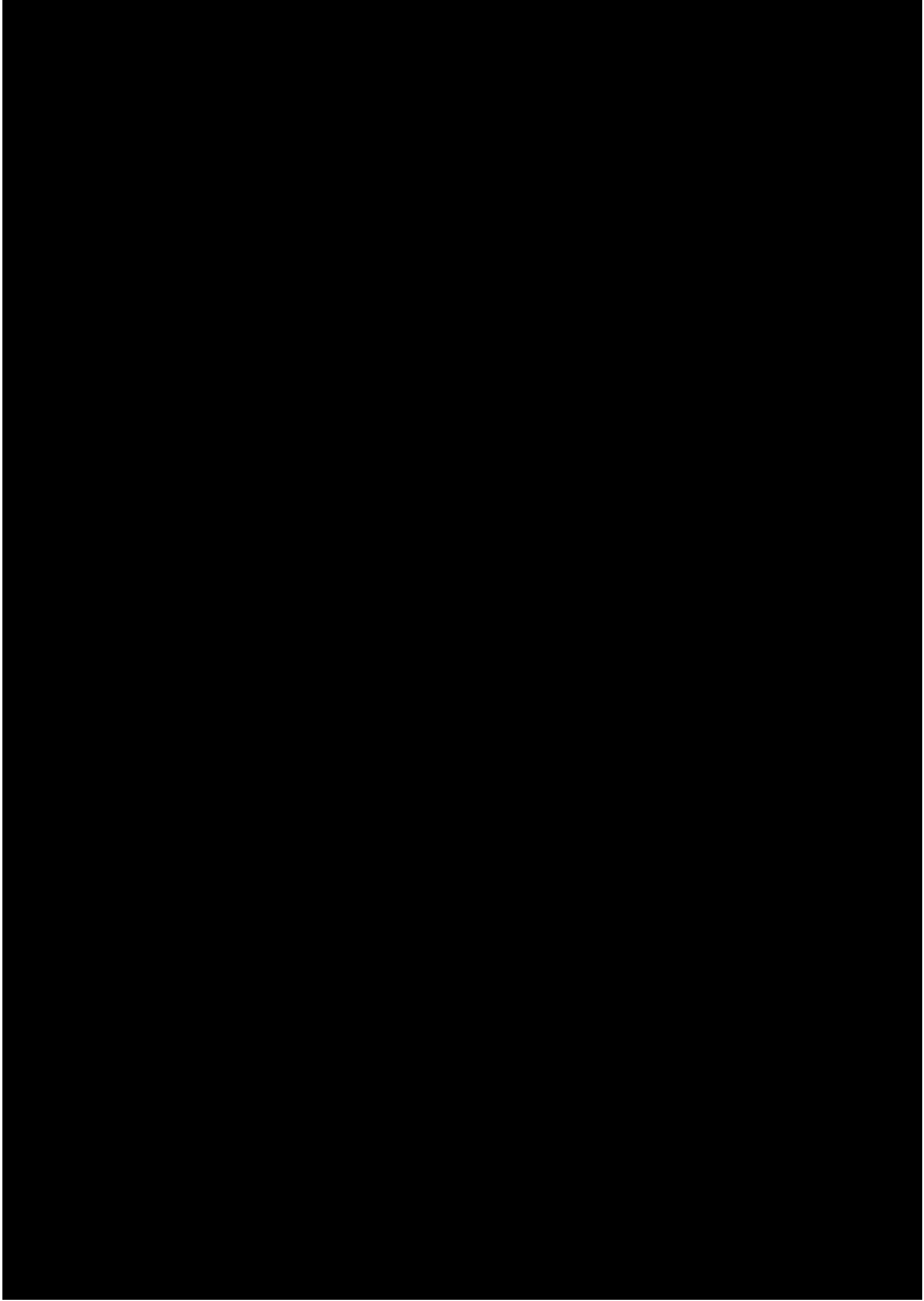


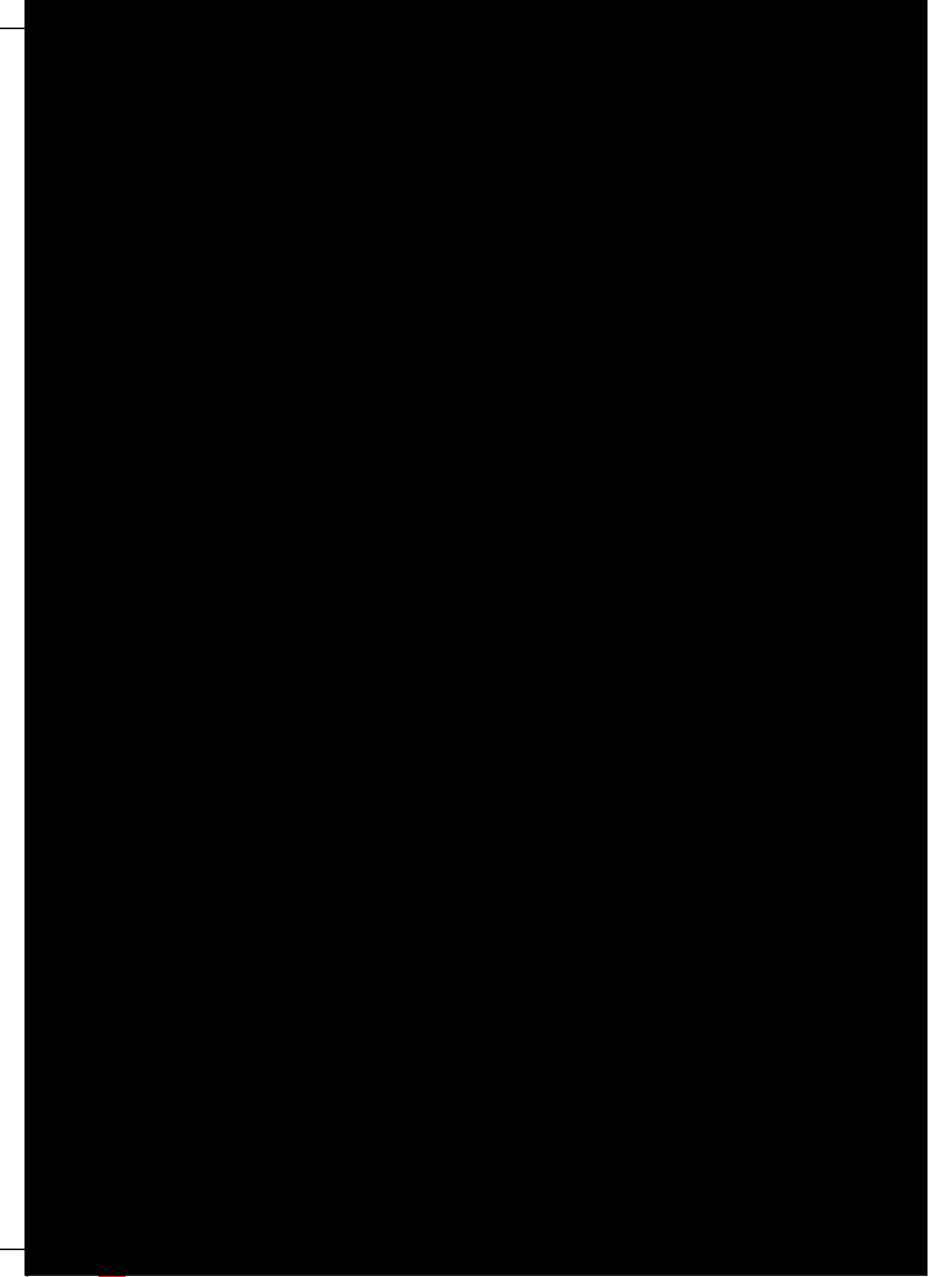


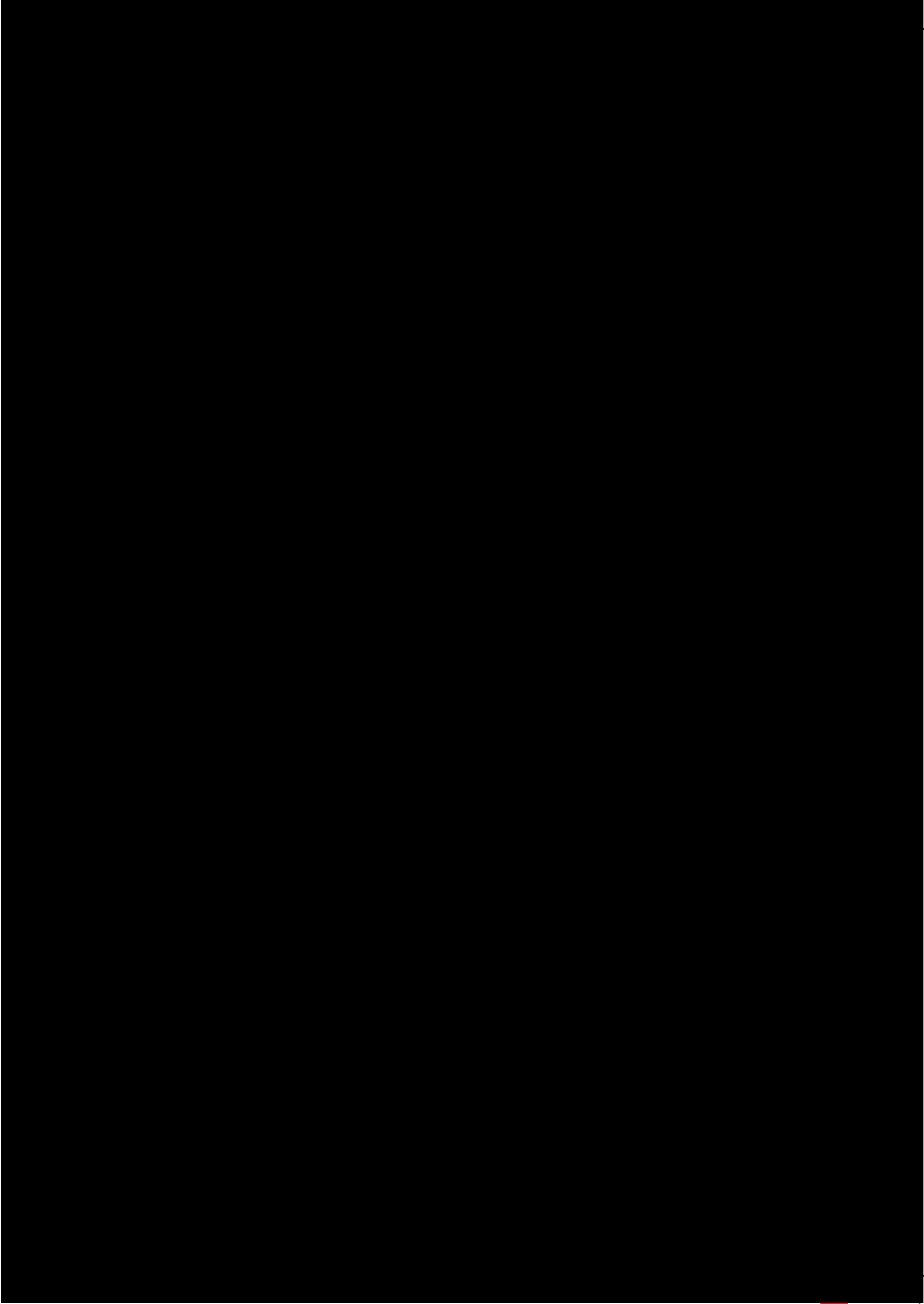


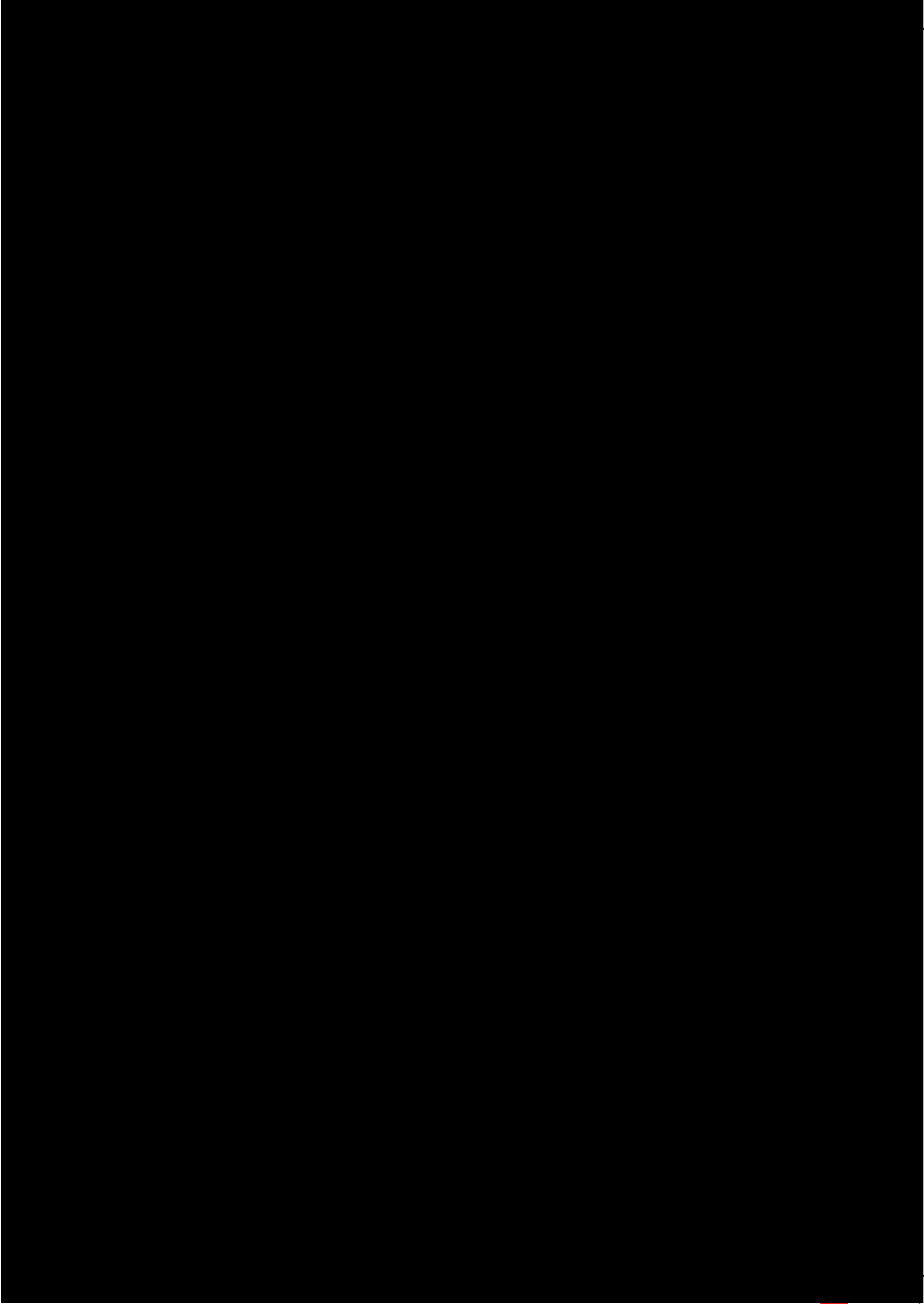


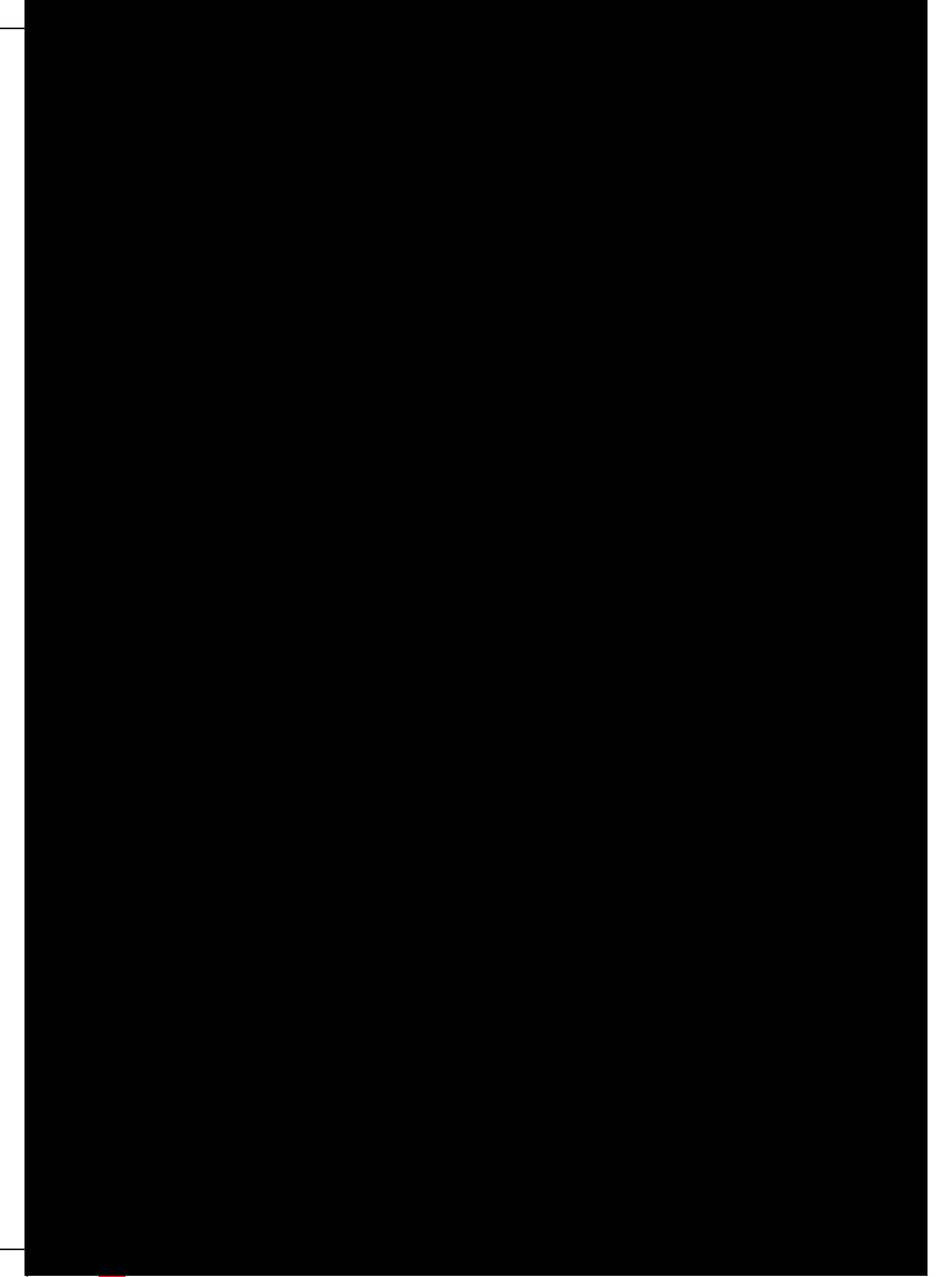


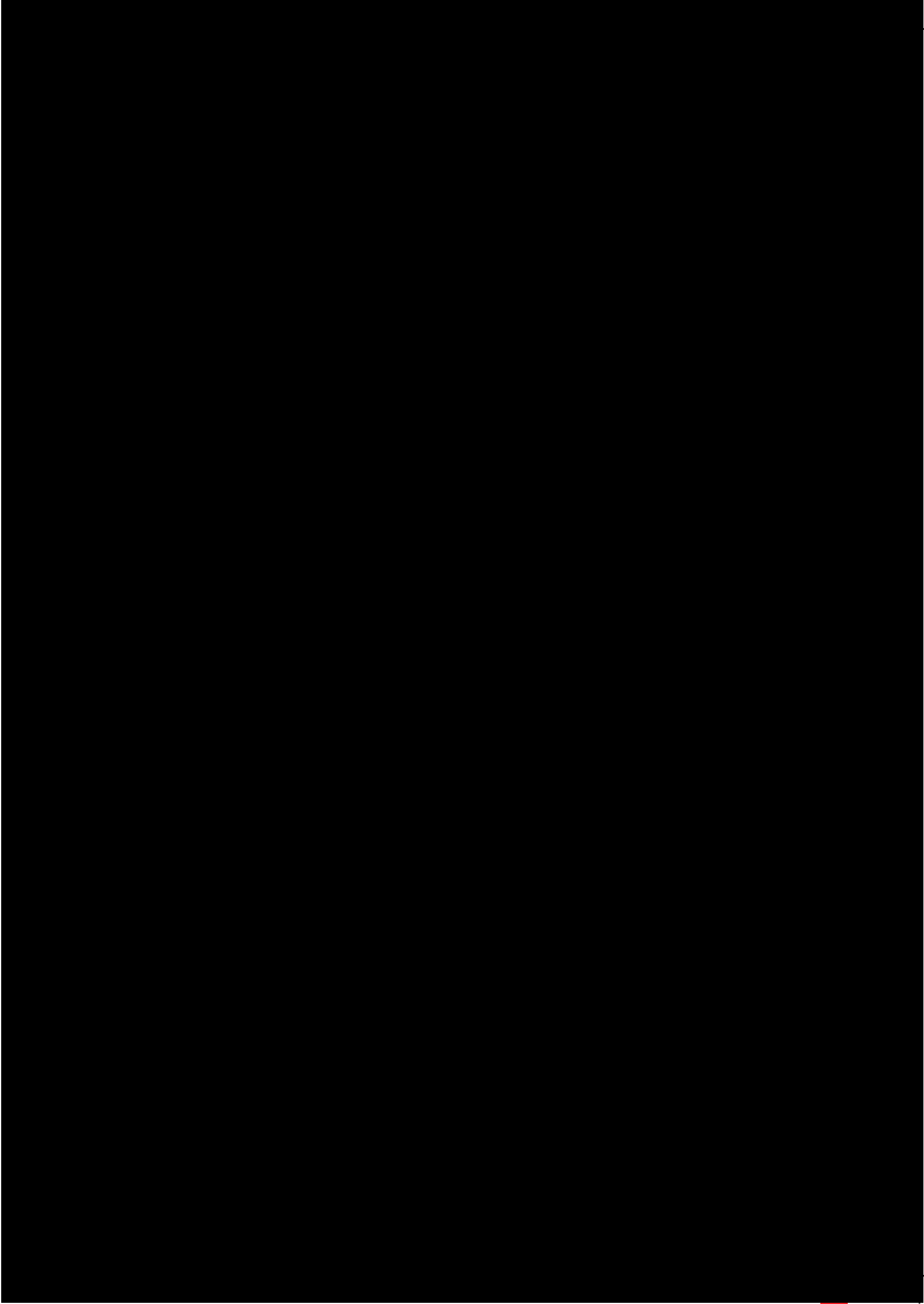












some of the factors that decide which plants will thrive on that soil. Thus, the topmost layer of the soil that contains humus and living organisms in addition to the soil particles is called the topsoil. The quality of the topsoil is an important factor that decides biodiversity in that area.

Modern farming practices involve the use of large amounts of fertilizers and pesticides. Use of these substances over long periods of time can destroy the soil structure by killing the soil micro-organisms that recycle nutrients in the soil. It also kills the Earthworms which are instrumental in making the rich humus. Fertile soil can quickly be turned barren if sustainable practices are not followed. Removal of useful components from the soil and addition of other substances, which adversely affect the fertility of the soil and kill the diversity of organisms that live in it, is called soil pollution.

The soil that we see today in one place has been created over a very long period of time. However, some of the factors that created the soil in the first place and brought the soil to that place may be responsible for the removal of the soil too. The fine particles of soil may be carried away by flowing water or wind. If all the soil gets washed away and the rocks underneath are exposed, we have lost a valuable resource because very little will grow on the rock.

- Study the amount of soil that is carried out of the trays now. Is the amount the same in both the trays?
- Is the amount of soil that is carried out more or less or equal to the amount washed out earlier?

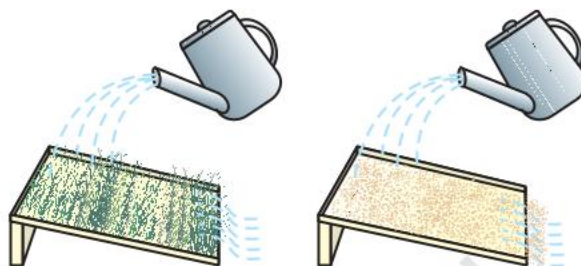


Fig. 14.4: Effect of flowing water on the top-soil

The roots of plants have an important role in preventing soil erosion. The large-scale deforestation that is happening all over the world not only destroys biodiversity, it also leads to soil erosion. Topsoil that is bare of vegetation, is likely to be removed very quickly. And this is accelerated in hilly or mountainous regions. This process of soil erosion is very difficult to reverse. Vegetative cover on the ground has a role to play in the percolation of water into the deeper layers too.

Activity 14.11

- Take two identical trays and fill them with soil. Plant mustard or green gram or paddy in one of the trays and water both the trays regularly for a few days, till the first tray is covered by plant growth. Now, tilt both the trays and fix them in that position. Make sure that both the trays are tilted at the same angle. Pour equal amount of water gently on both trays such that the water flows out of the trays (Fig. 14.4).
- Study the amount of soil that is carried out of the trays. Is the amount the same in both the trays?
- Now pour equal amounts of water on both the trays from a height. Pour three or four times the amount that you poured earlier.

Questions

1. How is soil formed?
2. What is soil erosion?
3. What are the methods of preventing or reducing soil erosion?

14.4 Biogeochemical Cycles

A constant interaction between the biotic and abiotic components of the biosphere makes it a dynamic, but stable system. These interactions consist of a transfer of matter and energy between the different components of the biosphere. Let us look at some processes involved in the maintenance of the above balance.

14.4.1 THE WATER-CYCLE

You have seen how the water evaporates from the water bodies and subsequent condensation of this water vapour leads to rain. But we don't see the seas and oceans drying up. So, how is the water returning to these water bodies? The whole process in which water evaporates and falls on the land as rain and later flows back into the sea via rivers is known as the water-cycle. This cycle is not as straight-forward and simple as this statement seems to imply. All of the water that falls on the land does not immediately flow back into the sea. Some of it seeps into the soil and becomes part of the underground reservoir of fresh-water. Some of this underground water finds its way to the surface through springs. Or we bring it to the surface for our use through wells or tube-wells. Water is also used by terrestrial animals and plants for various life-processes (Fig. 14.5).

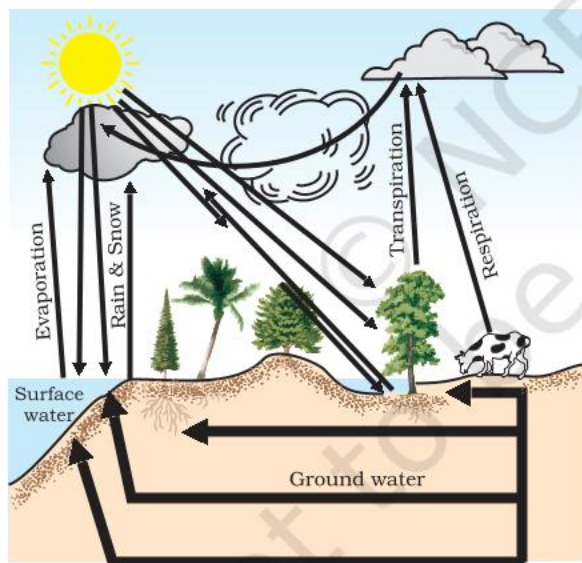


Fig. 14.5: Water-cycle in nature

Let us look at another aspect of what happens to water during the water-cycle. As you know, water is capable of dissolving a large number of substances. As water flows through or over rocks containing soluble minerals, some of them get dissolved in the

water. Thus rivers carry many nutrients from the land to the sea, and these are used by the marine organisms.

14.4.2 THE NITROGEN-CYCLE

Nitrogen gas makes up 78% of our atmosphere and nitrogen is also a part of many molecules essential to life like proteins, nucleic acids (DNA and RNA) and some vitamins. Nitrogen is found in other biologically important compounds such as alkaloids and urea too. Nitrogen is thus an essential nutrient for all life-forms and life would be simple if all these life-forms could use the atmospheric nitrogen directly. However, other than a few forms of bacteria, life-forms are not able to convert the comparatively inert nitrogen molecule into forms like nitrates and nitrites which can be taken up and used to make the required molecules. These 'nitrogen-fixing' bacteria may be free-living or be associated with some species of dicot plants. Most commonly, the nitrogen-fixing bacteria are found in the roots of legumes (generally the plants which give us pulses) in special structures called root-nodules. Other than these bacteria, the only other manner in which the nitrogen molecule is converted to nitrates and nitrites is by a physical process. During lightning, the high temperatures and pressures created in the air convert nitrogen into oxides of nitrogen. These oxides dissolve in water to give nitric and nitrous acids and fall on land along with rain. These are then utilised by various life-forms.

What happens to the nitrogen once it is converted into forms that can be taken up and used to make nitrogen-containing molecules? Plants generally take up nitrates and nitrites and convert them into amino acids which are used to make proteins. Some other biochemical pathways are used to make the other complex compounds containing nitrogen. These proteins and other complex compounds are subsequently consumed by animals. Once the animal or the plant dies, other bacteria in the soil convert the various compounds of nitrogen back into nitrates and

