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REPRINTED FROM

*The New York Medical Journal*

*for January 26, 1889.*





A PHOTOGRAPHIC STUDY OF THE  
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Two years ago I had the honor of presenting a paper to this Association, in which I made an effort to explain, to some extent, the reasons for the diversity of opinion existing among writers on voice production, regarding the appearance of the larynx during the formation of tones in the singing voice. The photographic demonstration made at that time served to show, at least, that nature has many ways of accomplishing the same result, and that different larynges do not always act exactly alike while producing the same tones, even in the same class of voice. To-day I propose to present more facts gleaned from the study of a very large number of photographs taken since then.

There are many movements which take place in the larynx which may be seen by the eye but which can not be shown in photographs, and again there are many changes

\* An abstract of a paper read before the American Laryngological Association at its tenth annual congress.



which the eye can not see or the mind grasp which are caught and held upon the sensitive plate. The value of photography in the study of the physiology of the larynx lies in the fact that with its aid the exact conditions occurring at any given time are caught and held, and we are thus able to compare two or more conditions at the same time and at leisure.

The size of an object photographed upon a sensitive plate depends upon its distance from the lens. The shorter the distance between the object and lens the larger will the image appear in the negative, and the longer the distance the smaller the image. In laryngeal photography the size of the image of the larynx depends mainly upon the position of the lens—in other words, upon the focus used; but it does not depend entirely upon this, for the larynx occupies different positions in the neck while singing notes in different parts of the scale. The difference, however, is so slight that a change of focus is rarely needed in order to obtain perfectly sharp photographs in any part of the gamut.

If the larynx rose as the voice ascended the scale, and occupied the highest position in the neck while the highest note was being emitted and the lowest while the lowest note was being sung, then with the same focus the image would appear largest in the highest note and smallest in the lowest note. This, however, does not appear to be the case. As will be shown in this demonstration, physiological variations in the size of the cavity of the larynx occur at different points in the scale. If the epiglottis or any of the other structures of the larynx should appear larger in one photograph than in any of the others of the same subject, it would, of course, be apparent that the image as a whole was increased in size. In this investigation, when two or more photographs were taken of one larynx, the same focus was always employed. The relative sizes of the photographs

will be seen upon the screen, for, though enlarged positives were made from them, the degree of enlargement was always exactly the same.

It would, no doubt, be more instructive and comprehensive if I should compare the results of this investigation with the most generally accepted theories of the action of the larynx as seen in the mirror, but this would be impossible in the short time at my disposal to-day.

The study of the singing voice has such a broad range that it will be impossible for me to deal with more than one of its divisions at this time. The limited time in which I must speak will suffice only for the consideration and demonstration of the appearance of the larynx in the formation of the *registers* of the voice.

First of all, let us understand what is meant by the term register. Garcia defines it as a "series of consecutive homogeneous sounds going from low to high produced by the action of a certain mechanism." Behnke says that "a register consists of a series of tones which are produced by the same mechanism," and Sir Morell Mackenzie's definition is "the series of tones of like quality producible by a particular adjustment of the vocal cords." These definitions imply that different mechanisms are necessary for the production of the voice in different portions of the scale, and that each series of tones produced by the same mechanism represents what is known as a register.

Writers are generally agreed as to what is meant by a register, but there is a great lack of uniformity in their belief as to their number as well as to the appearance of the larynx in their formation. Some believe that there are but two registers. Others are of the opinion that there are three, and others again insist that there are five. My own opinion is that the female voice has three registers and the male voice two. Having stated my belief, I will now proceed to demon-

strate by means of photographs, to be shown upon the screen, the changes which occur in the larynx at the breaks from one register to another, and the points at which these breaks occur. I will consider first the action of the female larynx. [Several hundred photographs were taken during this investigation, twenty-five of which, showing the larynges of thirteen subjects, were thrown upon the screen during the reading of the paper. They showed the changes which occurred in the mechanism of the larynx at the points of transition from one register to another.]

While most of the photographs which will be exhibited to-day were being taken, the tongue of the subject was held out, for when it remained in the mouth the anterior insertions of the vocal bands could rarely be exposed. I am unable to detect any difference in the relative positions of the various structures of the larynx whether the tongue is protruded or remains in the mouth.

The two photographs now seen upon the screen were taken of the larynx of a contralto while singing F sharp, treble clef, top line. The first of the pair was taken while the tongue was in the mouth, and the second while it was protruded. The only differences to be seen are those caused by the shadows, the slight difference in the position of the epiglottis—it being a trifle more elevated in the second than the first—and that caused by the difference in the force of the air-blast. The blast was greater when the tongue was in the mouth, and therefore the space between the vocal bands is a little wider in the first of the pair. It is easier to sing a loud tone when the tongue is in than when it is held out, and when it is held out the epiglottis is raised higher than when the tongue is not protruded.

A number of the subjects used in this investigation were not aware of any sudden change in quality in any part of their singing voices, nor could I detect it while listening to

their voices as they sang up the scale, or see sudden changes in the mechanism while looking sharply for them in the mirror; but, nevertheless, such changes were invariably disclosed in the photographs taken of four or five notes below and above the points at which they are supposed to occur. Others, again, were not conscious of a change in sensation, though a change in the quality of the voice could be heard and a slight change in the appearance of the glottis seen in the mirror, but the character of the change could not always be positively ascertained until it was disclosed in the photographs. When the notes at which the changes occurred were determined by the photographs and the changes themselves were displayed, they could easily be distinguished by the eye with the aid of the laryngoscope, but the contrast between the mechanism of the vocal bands before and after the break was never as clearly shown in the laryngoscope as in the photographs.

In the series of photographs which I took a number of years ago I failed to find evidences of sudden changes in the mechanism of the vocal bands, and in the paper already referred to, which I read before this Association two years ago, I made use of these words: "That certain changes do occur in many larynges while singing up the scale can be easily demonstrated; . . . but these changes are, I believe, almost always gradual, not sudden." In another part of the paper, when referring to a portfolio of photographs, I said: "The portfolio contains a soprano, contralto, tenor, and bass series, all of which bear me out in the statement that sudden changes in the positions of the vocal bands, as the trained voice mounts the scale, are rarely apparent." An examination of the series of photographs of female larynges contained in the portfolio referred to, reveals the existence of sudden changes in every instance. I am therefore forced to the conclusion that, as I was ignorant of the

nature of these changes, I did not recognize them when I saw them.

A slight change in the shape of the glottic chink may easily escape notice unless one is familiar with the exact conditions to be looked for and the neighborhood in which they may be found. Judging from the slight difference in the appearance of some of the larynges which have just been shown, it is scarcely to be wondered at that changes in the mechanism of the vocal bands are frequently overlooked in the mirror. One of the main motives for the preparation of this paper was to supply positive information concerning these changes by demonstrating their occurrence.

A very careful search for changes in the mechanism of the vocal bands in the larynges of fifty or more female singers has failed to reveal more than two—namely, at or near F sharp, treble clef, first space, and at or near F sharp, treble clef, fourth line. That these changes occur and are apparent to the eye is conclusively proved by the photographs.

It is believed by many writers that when the voice breaks from one register to another the epiglottis is suddenly raised. I am of the opinion that, instead of its being suddenly raised, it is suddenly depressed. My reason for this belief is that, in almost every instance, I have found it lower in the photographs showing the change than in those representing the note immediately preceding it. In a number of instances I found it impossible to expose the entire length of the vocal bands at the note on which the change occurred, though the anterior insertions could be easily seen during the production of the note before the break. In such cases the photographs showed that when the epiglottis was well raised the change had not occurred, but the mechanism of the lower register was continued upward. When, however, the change in the mechanism was

displayed, the epiglottis was depressed enough to cut off a view of the anterior commissure.

During the production of the lower notes of any voice the vibrations of the vocal bands can usually be seen, but in the middle and upper notes they can not be detected. As to what portions of the vocal bands vibrate in the middle and upper notes neither the photographs nor inspection with the laryngoscope give any positive information. From what has already been demonstrated to-day, and from the demonstration of two years ago, we must conclude that there are no positively characteristic appearances of the glottis in the different registers or different portions of the scale. In the lowest notes of the male voice the chink may be elliptical or open widest behind. In the middle and upper notes the chink may be linear or open widest behind. In the falsetto register the chink may be open in its whole length, or stop-closure may occur in front, or behind, or both. In the lower register of the female voice there is something like uniformity, for the chink is almost invariably open widest behind. In the middle register it may be linear or elliptical, or the edges of the vocal bands may be curved inward. In the upper register, as we have seen to-day, the chink may be open in its entire length, or stop-closure may occur, but of that more will be said while dealing with another portion of the subject which it was my original intention to consider to-day—namely, the appearances of the larynx in the production of variations in the pitch of the voice. Time will not permit it to be properly presented this afternoon.

The conclusions which may be drawn from this study are :

1. That protrusion of the tongue does not alter the laryngoscopic appearances.
2. That in the female voice there are three registers. This renders two changes necessary in the mechanism of

the vocal bands. These changes are always accompanied by changes in the quality of the voice. The lower break occurs at or near F sharp, treble clef, first space; and the upper break at or near F sharp, treble clef, top line. The change of mechanism consists of a shortening of the vocal bands, an appearance of an increase in their tension, and a change in the shape of the chink of the glottis. The change in the mechanism is usually accompanied by a backward movement of the epiglottis.

The change in the shape of the chink at the lower break consists usually of a wider opening of the ligamentous portion of the glottis, and partial or complete closure of the cartilaginous portion of the glottis. At the upper break the chink may simply be reduced in length and width, or a part of the ligamentous and all of the cartilaginous portion of the glottis may be closed.

3. That in male voices possessing the falsetto range there are two registers. The transition from the chest to the falsetto usually occurs somewhere between C sharp, bass clef, first line above staff, and the F sharp above.

The change in the mechanism consists usually of a sudden shortening of the vocal bands—though occasionally they are increased in length—an appearance of increased tension, and an alteration in the shape of the glottic chink. The edges of the vocal bands may be brought into apposition in front or behind, or both in front and behind, or the chink of the glottis may be open in its entire length, in which case the shape is altered, but the area of the space between the vocal bands is about the same as is necessary for the production of the note before the break.

The falsetto tones are therefore produced by stop-closure and change in the length and tension of the vocal bands, or by change in the length and tension without stop-closure.



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