Typesetting the Holy Bible in Hebrew, with TEX

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Abstract

This paper presents *Tiqwah*, a typesetting system for Biblical Hebrew, that uses the combined efforts of TEX, METAFONT and GNU Flex. The author describes its use and its features, discusses issues relevant to the design of fonts and placement of floating diacritics, and gives a list of rare cases and typographical curiosa which can be found in the Bible. The paper concludes with an example of Hebrew Biblical text (the beginning of the book of Genesis) typeset by *Tiqwah* .

Introduction

The *Tiqwah* system uses the possibilities of TEX, METAFONT and GNU Flex to typeset Biblical Hebrew. This is not a simple task: (a) special fonts had to be created, described in the section 'Fonts for typesetting the Holy Bible in Hebrew' on page 4; (b) several levels of diacritics are required; they have to be entered in a reasonable way (see 'Vowels.' on page 3, and 'Masoretic accents and other symbols.' on page 3), and placed correctly under or over the characters (see 'An algorithm for placing floating diacritics.' on page 6). The Bible being the most demanding Hebrew text (from the typographical point of view), *Tiqwah* can trivially be used to typeset any other Hebrew text, classical or modern; in addition to Tiberian vowels, Babylonian and Palestinian vowels are also included in the font, as are special characters for Yiddish.

This paper is divided into three parts: the first one, more pragmatic, describes the requirements and use of the *Tiqwah* system; the second one discusses the design of the fonts and the algorithm of floating diacritics placement; finally, the third part gives a list of rare cases and typographical curiosa found in the Hebrew Bible, and the way to produce them through *Tiqwah*.

But first, for the reader not familiar with the Hebrew language, a short introduction to the Hebrew system of diacritization.

Diacritization. In Hebrew, as in other Semitic languages, only consonants and long vowels are written as letters: the reading process includes a permanent "guessing" of words out of the available data—the consonants and long vowels, as well as the grammatical, syntactic and semantic context.[1] To prevent misunderstandings, in cases where the short vowels cannot be guessed out of the context (for example in names or foreign words), or in cases where the text is extremely important and should by no means be altered (the case of holy texts, like the Bible), short vowels have been added, in the form of diacritics. This is the first level of diacritization; it can be applied to any text; at school, children first learn vowelized Hebrew.

A second degree of diacritization is the use of *cantillation marks* or *Masoretic marks* or *neumes*.[2] This method of diacritization applies only to the Hebrew Bible.

Finally, a third degree of diacritization and markup (less important in volume than the two previous ones) consists of using editorial marks for

[1] tr t rd ths t s wht I mn → try to read this to see what I mean.

[2] One reads in (Levine 1988, pp. 36–37): "... unlike Psalmodic technique which reserves its motifs for a single syllable toward the phrase-end, Biblical chant assigns a motif to each word. It does this with signs called *neumes* (*te'amim* in Hebrew). ... The root of "neume" in Hebrew, *ta'am* has several meanings: 'taste'; 'accent'; 'sense'. Neumes impart taste (intonation) to Scripture through melody, accent through placement (above or below the stressed syllable), and sense (rhetoric) by their ability to create a pause or to run words together. In addition to these functions, neumes provide a means of memorizing the intonation, accentuation, and rhetoric of the handwritten scrolls read publicly, for only consonants appear on the scrolls. Vowels and punctuation—as well as neumes—appear only in *printed* editions of the Hebrew Bible."

scholarly editions (locations where text is missing, diverging sources, etc.). For this purpose, mainly two signs are used: the *circellus* (a small circle) and the *asterisk*. Also a dot is sometimes placed over each letter of a word—it is called *punctum extraordinarium*.

It follows that printed Hebrew Biblical text can globally be subdivided into four strata:

4. Editorial marks
3. Cantillation marks
2. Vowels, semi-vowels and šewa
1. Text

The placement of diacritics falls into the following groups:

1. inside the letter: the *dageš* or *mappiq* dot;
2. over the letter: vowels (*ḥolem* in the Tiberian system of vowelization, and all Palestinian and Babylonian vowels), spirantization (*rafe*), cantillation marks (*zaqeph*, *rebia*, *gereš*, *garšayim*, etc.), editorial marks (*circellus*, *asterisk*, *punctum extraordinarium*);
3. under the letter: vowels (*ḥireq*, *ṣere*, *segol*, etc.), semi-vowels (*ḥaṭeph-pataḥ*, etc.), absence of vowel (*šewa*), cantillation marks (*silluq*, *atnaḥ*, etc.);
4. before the letter (on its right): prepositive cantillation marks (*dehi*, *yetib*, etc.);
5. after the letter (on its left): postpositive cantillation marks (*segolta*, *sinnor*, etc.).

All strata of diacritics can be combined. It has always been a typesetter's nightmare (or delight, depending on the case) to produce fully diacriticized Hebrew text: sometimes the combinations of diacritics get even wider than the character that carries them; in these cases, diacritics will *float* under (or over) the immediately following letter, according to rules given in the section 'An algorithm for placing floating diacritics.' on page 6. These actions can eventually change the appearance of the whole word. In section 'An algorithm for placing floating diacritics.' on page 6 we give an analytic approach of floating diacritic placement, and the corresponding algorithm used by *Tiqwah*'s TEX macros.

The reader can find more information on the grammar of Biblical Hebrew in Lettinga 1980; for an introduction to the modern edition of the Bible BHS (Biblia Hebraica Stuttgartensia), see Wonneberger 1990.

Using *Tiqwah*

Requirements. To typeset in Biblical Hebrew using *Tiqwah*, one needs a decent TEX system,[3] a relatively powerful machine (being able to run BigTEX) and the *Tiqwah* package,[4] consisting of a preprocessor written in GNU Flex, fonts written in METAFONT, and TEX macros. The preprocessor being written entirely in GNU Flex (without using any system-dependent subroutines), can be compiled in a straightforward manner on any platform having a GNU Flex executable and an ANSI C (preferably `gcc`) compiler.

Once *Tiqwah* has been installed, typesetting is done in two steps: an input file is prepared using the syntax described below; the preprocessor then reads this file, and produces a LATEX 2_ε (or plain TEX) file which can then be run through TEX in the usual way.[5]

Preparing the input file. If you wish to write your file in LATEX 2_ε, you have to include the line

```
\usepackage{tiqwah}
```

in the preamble. Plain TEX users will write

```
\input tiqwamac.tex
```

at the beginning. However, the author recommends the use of LATEX 2_ε, because of its powerful font selection scheme.

A *Tiqwah* input file contains text, TEX/LATEX macros, and *preprocessor directives*. The latter concern only Hebrew script. To type Hebrew text you need to enter *Hebrew mode*; this is done by the preprocessor directive `<H>`. To leave Hebrew mode, enter the directive `</H>`. For Yiddish, the directives are `<Y>` and `</Y>`. The directives `<H>` and `<Y>` are the only ones recognized by the preprocessor *outside* Hebrew/Yiddish mode.

Once you are inside Hebrew/Yiddish mode, you type Hebrew text in Latin transcription, from left

[3] In this context, by 'decent TEX system' we mean a TEX implementation featuring Peter Breitenlohner's TEX--XET as well as METAFONT implementation with user-configurable parameters (the internal parameter `max_font_dimen` of METAFONT has to take a value of at least 53, to be able to generate *Tiqwah* fonts).

[4] *Tiqwah* will be included in ScholarTEX; it is part of the long awaited version 1 of the latter, together with *new* Greek, Arabic, Syriac, Coptic and Akkadian cuneiform fonts.

[5] An adaptation of the *Tiqwah* system to Ω (the TEX extension prepared by John Plaice and the author) is under preparation: it will allow typesetting in Biblical Hebrew, without a preprocessor.

to right. No special indication needs to be given to TEX about font or writing direction switching—this is done automatically. The following sections describe the transcription you have to use as well as all other features of the preprocessor.

Letters. The Hebrew transcription of letters (consonants and long vowels) is given in Table 2 of the appendix (page 14); the Yiddish one will be given together with all other features of the Yiddish part of *Tiqwah*, in a forthcoming paper, dedicated entirely to this language.

Here is a simple example of code producing non-vowelized Hebrew text:

```
<H>ym hm*lx hw*' hm*qwm hn*mw*k b*ywtr
b*‘wlm</H>
```

will produce

ים המלח הוא המקום הנמוך ביותר בעולם.

Some notes concerning the transcription of letters of Table 2: there is no distinction between medial and final forms; these are automatically applied by TEX. The asterisk `*` transcribes the *dageš*, *mappiq* or *šureq* dot.[6] The broken lamed ל is used automatically whenever no upper diacritic is present;[7] this feature can be turned off by the command line option `-nobroken` of the preprocessor. The character ﭏ is a ligature of the letters *aleph* and *lamed*; a variant form of it is ﭏ. This ligature is not used in the Bible, and hence is not applied automatically by the preprocessor: it has to be explicitly requested by the code `'/l` (instead of `'l` which will produce the normal אל).

In the same table, the reader will also encounter the symbol ׆; it is called "*nun invers*" and is used in Nu 10:35–36 and Ps 107. The "broken waw" ו is used in Nu 25:12. See the section 'Inverted and broken letters' for more details.

Vowels. Hebrew vowels and their transcriptions are displayed in Tables C and D (p. 15). Table 3 displays the three systems of vowelization available: Tiberian (the most frequent one), Palestinian and Babylonian. Tiberian vowels are used by default. To switch to Palestinian or Babylonian, one uses the directives `<PALESTINIAN>` and `<BABYLONIAN>`. The directive for Tiberian is `<TIBERIAN>`. The same text can be typeset in any one of the three systems just by adding/removing one of these directives; here is an example of the same text, written in the three vowel systems:

ימלֵא פִּי תְּהִלָּתֶךָ הַיּוֹם תִּפְאַרְתֶּךָ
ימלא פי תהלתך היום תפארתך
ימלא פי תהלתך היום תפארתך

Most vowels can be entered in two different ways: either by a "phonetic" one- (or two-) letter code (`a` for *pataḥ*, `A` for *qameṣ*, etc.) or by a three-letter code in uppercase form, surrounded by `<` and `>` (`<PAT>` for *pataḥ*, `<QAM>` for *qameṣ*, etc.). Both methods are equivalent and can be arbitrarily mixed.

Vowels are entered *after* letters, except in the case of the *pataḥ furtivum*, where the code `<PTF>` has to be entered before `x`, `h*`, or `‘` (ח, הּ and ע are the only letters which can take a *pataḥ furtivum*[8]). The *rafe* accent can be found in table 5.

Below is the same example of simple Hebrew text with its transcription, this time vowelized:

```
<H>yAm ham*Elax hw*' ham*Aqw^om han*Amw*k"
b*"yw^oter b*A‘w^olAm</H>
```

will produce

יָם הַמֶּלַח הוּא הַמָּקוֹם הַנָּמוּךְ בְּיוֹתֵר בָּעוֹלָם

Masoretic accents and other symbols. Tables E and F (p. 16, 17) display Masoretic cantillation marks and miscellaneous symbols: the Sephardic *varika*, and punctuation marks *maqqeph*, *setuma*, *petuḥa*, *soph pasuq*. Two styles of Masoretic accents are provided: oldstyle (as found in BHK[9] and Holzhausen Bible 1889, Lowe and Brydone Bible 1948) and modern (as in BHS[9]). The distinction is made at the TEX level, by macros (`\modernmasoretic` and `\oldstylemasoretic`), which can be used inside or outside Hebrew mode; the default style is oldstyle. Table 6 shows the glyphs of modern Masoretic accents. The same remark as in the previous section, concerning alternative input of codes, applies in this case as well.

Masoretic accents are entered after the letter to which they belong; they can be placed before or after vowels belonging to the same letter—their order is not important. Prepositive accents are placed before the first letter of the word. Postpositive accents, such as *pašṭa*, placed *inside* a word, will be typeset *between* letters.

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[6] Following an advice by Philippe Cassuto, we will attempt to differentiate the *dageš* and the *šureq* applied to the letter *waw*, in the next version of *Tiqwah*.

[7] With one exception: the *ḥolem*.

[8] The combination "letter *‘ayin* with *pataḥ furtivum*" is not displayed in the table because it is graphically indistinguishable from the normal *‘ayin* with *pataḥ*. This can be changed if there is a demand for differentiation of the two *pataḥ* types.

[9] Throughout this paper, BHS will be the *Biblia Hebraica Stuttgartensia* BHS 1987, and BHK the *Biblia Hebraica* BHK 1925, edited by Rudolf Kittel.

Finally, Table 7 (page 17) displays a collection of typographical curiosa: symbols used in various contexts and for various purposes. The single and double quotes ׳ and ״ are used for numerals and abbreviations. The upper two dots diacritical mark are also used for numerals: they indicate thousands. The asterisk * is used both as an editorial mark (like the circellus, but apparently with slightly different meaning), and as a replacement character for missing letters (see the section 'Missing letters.' on page 10). The zero-like symbol **0** is used to indicate a missing word in Jdc 20:13 (Holzhausen Bible 1889, Lowe and Brydone Bible 1948 only). The isolated *dageš* is used to indicate a missing letter with *dageš*, in Jes 54:16 (BHS only). The "tetragrammaton" ײ is a symbol for the name of God; it can be obtained by the directives <YYY> or <TETRAGRAMMATON>. Finally, the dotted circle ◌ is used in textbooks as a basis for diacritics.

Other preprocessor directives. A few directives do not produce glyphs, and hence are not included in the tables:

1. <NIL> placed after a letter will prevent the final form to be applied to it. For example, for numerals or stand-alone letters which have to be in medial form:
   <H>k<NIL> k</H> will produce כ ך.
2. <EOW> placed after a letter will force it to be in final form, even if other letters follow. For example, in Jes 9:6 one reads לְםַרְבֵּה; this word has been entered as
   <H>l"ma<EOW>r"b*e<AZL>h</H>). See section 'Letters not obeying rules of contextual analysis.' on page 9 for more details.
3. <EMPTY> will produce an invisible character of normal width. It can be used as a basis for stand-alone diacritics in the case of missing words (see 'Missing words.' on page 11).
4. <SMALL> and <BIG> will produce small and big letters, see section 'Bigger and smaller letters.' on page 8 for more details; they act only on one letter at a time.

More features may be added to the preprocessor if necessary.

Running the preprocessor. Once you have prepared the input file, for example genesis.inp, you run the preprocessor by writing

```
tiqwah options < genesis.inp > genesis.tex
```

where *options* can be the following:

1. -h displays a few lines describing the command line options;
2. -p produces plain TEX instead of LATEX output (typesetting with *Tiqwah* in plain TEX is not recommended);
3. -l followed by a number, indicates the maximum line length of code produced by the preprocessor; default is 80. This applies only to commands inside Hebrew/Yiddish mode, the remainder of the file is not modified;
4. -nobroken disables the automatic broken *lamed* insertion. With this option,
   <H>w"l<SIL>'^o=yAla<RBM>d"t*iy</H> will produce וְלֹא־יָלַדְתִּי Jes 23:4; without it, you would get וְלֹא־יָלַדְתִּי. It should be noted that the *ḥolem* vowel fits on the broken *lamed*: a special "broken-lamed-with-ḥolem" glyph is provided in the font (לֹ);
5. -d produces debugging output sent to the stderr stream, for those who want to modify the code of the preprocessor.

Running TEX/LATEX. As usual, TEX has to be TEX--XET, otherwise you will get an error message about the unknown commands \beginR and \endR.

If you are using LATEX 2_ε, you have to include the line \usepackage{tiqwah} in the preamble; if you are using plain TEX (not recommended), write \input tiqwamac.tex instead.

We have completed the description of the preprocessor's use and features. Now we will turn ourselves to issues concerning the design of fonts and the placement of floating diacritics.

Fonts for typesetting the Holy Bible in Hebrew

Designing fonts for Biblical typesetting is quite a challenge: on the one hand, one has to face centuries of tradition, and the inevitable comparison with masterpieces of typography; on the other hand, unlike Western typography, there is no room for innovation: modern Hebrew typefaces are widely used in Israel and elsewhere, but certainly *not* for Biblical text! Working under such tight restrictions can be compared to composing fugues or painting Byzantine icons: there are very strict rules to struggle with, and you can't avoid being hooked by the masterpieces others have done and which fatally are out of reach...

Fortunately, digital font creation does not always need to be original and innovative (although at the end it always *will* have new features, since the phototypesetting machines are fundamentally different from the traditional presses). After all, we are in the age of *reproduction*...

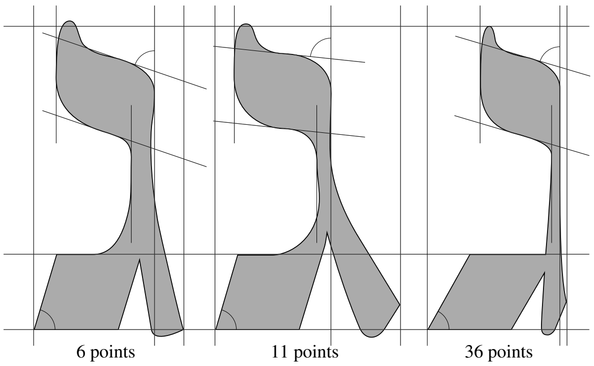

Figure 1: The letter ג at point sizes 6, 11, 36

The author started with the idea in mind to reproduce as faithfully as possible the most beautiful Hebrew font he could find. There seems to be a consensus among a large group of scholars that one of the most beautiful Hebrew types ever done was the one of the *Biblia Hebraica*, edited by Kittel and printed in Germany in the early twenties. Unfortunately the molds were lost in the bombing of Leipzig, so only printed copies of that book could be studied by the author to get the necessary information for reproducing the font.

Doing this, and studying other books as well, such as a Haggadah by Saul Raskin (Raskin 1941), printed in New York in 1941, and old Talmudic books printed in Vienna in the late XIXth century, the author realized that Hebrew fonts have a fascinating feature: there is a remarkable deviation between different point sizes (in TEXnical terms: they have a high degree of metaness). While for Latin typefaces the changes between small and large point sizes affect mostly the width of strokes, in Hebrew, letter shapes often change considerably. And what's even more unusual: changes that occur when going from small sizes to the normal size often occur the other way around when going from normal to large size: for example, one can see, in Fig. 1, the letter *gimel* at 6, 11, and 36 points (magnified so that they all have the same physical size). While the right tail of the letter moves more to the right when going from 6 to 11 points, it retracts again when going from 11 to 36, and almost becomes vertical.

Here is a (possible) explanation for this behaviour: the reasons for metaness in the small-to-normal range are different than those in the normal-to-large range. In the former case, the problem to solve is legibility. As a matter of fact, many Hebrew letters look quite similar in normal size: compare *samekh* and final *mem*, or *kaph* and *bet*, at 11 (or higher) points in the Table of Appendix A. Their distinctive features are so discrete that they could well disappear if the normal size was reduced linearly; a well-drawn small point Hebrew font has to bring these distinctive features to the foreground. Compare these letters again at 6 points: *kaph* and final *mem* are round while *samekh* and *bet* remain quadratic. On the other hand, when going from normal to large, one follows purely esthetic criteria: elegance is the main goal. In this context, Hebrew letters follow "Bodoni-like" esthetics: they have very important fat strokes and very fine thin ones. Hebrew letters use —even more than Latin letters— the effect of contrast between fat and thin strokes.

Being hooked by the beauty of this script the author decided not only to produce a most decent Hebrew font, but also to cover the whole range of optical METAmorphoses of the types. On table 1 of the appendix (page 13), the reader can see the first results of this adventure; they are by no means final! The author hopes to be able to improve these characters to meet the level of the Hebrew typographical tradition.

Technical details. Drawing a font with such a high degree of metaness is a process not far from *morphing*, a technique used more and more in video and cinema.[10] Nevertheless there is an important difference between METAFONT "morphing" and the usual morphing we see in movies. To morph two images, we are not changing the grayscale (or color) weight of each pixel, but the coordinates of Bézier curve control points. Interpolation becomes very uncertain, since it is by no means trivial that the set of interpolated Bézier curves will still produce a decent character shape.

The solution to this problem is to detect "tendencies" in the letter shape metaness and to be guided by these while morphing: for example, the lower left stroke of the letter *aleph* has the tendency of protruding to the left when point sizes become small. This has to be taken into account for all paths of this stroke, so that the transformation is homogeneous. The best way to do this is to determine "centers of gravity" which will move during the transformation; then it suffices to define all the important control points of the stroke with respect to a center of gravity: in this way the movement of the latter will produce an homogeneous move (and hence, transformation) of the whole stroke.

[10] *Morphing* is the continuous interpolation between two pictures; it has been used in special effects, for example to show faces being transformed into other faces.

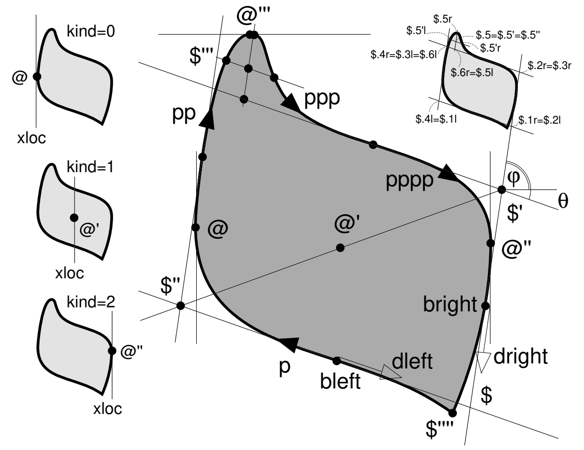

Figure 2: The METAFONT description of the character part "flame"

An important precaution is to limit the metaness of certain quantities to a certain range of point sizes. For example, the width of fat strokes can vary arbitrarily (after all, it is directly related to the letter point size), but other characteristics should not "vary too much"; in other words, they should remain stable outside of a certain point size range. That is the case, for example, of the "hanging left stroke" of letter final *pe*, in small point sizes; this stroke extrudes already to the left at point size 8; for point sizes lower than 8, the amount of extrusion remains stable, otherwise the character shape would be deformed; same phenomenon for the height of the intersection point of the vertical and the oblique stroke of letter final *ṣade*: after point size 24 the intersection height remains stable, since at this point size it has reached an extremal point. The idea of this paragraph could be stated as: "morphing should be applied only for interpolations inside the regular range; for extrapolations, the usual metaness (stroke widths etc.) is applied."

One of the most important parts of many Hebrew letters is the "flame" (or "crown"). Figure 2 shows the different METAFONT reference points and paths used for the definition of a standard METAFONT "flame"-subroutine.

Rashi. Besides the "quadratic" Hebrew font, which is shown in table 1 of the Appendix, the author has also developped a *Rashi* font. This type was used in Synagogue books for comments on the Biblical text. Synagogal books, which are often masterpieces of typography, combine several point sizes of *Rashi* and *quadratic* in various page setups. On the other

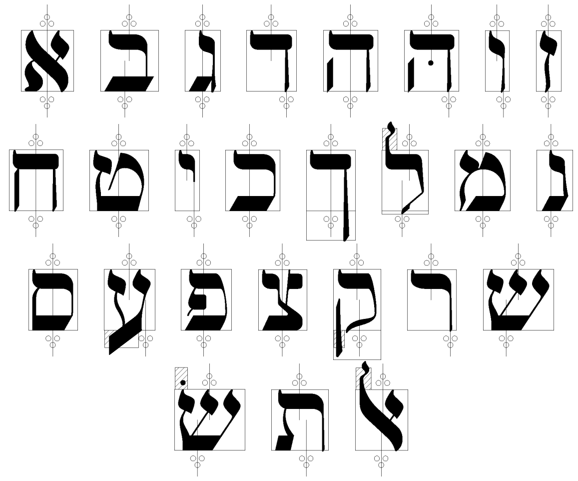

Figure 3: Upper and lower symmetry axes for Hebrew characters

hand, Rashi is not used in scholarly editions. Rashi is not diacriticized (neither vowels, nor cantillation marks); nevertheless, the author has included vowels, semi-vowels and šewa in the Rashi font, just in case somebody wants to break that rule...

The Rashi font has only the usual metaness (optical scaling through variation of stroke width). Here are the characters of point size 10, in their real physical size, compared with the quadratic font at the same size:

Rashi: אבגדהוזחטיכךלמםנןסעפףצץקרשת

Quadratic: אבגדהוזחטיכךלמםנןסעפףצץקרשת

In a forthcoming article, the author will give examples taken from Synagogal books with comments in Rashi.

An algorithm for placing floating diacritics. After a close study of the typesetting of diacriticized text in the Hebrew Bibles, and numerous discussions with Johannes de Moor, the author was led to the following considerations:

1. We divide the set of diacritics into two categories: *primary* and *secondary*. Primary diacritics are vowels, semi-vowels and šewa (stratum 2); all others are secondary ones (strata 3–4). Secondary diacritics are always appended to the left of primary diacritics belonging to the same letter.
2. Every consonant has an upper and a lower symmetry axis, on which diacritics are centered: these are not necessarily identified with the symmetry axis of the character's box: for example, the lower symmetry axis of character ר is going through the middle of the *vertical stroke*, and not through the middle of the imaginary character box (as its upper symmetry axis).

In Fig. 3, the reader can see the choice of upper and lower symmetry axes for each character, as well as the "forbidden zones", which should be avoided by diacritics[11].

3. Suppose that:
   - we have a letter L followed by letter L';
   - letter L carries a primary diacritic P and a secondary diacritic S, both under it, S being necessarily appended to the left of P;
   - the lower symmetry axis of letter L is A and the one of L' is A'.

   Then we have *three possible choices, in the following order of preference*:

   (a) P is centered on A (see Fig. 4, 1);

   (b) the group of diacritics SP is centered on A as a whole (see fig. 4, 2);

   (c) the group of diacritics SP is centered on A as a whole, furthermore a kern is added between L' and L (see fig. 4, 3) so that diacritic S does not overlap on L' or its diacritics.

Once these choices as well as their order of preference have been determined, the algorithm for placing diacritics under (or over) a word is the following:

```
for (letters of the word starting from the left)
{
    try choice (a)
    if ((a) not succesful) {
        try choice (b)
        if ((b) not succesful) {
            apply choice (c)
            }
        }
    go to next letter
    }
```

where the criterium of "success" is the fact that the diacritics of the current letter do not overlap with the following letter (if this letter has a descender part) or its diacritics, or its lower symmetry axis. Here is an example of such a situation. The reader can see a few (imaginary) words illustrating the three choices described above:[12]

[11] The reader will notice two letters *he* in Fig. 3, with different lower symmetry axes: the second one shows the axis used for the *pataḥ furtivum*. The same process is applied to the letter *ḥet*.

[12] These words are displayed in a magnified 8-point font, so that diacritics are larger, relative to characters and the three choices become more obvious.

(1) בבֶ֑ב (2) בבֶ֑ז

(3) בבֶ֑זֶ (4) בבֶ֑׃

In case (1), we have three letters *bet*, the medial one having a primary diacritic *segol* and a secondary diacritic *atnaḥ*. On the left side there is no diacritic, and the lower symmetry axis of the left *bet* is far enough from the *atnaḥ* of the medial letter to allow placement of the diacritics according to choice 1: the *segol* is centered under the letter, and the *atnaḥ* concatenated to it.

In case (2), instead of *bet* we have placed a *zayin* at the end of the word. There is no diacritic under that letter, but its lower symmetry axis is much closer to the medial *bet* than it was in case (1), so that now, the diacritics of the medial letter, placed as before, would inevitably touch the symmetry axis of the *zayin*. TEX automatically switches to choice 2, and checks that, without additional kerning, the diacritics remain indeed inside the authorized area.

In case (3), we add a diacritic *segol* to the letter *zayin*. Choice 2 is not valid anymore, and TEX automatically kerns letters *zayin* and the *bet* so that the *atnaḥ* is at a safe distance from the *segol* to the left of it. This is choice 3, and it always works, because there are no limits set on TEX's operation of kerning.

Word (4) has been included to show TEX's reaction in front of a punctuation mark: (a) TEX does not float the diacritic under the punctuation mark as in case (1), and (b) it does not switch either for choice 2, like in (2). The reason is that both operations (a) and (b) are reserved for letters which are considered as part of a whole (the *word*); the punctuation mark belonging to a different entity must be placed independently, and should not participate in the algorithm of floating diacritic placement. As the reader can see in (4), TEX kerns between the punctuation mark and the letter until the *atnaḥ* is clearly not under it anymore.

NOTES:

1. Certain characters have descenders: ץ ף ן ך ק or ascenders: ל; these parts of characters are considered "forbidden zones"—no diacritic should overlap or even touch them (forbidden zones are visible on fig. 3 as shaded areas).
2. The algorithm only concerns diacritics that are *centered* over or under the character with respect to the symmetry axes shown in Fig. 3; uncentered diacritics (like the *ḥolem*) obtain fixed positions before applying the algorithm. The

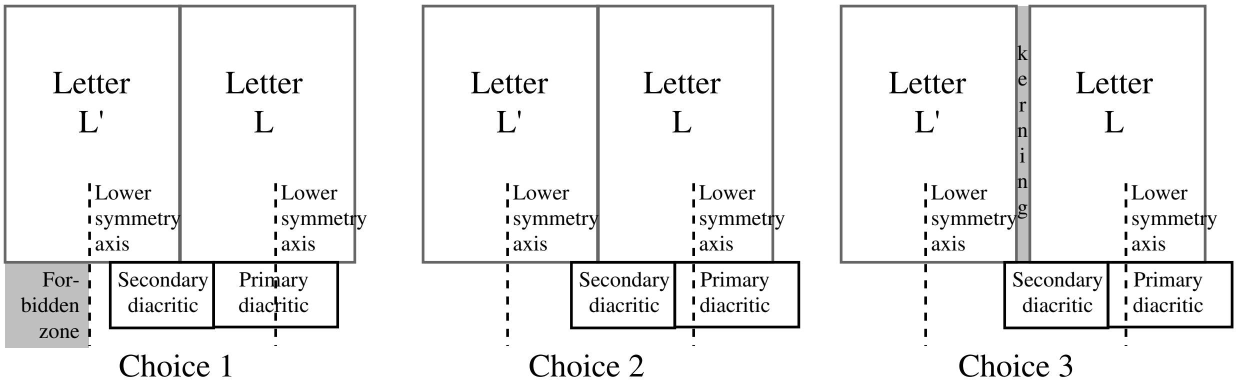

Figure 4: Three possible choices of diacritics positioning, in order of preference.

region they occupy becomes a *forbidden zone*, just like letter descenders or ascenders.[13]

3. If there are both upper and lower diacritics, the algorithm has to be applied twice, once for each case. Choices are independent, but a possible kerning due to application of choice 3 to one of the two parts could modify the choice applied to the other part.
4. If there is already a kern between two letters, it must be taken into account before applying the algorithm.
5. While inside a line, TEX is typesetting by counting blank space with respect to character boxes (and not diacritic boxes), at the beginning of a line the maximum between the width of diacritic box and the width of character box must be taken into account (so that diacritics do not protrude over the beginning of a line).

Rare cases and typographical curiosa

It is forbidden—and has always been forbidden—to change the text of the Hebrew Bible. The Masorets and other Bible commentors have proposed some modifications to the text, which had to be made apparent without changing the text itself. For this reason, many (typo-)graphical tricks have been used to indicate potential modifications of the text. These may differ from one Bible edition to the other (although they seem to be quite stable between rabbinical editions), and may not appear in modern study editions of the Bible, like the BHS. Here is a list of such curiosa, after a short search by the author,[14] as well as the way to achieve them with *Tiqwah*.

Bigger and smaller letters. These are letters bigger or smaller than ordinary text. They can appear at any location inside a word. They are vertically justified at the upper bar of Hebrew letters (and not at the baseline), so that big letters are protruding downwards only, and small letters are "hanging". The eventual *dageš* dot belongs to the point size of the letter itself (bigger or smaller than ordinary text), while the eventual diacritics are typeset in the same size as ordinary text. In the case of big letters, lower diacritics are lowered so that they keep the same distance to the letter as in the case of ordinary letters; in the case of small letters they are *not* raised, and remain at their default position.

Here are all possible occurences the author could detect:

- בְּרֵאשִׁית Gn 1:1,
- בְּהִבָּרְאָם Gn 2:4,
- וְלִבְכֹּתָהּ Gn 23:2,
- קַצְתִּי Gn 27:46,
- וּבְהַעֲטִיף Gn 30:42,
- הַכְזוֹנָה Gn 34:31,
- שִׁלֵּשִׁים Gn 50:23,
- נֹצֵר Ex 34:7,
- אַחֵר Ex 34:14,
- וַיִּקְרָא Lv 1:1,
- מוֹקְדָה Lv 6:2,

[13] An exception to this rule is the letter וֹ (*waw* with *ḥolem magnum*), where the right dot is sufficiently below the standard diacritic height for additional diacritics to be placed as if the dot was not there.

[14] The author would be grateful for any help or suggestions on completing this list.

- עַל־גָּחוֹן Lv 11:42 [big *waw*],
- וְהִתְגַּלָּח Lv 13:33,
- יִגְדַּל־נָא Nu 14:17 [big *yod*],
- שְׁמַע . . . אֶחָד Dt 6:4,
- מַמְרִים Dt 9:24,
- וַיַּשְׁלִכֵם Dt 29:28,
- הַלְיהוָה Dt 32:6,
- כְּכֹחִי Jos 14:11,
- צֹפָו Jes 56:1,
- וְצִוְחָתָהּ Jer 14:2,
- בְּסוּפָה Na 1:4,
- לַשָּׁוְא Ps 24:4 [small *waw*],
- וְכַנָּה Ps 80:16,
- מִשְׁלֵי Prv 1:1 [small final *nun*],
- וְנִרְגָּן Prv 16:28,
- אָדָם Prv 28:17,
- הַב | הַב Prv 30:15,
- וְגִישׁ Hi 7:6,
- שִׁבְטוֹ Hi 9:34,
- עַל־פְּנֵי־פָרֶץ Hi 16:14 [small final *ṣade*],
- חַף Hi 33:9,
- שִׁיר Cant 1:1,
- לִינִי Ru 3:13,
- לוֹא Thr 1:12,
- טָבְעוּ Thr 2:9,
- טוֹב Qoh 7:1,
- סוֹף Qoh 12:13,
- חוּר Est 1:6,
- פַּרְשַׁנְדָּתָא Est 9:7,
- פַּרְמַשְׁתָּא Est 9:9,
- וַיְזָתָא Est 9:9 [big *waw* and small *zayin*],
- וַתִּכְתֹּב Est 9:29,
- בִּשְׁפַרְפָּרָא Da 6:20,
- אָדָם 1Ch 1:1.

To produce big and small letters, one uses the preprocessor directives <BIG> and <SMALL> respectively. These affect only the first letter following them. For example, to obtain בִּשְׁפַרְפָּרָא Da 6:20, one writes
`<H>b*iS"<SMALL>par"<BIG>p*ArA<TIP>'</H>`.

Raised letters. At three locations in the Bible, the author encountered raised *'ayin* letters, and at one location, a raised *nun*. Contrary to small letters as described in the previous section, these are typeset in the regular point size. The diacritics remain under the normal baseline except in the case of a *pataḥ* diacritic, which was raised as well, in BHS and BHK.

Here are all occurences of raised *'ayin* the author could find:

- מִיַּעַר [in Holzhausen Bible 1889, Lowe and Brydone Bible 1948] or מִיַּעַר [in BHS and BHK] Ps 80:14,
- רְשָׁעִים Hi 38:13,
- מֵרְשָׁעִים Hi 38:15.
- The raised *nun* was encountered in בֶּן־מְנַשֶּׁה Jdc 18:30.

Both raised letters are regular characters of the *Tiqwah* font. The raised *'ayin* can be produced by the input code `'/` (`'/a` in the case of raised *'ayin* with *pataḥ*). The raised *nun* with *pataḥ* can be obtained by the input code `n//a` (`n` followed by a single slash `n/` produces the inverted *nun*, see section 'Inverted and broken letters').

Letters *aleph*, *resh* and *'ayin* with *dageš* dot. The author has found three locations in the Hebrew Bible, where the letter *aleph* takes a *dageš* dot: in BHS the dots are placed in the lower part of the letter; in BHK they are ignored; while in Holzhausen Bible 1889, Lowe and Brydone Bible 1948 they are placed in the upper or in the lower part of the letter. Here are these occurences, as they appear in Holzhausen Bible 1889, Lowe and Brydone Bible 1948:

- וַיָּבִאּוּ Gn 43:26,
- תָּבִיאּוּ Lv 23:17,
- וַיָּבִיאּוּ Esr 8:18.

At a single location in the Bible the author found the letter *'ayin* with *dageš*: בַּעְּפֹלִים 1S 5:12. This letter appears in Holzhausen Bible 1889, Lowe and Brydone Bible 1948 but not in BHS. In BHK a large dot is placed *over* the character.

Finally, the letter *resh* with *dageš* occurs in מָרַּת Prv 14:10.

To produce these letters with *Tiqwah*, use codes `'*`, `'/`, `r*` and `'*` as shown in table 2 of the appendix.

Letters not obeying rules of contextual analysis. In some cases a letter does not appear in final form as it should, and conversely a letter inside a word is written in final form (for example to indicate a contraction of two words). Here are two cases the author has detected: לְםַרְבֵּה Jes 9:6, with a final *mem* inside the word, and מִנ ׀ הַסְּעָרָה Hi 38:1, where the *nun* of the first word is not in final form.

To impose a final form one uses the preprocessor directive `<EOW>` (EOW stands for "end of word"), after the letter: `<H>l"ma<EOW>r"b*e<AZL>h</H>` to obtain the example above. To avoid a final form one uses the directive `<NIL>`, after the letter as well: `<H>mi<MER><NIL></H>` for the example. More technically, in the first case, the preprocessor considers it is at the end of a word and treats the two parts of the word as distinct—but concatenated—words; in the second case an invisible character of zero width makes it think it is *not* at the end of the word.

Letters with more than one vowel. Again because of contractions or other grammatical phenomena, a letter can carry more than one vowel. Here is an example: כְֹּאֲשֶׁר Ez 9:11, where the letter *kaph* carries both a *šewa* and a *ḥolem*. Input of such letters is straightforward.

Isolated *dageš*. The author encountered an isolated, vowelized *dageš* in BHS: הִן ֶּ Jes 54:16.

To obtain this character with *Tiqwah*, use the directive `<DAGESH>`. The invisible box of this character is sufficiently wide to carry vowels and/or other diacritics. It is treated as any other letter, so you have to use the directive `<EOW>` (see the section 'Other preprocessor directives.' on page 4) to obtain our unique example (otherwise the letter *nun* will not be final). Here is its *Tiqwah* code: `<H>hin<EOW><DAGESH>e<MEH></H>`.

Unusual letters. In Nu 10:35–36 as well as in Ps 107, one encounters the horizontally inverted letter *nun* ׆. In the critical apparatus of BHK one can read "׆ invers: [editio Bombergiana Jacobi ben Chajjim anni 1524/25] בנסע et כמתאננים". Both in BHS and BHK the types used for this character are not very satisfactory, while in Holzhausen Bible 1889, Lowe and Brydone Bible 1948 a type of the same quality as the ordinary *nun* is used.

This character is obtained by the code `n/`. It seems that other inverted characters may exist (an inverted *lamed* seems to be hidden in the Bible text...). They will be added to the *Tiqwah* system, whenever necessary.

In Nu 25:12, there is a "broken" *waw* with right *ḥolem*, in the word שָׁלוֹם. This character is obtained by the code `w/^o`.

Finally, there is a variant form of the letter *qoph*, in Ex 32:25, בְּקָמֵיהֶם, and in Nu 25:12, עַל־הַפְּקֻדִים. This letter is mentioned in the Masorah as "*qof* joined and without *taggim*" (see Yeivin 1980, §46); it can be obtained by the code `q/`.

Missing letters. The treatment of missing letters is typical of the work and restrictions of Masorets: they were not allowed to add letters that were missing, so while vowelizing the consonants they did so also for the missing letters, and by that action made their existence apparent.[15]

In Holzhausen Bible 1889, Lowe and Brydone Bible 1948 an asterisk is used to denote a missing letter. This asterisk is vowelized just like any ordinary letter. In BHS and BHK different methods are used: in some cases, empty space is left; in other cases no empty space is left and the diacritics of the missing character are just squeezed between those of (not missing) letters (a phenomenon occuring also in Holzhausen Bible 1889, Lowe and Brydone Bible 1948; for example in the word יְרוּשָׁלִָם Ps 137:6 where a *ḥireq* is squeezed between the *lamed* and the final *mem*).

Here are the missing letters detected by the author, as printed in Holzhausen Bible 1889 and in Lowe and Brydone Bible 1948:

- יִשְׁאַל־*ִ 2S 16:23,
- עַל־*ֵ 2S 18:20,
- וַ*ִתְגָּעַשׁ 2S 22:8,
- *ְשְׂבָכָה 1R 7:20,
- וְאֶת־תַּ*ְמֹר 1R 9:18,
- *ְמֶּלֶךְ 1R 15:18,
- מֵעֲלֵ* 1R 20:41,
- מֵאַ*ִן 2R 5:25,
- לְ*ַגִּיד 2R 9:15,
- *ְמֶּלֶךְ 2R 11:20,
- בֵּית־*ְמֶּלֶךְ 2R 15:25,
- וְ*ַכַּרְמֶל Jes 32:15,
- *ְתַּחַת Jes 55:13,
- *ְאָרֶץ Jer 10:13,
- *ָעָם Jer 17:19,
- וְ*ִהְיוּ Jer 18:23,
- *ְדָּבָר Jer 40:3,
- *ָרָשָׁע Ez 18:20,

[15] The reader can compare this with the glasses or gloves worn by the invisible man in H. G. Wells's homonymous novel.

- וְקִרְיָתָ*מָה Ez 25:9,
- לְשָׁכ֗וֹת* Ez 42:9,
- בַּיַּרְכָתַ֫*ם Ez 46:19,
- יַשְׁנוּ* Prv 4:16,
- יוֹלַ֫ד* Prv 23:25,
- עַד* Hi 2:7,
- יִגְ*אָלֵ Ru 3:13,
- כָל־*עַמִּים Thr 1:18,
- לֹא* Thr 2:2,
- אֵין* Thr 5:3,
- הִזְ*מִנְתּוּן Da 2:9,
- דֵי* Da 2:43.

In *Tiqwah* one writes <AST> to obtain the letter-like asterisk (warning, the ASCII asterisk * is used only for the *dageš*, *mappiq* and *šureq* dot!). If one prefers to leave an empty space, one can use the directive <EMPTY>. Unlike <NIL>, this one produces an invisible character with *non-zero* width; it can be vowelized just like any character. Finally, <NIL> can be used if we want to squeeze the diacritics of the missing character between the existing characters/diacritics.

Here is an example: <H>b"<AST>ag*iyd</H> will give the (imaginary) word בְ*ַגִּיד; by replacing <AST> by <EMPTY> in the code, one would get בְ ַגִּיד and finally, by using <NIL> instead of <AST> or <EMPTY>, the result would be בְַגִּיד.

Missing words. To indicate the location of missing words, all combinations of the preceding techniques are used. In BHK and BHS, empty vowelized characters are used; in Holzhausen Bible 1889, Lowe and Brydone Bible 1948, a single asterisk, in the middle of the diacritics of the missing word is used. In a single case, a digit zero is used instead of asterisk. Here are the missing words detected by the author, as printed in Holzhausen Bible 1889, Lowe and Brydone Bible 1948:

- 0 Jdc 20:13,
- * 2S 8:3,
- * 2R 19:31,
- * 2R 19:37,
- * Jer 31:37,
- * Jer 50:29,
- * Ru 3:6,
- * Ru 3:17.

To obtain the digit zero in *Tiqwah*, use the directive <ZERO>. For the remaining examples, the directives explained in the section 'Missing letters.' on page 10 are used in a straightforward manner.

Conclusion

As hinted by its name (*Tiqwah* means "hope" in Hebrew), the author has made this system hoping that it will lead to a revival of Biblical Hebrew typography. Its three main axes (fonts, typesetting, user interface) are based on three powerful programming languages: METAFONT for font creation, TEX for typesetting, and GNU Flex for preprocessing. The openness and flexibility of these languages guarantees the platform independence and consistency of the *Tiqwah* system.

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6 pt	8 pt	9 pt	10 pt	11 pt	12 pt	17 pt	24 pt	36 pt
א	א	א	א	א	א	א	א	א
ב	ב	ב	ב	ב	ב	ב	ב	ב
ג	ג	ג	ג	ג	ג	ג	ג	ג
ד	ד	ד	ד	ד	ד	ד	ד	ד
ה	ה	ה	ה	ה	ה	ה	ה	ה
ו	ו	ו	ו	ו	ו	ו	ו	ו
ז	ז	ז	ז	ז	ז	ז	ז	ז
ח	ח	ח	ח	ח	ח	ח	ח	ח
ט	ט	ט	ט	ט	ט	ט	ט	ט
י	י	י	י	י	י	י	י	י
כ	כ	כ	כ	כ	כ	כ	כ	כ
ך	ך	ך	ך	ך	ך	ך	ך	ך
ל	ל	ל	ל	ל	ל	ל	ל	ל
ל	ל	ל	ל	ל	ל	ל	ל	ל
מ	מ	מ	מ	מ	מ	מ	מ	מ
ם	ם	ם	ם	ם	ם	ם	ם	ם

6 pt	8 pt	9 pt	10 pt	11 pt	12 pt	17 pt	24 pt	36 pt
נ	נ	נ	נ	נ	נ	נ	נ	נ
ן	ן	ן	ן	ן	ן	ן	ן	ן
ס	ס	ס	ס	ס	ס	ס	ס	ס
ע	ע	ע	ע	ע	ע	ע	ע	ע
פּ	פּ	פּ	פּ	פּ	פּ	פּ	פּ	פּ
ףּ	ףּ	ףּ	ףּ	ףּ	ףּ	ףּ	ףּ	ףּ
צ	צ	צ	צ	צ	צ	צ	צ	צ
ץ	ץ	ץ	ץ	ץ	ץ	ץ	ץ	ץ
ק	ק	ק	ק	ק	ק	ק	ק	ק
ר	ר	ר	ר	ר	ר	ר	ר	ר
שׁ	שׁ	שׁ	שׁ	שׁ	שׁ	שׁ	שׁ	שׁ
ת	ת	ת	ת	ת	ת	ת	ת	ת
ﭏ	ﭏ	ﭏ	ﭏ	ﭏ	ﭏ	ﭏ	ﭏ	ﭏ

Table 1: Hebrew characters in point sizes 6–36

א	ב	ג	ד	ה	ו	ז	ח
'	b	g	d	h	w	z	x
ט	י	כך	ל	מם	נן	ס	ע
T	y	k	l	m	n	s	`
פף	צץ	ק	ר	שׁ	שׂ	ש	ת
p	Y	q	r	W	S	W/	t
אּ	בּ	גּ	דּ	הּ	וּ	זּ	חּ
'*	b*	g*	d*	h*	w*	z*	x*
טּ	יּ	כּךּ	לּ	מּם	נּןּ	סּ	עּ
T*	y*	k*	l*	m*	n*	s*	`*
פּ	צּ	קּ	רּ	שּׁ	שּׂ	שּ	תּ
p*	Y*	q*	r*	W*	S*	W/*	t*
ל	לּ	ﭏ	ﭏ	אּ	נ	וֹ	ק
L	L*	'/l	'/L	'/	n/	w/^o	q/

Table 2: Hebrew letters and their input codes

Name	Ḥireq	Ṣere	Segol	Pataḥ	Qameṣ	Ḥolem	Qibbuṣ
Tiberian	◌ִ	◌ֵ	◌ֶ	◌ַ	◌ָ	◌ֹ	◌ֻ
Palestinian							
Babylonian							
Input	`i`	`e`	`E`	`a`	`A`	`o`	`u`
Alt. input	`<HIR>`	`<SER>`	`<SGL>`	`<PAT>`	`<QAM>`	`<HOL>`	`<QIB>`

Table 3: Hebrew vowels (Tiberian, Palestinian & Babylonian) and their input codes

	Ḥaṭeph-			Pataḥ		Mater	
Šewa	Pataḥ	Segol	Qameṣ	furtivum		lectionis	
◌ְ	◌ֲ	◌ֱ	◌ֳ	חַ	הַּ	וֹ	אֹ
`"`	`Ha`	`HE`	`HA`	`+x`	`+h`	`w^o`	`'^o`
`<SWA>`	`<HPA>`	`<HSE>`	`<HQA>`	`<PTF>x`	`<PTF>h*`	`w<RHO>`	`'<RHO>`
	ה	ש	ם	ה	ש	ם	
	`<UHE>`	`<USH>`	`<USA>`	`<LHE>`	`<LSH>`	`<LSA>`	

Table 4: Special Hebrew vowels, special characters and their input codes

Silluq	Atnaḥ	Ṭiphḥa	Mereka	Munaḥ	Mehupak	Mereka kepula	Darga
<SIL>	<ATN>	<TIP>	<MER>	<MUN>	<MEH>	<MEK>	<DAR>
Xsil	Xatn	Xtip	Xmer	Xmun	Xmeh	Xmek	Xdar
	Zaqeph						
Galgal	parvum	magnum	Rebia magnum	Gereš	Garšayim	Pazer	Pazer magnum
<GAL>	<ZQP>	<ZQM>	<RBM>	<GER>	<GAR>	<PAZ>	<PZM>
Xgal	Xzqp	Xzqm	Xrbm	Xger	Xgar	Xpaz	Xpzm
Azla	‘Ole weyored	‘Illuy	Šalšelet	Ṣinnorit	Circellus	Tebir	Rafe
<AZL>	<OLE>	<ILL>	<SHP>	<SIN>	<CIR>	<TEB>	<RAF>
Xazl	Xole	Xill	Xshp	Xsin	Xcir	Xteb	Xraf
		Postpositivi					
Punctum extraordi-dinarium	Varika	Circellus	Lineola (paseq)	Segolta	Sinnor, Zarqa	Pašṭa	Teliša parvum
<PUN>	<VAR>	<PCR>	<LIN>	<SEG>	<ZAR>	<PAS>	<TLP>
Xpun	Xvar	Xpcr	Xlin	Xseg	Xzar	Xpas	Xtlp
Praepositivi							
Rebia mugrash	Dehi	Yetib	Teliša magnum	Setuma	Petuḥa	Maqqeph	Soph pasuq
<REM>	<DEH>	<YET>	<TLM>	<SET>	<PET>	=	:
Xrem	Xdeh	Xyet	Xtlm	Xset	Xpet		

Table 5: Oldstyle Hebrew masoretic accents and their input codes

Atnaḥ	Ṭiphḥa	Mereka	Mereka kepula	Darga	Galgal	Gereš	Garšayim
<ATN>	<TIP>	<MER>	<MEK>	<DAR>	<GAL>	<GER>	<GAR>
Xatn	Xtip	Xmer	Xmek	Xdar	Xgal	Xger	Xgar
			Postpositivi		Praepositivi		
Pazer	Azla	Ṣinnorit	Tebir	Sinnor, Zarqa	Pašṭa	Rebia mugrash	Dehi
<PAZ>	<AZL>	<SIN>	<TEB>	<ZAR>	<PAS>	<REM>	<DEH>
Xpaz	Xazl	Xsin	Xteb	Xzar	Xpas	Xrem	Xdeh

Table 6: Modern Hebrew masoretic accents and their input codes

’	”		*	*	0	·		
!	!!	<MIL>	<AST>	<ASA>	<ZERO>	<DAGESH>	<YYY>	<XXX>
		Xmil	Xast	Xasa	Xzer	Xdag	Xyyy	Xxxx

Table 7: Miscellaneous symbols and their input codes

בראשית

GENESIS

Caput I. א

בְּרֵאשִׁית בָּרָא אֱלֹהִים אֵת הַשָּׁמַיִם וְאֵת הָאָרֶץ׃ וְהָאָרֶץ
הָיְתָה תֹהוּ וָבֹהוּ וְחֹשֶׁךְ עַל־פְּנֵי תְהוֹם וְרוּחַ אֱלֹהִים
מְרַחֶפֶת עַל־פְּנֵי הַמָּיִם׃ וַיֹּאמֶר אֱלֹהִים יְהִי אוֹר וַיְהִי־אוֹר׃
וַיַּרְא אֱלֹהִים אֶת־הָאוֹר כִּי־טוֹב וַיַּבְדֵּל אֱלֹהִים בֵּין הָאוֹר
וּבֵין הַחֹשֶׁךְ׃ וַיִּקְרָא אֱלֹהִים ׀ לָאוֹר יוֹם וְלַחֹשֶׁךְ קָרָא
לָיְלָה וַיְהִי־עֶרֶב וַיְהִי־בֹקֶר יוֹם אֶחָד׃ פ
וַיֹּאמֶר אֱלֹהִים יְהִי רָקִיעַ בְּתוֹךְ הַמָּיִם וִיהִי מַבְדִּיל בֵּין מַיִם
לָמָיִם׃ וַיַּעַשׂ אֱלֹהִים אֶת־הָרָקִיעַ וַיַּבְדֵּל בֵּין הַמַּיִם אֲשֶׁר
מִתַּחַת לָרָקִיעַ וּבֵין הַמַּיִם אֲשֶׁר מֵעַל לָרָקִיעַ וַיְהִי־כֵן׃
וַיִּקְרָא אֱלֹהִים לָרָקִיעַ שָׁמָיִם וַיְהִי־עֶרֶב וַיְהִי־בֹקֶר יוֹם
שֵׁנִי׃ פ
וַיֹּאמֶר אֱלֹהִים יִקָּווּ הַמַּיִם מִתַּחַת הַשָּׁמַיִם אֶל־מָקוֹם אֶחָד
וְתֵרָאֶה הַיַּבָּשָׁה וַיְהִי־כֵן׃ וַיִּקְרָא אֱלֹהִים ׀ לַיַּבָּשָׁה אֶרֶץ
וּלְמִקְוֵה הַמַּיִם קָרָא יַמִּים וַיַּרְא אֱלֹהִים כִּי־טוֹב׃ וַיֹּאמֶר
אֱלֹהִים תַּדְשֵׁא הָאָרֶץ דֶּשֶׁא עֵשֶׂב מַזְרִיעַ זֶרַע עֵץ פְּרִי
עֹשֶׂה פְּרִי לְמִינוֹ אֲשֶׁר זַרְעוֹ־בוֹ עַל־הָאָרֶץ וַיְהִי־כֵן׃ וַתּוֹצֵא
הָאָרֶץ דֶּשֶׁא עֵשֶׂב מַזְרִיעַ זֶרַע לְמִינֵהוּ וְעֵץ עֹשֶׂה־פְּרִי
אֲשֶׁר זַרְעוֹ־בוֹ לְמִינֵהוּ וַיַּרְא אֱלֹהִים כִּי־טוֹב׃ וַיְהִי־עֶרֶב
וַיְהִי־בֹקֶר יוֹם שְׁלִישִׁי׃ פ

Figure 5: The book of Genesis, as printed in an 1889 Viennese Bible