It Shouldn't Have to be Trachelodynia — A New Pedagogical Approach to Greek Root Based English Medical Vocabulary

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1. INTRODUCTION

Numerous pedagogies concerning the teaching of English vocabulary to Japanese students have been outlined in recent academic papers, pedagogies concerning both instructional methodologies (Hulstijn, Hollander & Greidanus, 1996; Hunt & Beglar, 1998; Nation, 1990 & 1994; *inter alia*) and teaching material creation (Schmitt, N. & Schmitt, D., 1995; Stapleton & Glick, 1998; *inter alia*). This paper is somewhat of a departure from the above approaches, utilising, as will be shown, a traditional Japanese teaching methodology to support what will be demonstrated to be a singularly more effective (in terms of time and energy) method of teaching Japanese students English medical vocabulary.

Whilst the contents of this paper are necessarily aimed at those who teach at medical or dental universities or colleges in Japan, it is hoped that even those who are required to teach shorter one or two semester English courses for medical or dental faculties in larger establishments will find the approach contained herein beneficial.

§2 of this paper will deal with the rationale behind the approach, essentially the commonality between the structure of much English medical vocabulary, containing as it does large numbers of roots derived from ancient Greek, and that of the Japanese language (and more particularly its orthographical system), composed as it is of single or compounded logograms of Chinese origin. In §3, I will move on to the core of the pedagogy, a corpus of some 200 of the major Greek-based roots found in English medical vocabulary, along with their Japanese logographic equivalents. §4 will attempt an analysis of the effectiveness of the method, with conclusions contained in §5.

2. RATIONALE

A glance at any medical English textbook will reveal the considerable amount of time and effort required for a student to memorise the almost infinite number of vocabulary items necessary to attain the standard of proficiency required to read an academic paper or follow the proceedings of a medical conference. Many of the former are nowadays often written, and the vast majority of the latter conducted, in English. Since medicine is a vocational subject, virtually all students will eventually enter the medical profession or undertake research, and so, unlike most other university subjects, the ability to understand English (in its written form at the very least) is of huge practical importance. The rationale, therefore, behind this paper is to enable Japanese medical students to absorb large quantities of English medical vocabulary as quickly as possible by employing a method pedagogically familiar to them.

The Japanese language is written using a combination of three different orthographies

(leaving aside both the Roman alphabet, occasionally used in citing foreign names or words, and the Arabic numeral system) known as *kanji*, *hiragana* and *katakana*. *Kanji*, or Chinese logographic characters, were imported from China (initially via the Korean peninsula) during an intense period of cultural exchange between the 5th and 8th centuries AD and form the core of the Japanese writing system. It is to be noted however, that the form of many of these characters was simplified in China after the 1949 revolution and yet others simplified in Japan between 1946 and 1949 (for more detail, see Hammitzsch, 1981), so the two systems are not now wholly identical[1]. Due to the fact that kanji were borrowed at different times from different Chinese dialects, many have more than one Chinese reading (or *on'yomi*). For example, the kanji 行 has three *on'yomi*: *kou* as in 銀行 (*ginkou*, 'bank'), *gyou* as in 行事 (*gyouji*, 'event') and *an* as in 行脚 (*angya*, 'pilgrimage'), as well as two 'native' Japanese readings (or *kun'yomi*), in this case *iku*, 'to go', and *okonau*, 'to take place'[2].

When kanji are compounded with others, however, it is the *on'yomi* that are generally employed in the pronunciation of the new word. Hence compounds spawned by the kanji 新, 'new', which has one *on'yomi*, read *shin*, such as 新聞 (*shinbun*, 'newspaper', lit. 'new + hear'), 革新 (*kakushin*, 'innovation', lit. 'reform + new') and 新幹線 (*shinkansen*, 'the bullet train', lit. 'new + main + line') all employ the *on'yomi*. Japanese schoolchildren are thus faced with the daunting task of having to learn not only the approximately 2,000 kanji the Japanese Ministry of Education deems requisite for compulsory school education, but also numerous different readings for each. This familiar (to a Japanese) learning process is what will be hijacked in this paper in order to acquire the meanings of Greek roots used in English medical vocabulary.

English is also, of course, well-known as a language replete with loan words, especially in the fields of science and religion. The languages from which such words have been borrowed stem naturally from cultural exchange (or conquest), as well as from the perceived prestige or learnedness of a language in any given era. The realm of science thus largely draws its vocabulary from ancient Greek and Latin, the languages of learning in mediaeval and Renaissance Europe. There is, however, a huge gulf between Japanese and English in the etymological transparency of scientific terms. Since English is written in an (ostensibly) phonetic orthography, the meaning of any ancient Greek or Latin roots employed in scientific compounds is opaque to any who have not studied these languages — indeed the decline in the teaching of the classics in schools has only served to intensify this process during the last half century. In Japanese, by contrast, the use of a

[1] *Hiragana* is used to write words for which no kanji exists or for which the kanji is now generally held to be obscure (this can, of course, be a very subjective matter) and also to indicate grammatical function (e.g. verb declension, particles of possession and place etc. and sentence final particles expressing subtle nuances of meaning). The use of *katakana* is nowadays restricted to writing foreign (i.e. non-Chinese) borrowings, animal and plant names, indicating emphasis (akin to the use of italics in English) or, somewhat curiously, indicating that a foreigner is speaking Japanese (a usage especially prevalent in *manga*).

[2] For a more thorough treatment of the history of the Japanese orthographical system, see Miller (1967) and Shibatani (1991) *inter alia*.

predominantly logographic orthography means that the meaning of a scientific or technical neologism is far more readily transparent. A single example should make this difference clear. An average English-speaker, untrained in medicine, asked to define the word *metralgia* would be, with very few exceptions, unable to do so. However, an average Japanese-speaker, again untrained in medicine, asked to define the word *shikyuutsuu* written down in kanji as 子宮痛, would have no trouble whatsoever in offering a definition: since 子宮 (*shikyuu*) means *uterus* and 痛 (*tsuu*) means *pain*, the word clearly means 'pain in the area of the uterus'.

It is to be noted, nevertheless, that by no means all medical English vocabulary is composed of components derived from ancient Greek roots. Although the terminology used for diseases, conditions, treatments and technologies frequently employs Greek, anatomical names tend towards Latin. Thus, while the myriad muscles in the human body bear individual Latin appellations such as *orbicularis oris*, *pectoralis major* and *extensor carpi radialis longus*, a condition, disease or treatment connected with muscles in general will quite regularly utilise the Greek root *my(o)-*, as in *myalgia, myoma* or *myoplasty*.

The huge advantage that ideograms offer in this respect provides a pedagogical opportunity to increase the scope of Japanese students' medical English vocabulary. Building on the fact that Japanese students are familiar with any single character having a number of different readings, the method outlined below creates a new *kun'yomi* (the English translation of the kanji, which in most cases the student should already know) and a new *on'yomi* (a borrowed Greek reading rather than a borrowed Chinese reading). The systematic (albeit rote) learning of two new readings for the 200 kanji items (kanji which medical students already know) as laid out in Appendix A will enable students to envisage Greek root based English medical vocabulary items in terms of familiar kanji and ascertain the meaning of the whole without having to resort to the learning of tens of thousands of individual lexical items.

3. CORPUS

Appendix A shows the list of 200 Greek roots along with their kanji or kanji compounds. The author is unaware of any published frequency list of Greek-based roots used in English medical terminology and so, initially, the creation of such a list was undertaken. It soon became apparent, however, that, since its construction would require the compiling of (a) a general medical English vocabulary corpus (a huge undertaking in itself), (b) a lexical frequency list based on said corpus, and, finally, (c) a frequency list of the individual Greek roots themselves (where used), the final frequency totals of individual Greek roots would be so small as to be to all intents and purposes statistically invalid. The selection of items contained in Appendix A is thus based on lists of Greek roots given in the forewords and appendices of various medical dictionaries and Medical English textbooks (Anderson, 1994; Brooks, 1994; Glendinning & Holmstroem, 1987; Glick & Holst, 1998; Greenhalgh, 1993 *et al.*), as well as on personal experience. Doubtless, a few minor Greek roots are not contained in the corpus, but the author feels confident that all the most frequent Greek roots, as well as the bulk of the more minor

ones, are.

The table in Appendix A is divided into five columns (numbered from the left below) which show the following:

(1) Kanji number. The 200 roots are split into eight categories (anatomy, bodily secretions, observations, prepositions, treatments, technology, psychology, and general) and ordered category-internally either alphabetically or conceptually by *kun'yomi* (i.e. the English meaning). This eight-category division enables the teacher to either focus on certain types of medical vocabulary or to cover a certain proportion of each category should there be any constraints on class hours.

Greek-based roots in certain categories are much more frequent than in others: the prepositions category, for example, consists of some of the most frequent (though arguably some of the most difficult in terms of ambiguity) Greek roots and ought to be thoroughly covered in any course. Items in this category are also useful for non-medical English and thus serve the dual purpose of reinforcing the student's general English technical vocabulary. Other categories, such as the bodily secretions, psychology and general categories, contain much less frequent items, although the latter, like prepositions, is also useful for broadening students' general English vocabulary base.

(2) Kanji or Kanji Compound. Where possible, a single kanji is preferred to a two-character compound, however this is not always possible for two reasons. Firstly, some English words (e.g. [2] *bladder*, [38] *muscle*, [67] *semen*, [110] *convulse*) simply do not have a corresponding one-character translation. Secondly, a 2-character compound (or in a very few instances, a 3- or even a 4-character compound) was deemed necessary in some cases for reasons of clarity or in order to avoid ambiguity. The single character [24] 心 (*kokoro*), for example, has the core meaning of *heart* but covers a gamut of nuances somewhat similar to the metaphorical usages of its English equivalent. The 2-character compound listed, 心臓 (*shinzou*) refers unambiguously to the bodily organ. Similarly, its Greek root equivalent, *cardi(o)-* etc., is only used as an English Greek-root base to refer to the bodily organ, never in a metaphorical sense.

In some instances, the Greek root has two or three possible English translations and hence also two or three possible kanji translations (e.g. [103] *green/chlorine*, [149] *next to/like/abnormal*, [166] *science/theory*, [174] *(hu)man*). There are also cases where there is more than one English translation but only one possible kanji translation (e.g. [41] *neck/cervix*, [134] *paralysis/stroke*, [138] *tumour/swelling*, [173] *mind/soul*), and one example where there is only one possible English translation but more than one possible kanji translation ([148] *against*).

(3) *Kun'yomi* (English meaning). In the few instances where there are two different Greek roots for the same English meaning (and Japanese kanji), these are listed as

two separate entries: [57] & [58] *uterus*, [120] & [121] *disease*, [132] & [133] *pain*, and [135] & [136] *seizure*. In addition, footnotes outlining differences between the two Greek roots are given in Appendix B.

(4) *On'yomi* (Greek root). In the majority of cases Greek roots are evidenced by both prefixes and suffixes, both of which can also function (where forms exist) as infixes. Prefixes and suffixes are indicated by the standard use of a hyphen at either the beginning or the end of the cited form, whilst brackets indicate the connecting vowel used when a prefix (or infix) is compounded[3]. When the form following the prefix or infix begins with another vowel, the connecting vowel is generally elided. Brackets in the case of suffixes (e.g. [48] *-derm(a),* [125] *-morph(ia),* [128] *-gen(ic)*) or other non-final brackets in the case of prefixes (e.g. [3] *(h)(a)emo- ... -(a)emic,* [175] *gyn(a)ec(o)-,* [176] *p(a)ed(o)-*) indicate an alternative form or spelling. In the latter instance, American spelling favours the form without the extra vowel whilst British spelling favours its inclusion (e.g. UK *haemoglobin* v. US *hemoglobin*).

As regards pronunciation, no indication is given since students will, on the whole, be required to recognise forms and ascertain their Japanese meaning, rather than reproduce them. Briefly, however, their spelling rules mirror those of other English words (as far as English can be said to have spelling rules) with the following provisos: 'ch' = /k/ (e.g. [197] *arch(i)-* etc.); 'ph' = /f/ (e.g. [190] *physio-*); initial 'gn' and 'pn' both = /n/ (e.g. [27] *gnath(o)-* etc. and [34] *pneum(o)-* etc.); 'rh' = /r/ (e.g. [111] *-rrh(o)ea*); initial 'ps' = /s/ (e.g. [173] *psych(o)-*); 'z' = /ts/ (e.g. [91] *schizo-*); and initial 'x' = /z/ ([105] *xanth(o)-*).[4]

(5) Example Medical Term. Where possible, more common terms have been selected.

Kanji, English terms or Greek roots that require further elucidation or explanation are indicated by footnotes given in Appendix B.

4. ANALYSIS

In order to analyse the efficacy of the approach outlined in §2 and §3 above, a measurement of the accuracy of Greek root based English medical terms input into the Appendix A corpus *vis-à-vis* the resulting Japanese output (hereinafter referred to as the JO) is required. In other words, how closely does the Japanese medical term a student would obtain from using the corpus's 'Greek root = kanji' algorithm mirror the actual medical term (i.e. the Japanese translation, hereinafter referred to as the JT) (s)he would obtain from simply consulting an English-Japanese medical dictionary?

[3] This connecting vowel is frequently *–o* due to the grammatical rules governing compound formation in ancient Greek.

[4] The actual pronunciation of the original Greek and the English borrowed forms are frequently radically different. Further analysis of this is, however, beyond the scope of this paper.

As the author is unaware of any published statistical method for quantifying the accuracy of (machine or human) translation between lexical items, both with meaning X, composed of foreign roots in language Y and logograms in language Z, it has been necessary to devise a schema to do so. The measurement of accuracy to be outlined below will be termed the 'Coefficient of Translation Transparency' (henceforth referred to as the CTT). By its very nature, however, the CTT is heavily orientated towards Japanese and would not be applicable for statistical quantification between other languages. The overall accuracy of the approach (i.e., its average CTT) will be based on measuring the individual CTTs of 30 randomly chosen Greek root based medical English vocabulary items.

Using Urbaniak & Plous's (1999) *Research Randomizer*, 300 three-number arrays of random numbers were generated, the three numbers in each array corresponding respectively to a page number (range 1–1859), column number (range 1–2) and word heading number (range 1–15) in *Dorland's Illustrated Medical Dictionary* (Anderson, 1994). Where a given column contained fewer word headings than the generated random number, the final word heading in the column was selected. Whilst this process does favour word headings in column-final position, since these column-final entries occupy such a position in a wholly arbitrary manner anyway, the selection is still down to one of chance. In all cases where a page number or column number elicited a diagram, or where the word heading number did not elicit a word composed of Greek roots, or contained a Greek root not included in Appendix A, the entire three-number array was rejected. This process was repeated until 30 random Greek-root English medical lexical items were generated, a process that, in fact, took 209 arrays to achieve.

Table 1 below lists these randomly generated items in alphabetical order and is divided into six columns (numbered from the left below) which show the following:

(1) English Input. The randomly generated items with their constituent Greek roots separated by hyphens. As can be seen, the vast majority of the English Input consists of two-root lexical items, there being only 6 three-root words and no forms with four roots or more.

(2) Appendix A References. The Appendix A corpus kanji numbers of the English Input Greek roots (see (1) above) and corresponding JO kanji (see (3) below), again seperated by hyphens.

(3) Japanese Output (JO). This shows the kanji generated for each of the Greek roots of the word in the English Input column (see (1) above) using the Appendix A corpus. Here, the separate kanji (compound) outputs are separated by commas and where two kanji (compounds) are possible (e.g. [151] 無/不 in *amyoesthesia*), these are separated by a backslash.

(4) Japanese Translation (JT). The correct Japanese translations of the terms in the

English Input column (see (1) above), using the most well-known and prestigious English-Japanese medical dictionary (Katou, 1972). Note that in two cases, *aseptic* and *thanatology*, there are two possible JTs.

(5) JO/JT Breakdown. Each of the 2 or 3 kanji (compounds) in the JO (see (3) above) is assigned a percentage (see (i)–(v) below), whose average equals the CTT (see (6) below).

(6) Coefficient of Translation Transparency (CTT). The average of each of the 2 or 3 kanji (compounds) in the JO/JT Breakdown (see (5) above), in the form of a percentage, whereby a CTT of 100% equals a perfect translation and a CTT of 0% indicates a complete mistranslation. Where there are two possible JTs (see (4) above) and hence two possible JO/JT Breakdowns (see (5) above), two CTTs are obtained (JO with JT^1 and JO with JT^2) and these are again averaged. For example, *thanatology* elicits two JTs, i.e. two different but perfectly acceptable words for *thanatology* in Japanese: 死相論 (*shisouron*) and 死因学 (*shiingaku*). Two different JO/JT breakdowns are thus obtained: JO with JT^1 (100% and 80%) and JO with JT^2 (60% and 100%). The CTT for the first is 90% and for the second 80%, thus the final averaged CTT is 85%.

The rationale behind the CTT, as stated previously, is to give an indication of the transparency or opacity of a JO produced by the 'Greek root = kanji' algorithm as compared to its 'real' JT, utilising the corpus in Appendix A. To this end, it can be seen below that any kanji (compound) input into this algorithm can undergo change in up to five different ways (see (i) – (v) below). Each of these respective alterations affects the transparency or opacity of the output to varying degrees and thus, from a statistical point of view, the logical approach is to multiply each kanji (compound) by a quotient whose size reflects the effect of the alteration, and whose end sum (the CTT) will fall on a scale wherein 100% equals complete transparency, 0% equals complete opacity, and 50% equals a borderline case[5].

At the outset, therefore, all JO kanji (compounds) begin with 1 point and, after being multiplied by two or more of these quotients, the end result is multiplied by 100 to produce a percentage CTT. The quotient by which each JO kanji (compound) is multiplied to give the figures shown in the JO/JT Breakdown column (see (5) above) is ascertained by the following criteria:

(i) Compound Reduction Quotient: where only half the kanji compound in the JO is

[5] The fact that '50% equals a borderline case' is, of course, subjective and somewhat arbitrary, nevertheless necessary. The values assigned to each of the five quotients following is an attempt to create a final CTT where a value of less than 50% indicates opacity.

English Input	Appendix A References	Japanese Output	Japanese Translation	JO/JT Breakdown (%)	CTT (%)
a-myo-esthesia	151-38-185	不/無, 筋肉, 感	無筋覚	100,80,90	**90%**
anti-an-emic	148-151-3	抗/対, 不/無, 血	抗貧血性	100,90,80	**90%**
a-septic	151-115	不/無, 腐	無菌 or 防腐	100,0 or 0,100	**50%**
chlor-uria	103-69	緑/塩素 ,尿	塩類尿	90,100	**95%**
di-plegia	97-134	二, 麻痺	両痺	90,80	**85%**
galact-emia	64-3	乳, 血	血乳	95,95	**95%**
gastro-scopy	51-167	胃, 観	胃鏡検査法	100,0	**50%**
gloss-ectomy	55-161	舌, 切除	舌切除	100,100	**100%**
hemo-stasis	3-116	血, 止	止血	95,95	**95%**
hepatico-stomy	33-37	肝 ,口	肝管瘻設置術	100,0	**50%**
hyper-somia	142-5	上/超, 体	巨大症	0,0	**0%**
malac-oma	81-137	軟, 腫瘍	軟化部	100,0	**50%**
macro-melia	71-31	巨大, 肢	巨大肢	100,100	**100%**
meso-blast	145-118	中, 芽細胞	中胚芽	100,38	**69%**
micro-blast	72-118	小, 芽細胞	小赤芽球	60,38	**49%**
mono-neural	96-42	一, 神経	一神経	100,100	**100%**
mono-plegic	96-134	一, 麻痺	単麻痺	90,100	**95%**
myo-cyt-oma	38-10-137	筋肉, 細胞, 腫瘍	筋細胞腫	80,100,80	**87%**
neur-oid	42-126	神経, 様	神経様	100,100	**100%**
oste-algia	6-132	骨, 痛	骨痛	100,100	**100%**
para-lalia	149-188	周囲/副/錯, 片言	錯音症	100,0	**50%**
par-encephalia	149-7	周囲/副/錯, 脳	先天性脳奇形	0,36	**18%**
path-osis	121-122	疾病, 病態	病的状態	64,64	**64%**
peri-orch-itis	150-53-129	周, 睾丸, 炎症	睾丸膜炎	0,100,48	**49%**
podo-graph	19-168	足, 記器	足底描写器	80,51	**66%**
sarc-oma-genic	18-137-128	肉, 腫瘍 , 発生	病腫発生	0,80,100	**60%**
spleno-hepato-megaly	50-33-70	脾, 肝, 大	肝脾腫	95,95,0	**63%**
syn-dactylia	154-13	結合, 指	合指症	80,80	**80%**
thanat-ology	180-166	死 , 学/論	死相論 or 死因学	100,80 or 60,100	**85%**
tri-cephalus	98-23	三, 頭	三頭体	100, 60	**80%**

Table 1: Randomly Generated Greek Root Based English Medical Vocabulary Items and their Corresponding CTTs

present in the JT, that kanji compound is multiplied by 0.8. For example, the JO of the [38] *-myo-* component of ***myocytoma*** is 筋肉 (***kinniku***), but in the JT this compound is reduced to a simple 筋.

Reduction of two-kanji compounds to just one kanji is not a major barrier to understanding and most Japanese students should easily be capable of ascertaining what the real JT is.

(ii) Thematic Compounding Quotient: where a single kanji in the JO becomes a kanji compound in the JT, then the JO kanji is multiplied by 0.8 if the extra kanji forms a natural (thematic) compound. For example, the *podo-* of ***podograph*** gives the JO

[19] 足, but in the JT this is compounded to 足底 (*sokutei*). The 底, however, since it means 'bottom' or 'base', forms a natural compound, indeed one more precise than the English.

The relatively high value of this quotient reflects the fact that thematic compounding is generally not a barrier to comprehending the whole meaning of the lexical item.

(iii) Athematic Compounding Quotient: where the extra kanji is totally unrelated and alters significantly the nuance or meaning, then the JO kanji is multiplied by only 0.6. For example, the *micro-* of *microblast* outputs simply [71] 小, but this is enlarged to 小赤 (*shouseki*) in the JT, the kanji 赤, 'red', adding a whole new athematic component to the meaning.

The lower value of this athematic quotient *vis-à-vis* its thematic counterpart mirrors the somewhat higher possibility of the extra kanji obscuring the total meaning.

(iv) Synonym Replacement Quotient: where a JO kanji is replaced with a kanji of essentially the same meaning in the JT, the JO kanji is multiplied by 0.9. For example, the *di-* of *diplegia* elicits [97] 二, 'two', but this is replaced with 両, 'both', in the JT.

Synonym replacement, more so than thematic compounding, is extremely unlikely to cause any confusion in the overall meaning, hence its high quotient.

(v) Misordering Quotient: where all the kanji (compounds) in the JO are identical to those in the JT but in a different order, all the misordered JO kanji are multiplied by 0.95, this multiplier reflecting the high degree of transparency a change in order retains. For example, *galectemia* gives a JO of 乳血 but a JT of 血乳 (*ketsunyuu*).

Of all five quotients listed here, misordering presents the least problems in terms of extracting the true translation, hence it receives the highest quotient value.

To illustrate using a simple example, we shall consider *amyoesthesia*, the first randomly generated word in alphabetical order shown in Table 1 above. The JO of [151] *a-* can be either 不 or 無 and since the JT is 無, this is not effected by any of the quotients above and receives the full 1 point. The second Greek root, [38] *-myo-*, elicits a JO of 筋肉 (*kinniku*) but this undergoes compound reduction, (i) above, to a JT of just 筋 and hence receives 0.8 points. The final component, *-esthesia*, gives a JO of [185] 感, 'sense' or 'feel', but this undergoes synonym replacement, (iv) above, in the JT to 覚, 'sensation' or 'perception', a kanji with a very similar meaning and hence receives 0.9 points. The three JO kanji (compound) scores (1.0, 0.8, 0.9) are averaged and percentagised to give a final CTT of 90%, indicating a high degree of transparency.

A more complex example where a single JO kanji (compound) is affected by several

quotients simultaneously would be the case of *microblast*. Here the first JO kanji compound is relatively simple: [72] 小 shows up in the JT as 小赤 (*shouseki*), a clear case of athematic compounding (see (iii) above) and thus receives a multiplier of 0.6. The second JO compound, [118] 芽細胞, is much more complex. This undergoes reduction twice (i.e. the second, 細, and third, 胞, kanji of the compound do not appear in the JT) and athematic compounding once (i.e. the unrelated kanji 球, 'ball' or 'globe', is appended to the remaining 芽). The quotients by which this second compound are thus effected are 0.8, 0.8 and 0.6 respectively, producing a final points total of 0.38 (i.e. 0.8 x 0.8 x 0.6). The two points totals for *micro-* (0.6) and *-blast* (0.38) are averaged and percentagised to give a final CTT of 49%, indicating a JO hovering on the boundary of transparency and opacity.

Of the 30 randomly generated words in Table 1, it can be seen that five (*glossectomy, macromelia, mononeural, neuroid* and *ostealgia*) have a CTT of 100% (i.e. complete transparency), a further eleven have a CTT of over 80%, and only one (*hypersomia*) has a CTT of 0% (i.e. complete opacity). Taking 50% as the benchmark between transparency and opacity of translation as mentioned above, we can see that 21 of the 30 lexical medical items lie on the side of transparency, only 4 (*hypersomia, microblast, parencephalia* and *periorchitis*) lie within the sphere of opacity, whilst 5, having CTTs of 50%, straddle the border. As a whole, the CTT average is 72.2%.

5. CONCLUSION

Clearly, learning the kanji (compound) equivalents of the 200 Greek roots in Appendix A is not going to provide Japanese medical students with a perfect translation of an English medical term every time. If this were the case, computer translation software would be child's play, none of us would have to invest time in learning foreign languages, and indeed none of us in the educational profession would have employment. Such is the nature of language. As an alternative, however, to the traditional method of rote-learning tens of thousands of difficult lexical items, it is without doubt quicker, for the intelligent student (which, given the nature of the Japanese university entrance examination system, most medical and dental students are) easily accessible, and, as shown in the analysis in §4 above, undoubtedly effective.

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Appendix A - The Kanji-Greek Root Corpus

No	Kanji	*Kun'yomi*	*On'yomi*	Example
			ANATOMY	
1	腕	arm	brachi(o)-/-brachia/-brachic	brachiocephalic
2	膀胱	bladder	cyst(o)-/cysti-/cystido-/-cystia/-cystic	cystitis
3	血	blood	(h)(a)emo-/(h)(a)emat-/-(a)emia/-(a)emic	haemoglobin
4	血管	blood vessel	angi(o)-	periangitis
5	体	body	somat(o)-/-somy/-some/-somia	somatopathy
6	骨	bone	oste(o)-	osteogenisis
7	脳	brain	encephal(o)-/-encephalic/-encephalia	encephalitis
8	乳房	breast[1]	mast(o)-/-mastia	mastectomy
9	軟骨	cartilage	chondr(o)-	chondrotomy
10	細胞	cell[2]	cyt(o)-/-cyte	cytology
11	頬	cheek	mel(o)-	meloplasty
12	胸	chest	steth(o)-	stethoscope
13	指	digit (finger/toe)	dactyl(o)-/-dactyly	brachydactyly
14	耳	ear	ot(o)-/-otic	otoplasty
15	卵	egg	oo-	ooblast
16	眼	eye	ophthalm(o)-/-ophthalmic/-ophthalmia	ophthalmograph
17	脂	fat	lip(o)-	lipectomy
18	肉	flesh	sarc(o)-	sarcoma
19	足	foot	pod(o)-/-pus/-podia	macropodia
20	腺	gland	aden(o)-	adenitis
21	毛	hair	trich(o)-/-trichia/-trichic	glossotrichia
22	手	hand	ch(e)ir(o)-/-ch(e)iria	cheiroplasty
23	頭	head	cephal(o)-/-cephalia/-cephalic	hemicephalia
24	心臓	heart	cardi(o)-/-cardia/-cardic	cardiologist
25	腰	hip	ischi(o)-	ischiodynia
26	腸	intestine	enter(o)-/-entery/-enteron	dysentery
27	顎	jaw	gnath(o)-/-gnathia/-gnathic	orthognathic
28	関節	joint	arthr(o)-/-arthric	arthritis
29	腎	kidney	nephr(o)-/-nephria/-nephric	nephralgia
30	脚	leg	skel(o)-/-skelous	skelasthenia
31	肢	limb	mel(o)-/melos-/-melia	melomelus
32	唇	lip	cheil(o)-/-cheilia	acheilia
33	肝	liver	hepat(o/i)-/hepatico-/-hepatic	hepatitis
34	肺	lung	pneum(o)-/-pneumon	pneumonia
35	髄	marrow	myel(o)-/-myelia/-myelic	myelogram
36	膜	membrane	chori(o)-	chorioid
37	口	mouth	stomat(o)-/-stomy/-stomatic	stomatorrhagia
38	筋肉	muscle	my(o)-	myocardia
39	爪	nail	onych(o)-	onychectomy
40	臍(帯)[3]	navel/umbilical cord	omphal(o)-/-omphalia/-omphalic	omphalorrhagia
41	頸	neck/cervix[4]	trachel(o)-	trachelodynia
42	神経	nerve	neur(o)-/-neural	neuralgia
43	乳首	nipple	thel(e/o)-/-thelia/-thelic	thelitis
44	鼻	nose	rhin(o)-/-rhinal/-rhine	rhinolith

No	Kanji	*Kun'yomi*	*On'yomi*	Example
45	卵巣	ovary	oophor(o)-[5]	oophorostomy
46	陰茎	penis	phall(o)-	phallorrhagia
47	直腸	rectum	proct(o)-/-proctia	proctoscope
48	膚	skin	derm(a/o)-/dermat(o)-/-derm(a)/-dermic/-dermia	dermatology
49	脊	spine	rachi(o)-	rachigraph
50	脾	spleen	splen(o)-/-splenia/-splenic	perisplenic
51	胃	stomach	gastr(o)-/-gastria/-gastric	gastrectomy
52	腱	tendon	ten(o)-/tenont(o)-	tenodynia
53	睾丸	testicle	orchi(o)-/-orchid	triorchid
54	咽	throat	pharyng(o)-/-pharyngeal	pharyngitis
55	舌	tongue	gloss(o)-/-glossal/-glottic/-glossis	glossolalia
56	歯	tooth	odont(o)-/-dont/-dontia/-dontic	orthodontic
57	子宮	uterus	hyster(o)-[6]	hysterectomy
58	子宮	uterus	metr(o)-[6]	metrography
59	膣	vagina	colp(o)-	colpospasm
60	脈	vein	phleb(o)-	phlebonarcosis
61	気管	windpipe	bronch(o)-	bronchitis

BODILY SECRETIONS

62	胆汁	bile	chol(o/e)-/-cholia/-cholic	hypercholia
63	糞	faeces	copr(o)-	coprolalia
64	乳	milk	galact(o)-	galactemia
65	粘液	mucus	myx(o)-	myxocyte
66	唾	saliva	sial(o)-	sialophagia
67	精液	semen	spermat(o)-/sperm(o)-	spermatology
68	汗	sweat	hidr(o)-	hypohidrosis
69	尿	urine	ur(o)-/uron(o)-/-uria/-uric	uroscopy

OBSERVATIONS

70	大	big	mega-/megal(o)-/-megaly	megadont
71	巨大	large[8]	macr(o)-	macrencephalia
72	小	small	micr(o)-	microscope
73	冷(凍)	cold, freeze	cry(o)-	cryotherapy
74	熱[7]	hot	therm(o)-/-thermia	hypothermia
75	速	fast	tach(y/o)-	tachycardia
76	遅	slow	brady-	bradycardia
77	多	many	poly-	polyneural
78	少	few	olig(o)-	oligopnea
79	未	less	mi(o)-/mei(o)-	meiogenic
80	硬	hard	scler(o)-	scleroderma
81	軟	soft	malac(o)-/-malacia	osteomalacia
82	短	short	brachy-	brachyskelous
83	狭	narrow	sten(o)-	stenosis
84	細	slender	lept(o)-	leptocephalic
85	広	wide	platy-	platyrrhine

No	Kanji	*Kun'yomi*	*On'yomi*	Example
86	偽	false	pseud(o)-	pseudocyst
87	定	fixed	-pexy	nephropexy
88	隠	hidden	crypt(o)-	cryptolith
89	新	new	ne(o)-	neoplasm
90	球	round	spher(o)-	spherocyte
91	分裂	split	schist(o)-/schiz(o)-/schis(o)-	schizophrenia
92	直	straight	orth(o)-	orthopnoea
93	弱	weak	asthen(o)-/-asthenia	neurasthenia
94	甘	sweet	glyc(o)-/gluc(o)-	glycemia
95	半	half	hemi-	hemimelia
96	一	one	mon(o)-	monodactyly
97	二	two	di-	digastric
98	三	three	tri-	trichromasy
99	色	colour	chrom(o)-/chromat(o)-/-chromia	chromatopsia
100	黒	black	melan(o)-	melanoma
101	白	white	leuk(o)-/leuc(o)-	leukemia
102	青	blue	cyan(o)-	cyanuria
103	緑/塩素	green, chlorine[9]	chlor(o)-	chloroma
104	赤	red	erythr(o)-	erythroderma
105	黄	yellow	xanth(o)-	xanthochromia
106	破	break/destroy	clast(o)-/-clast	clastogenic
107	漏出	burst forth	-rrhagia	menorrhagia
108	運	carry/conduct	phor(o)-/-phore/-phoria	phorocyte
109	変	change	met(a)-	metatrophic
110	痙攣	convulse	spasm(o)-/-spasm/-spastic	spasmogen
111	流	flow	rheo-/-rrh(o)ea	diarrhea
112	成長	grow	aux(o)-	auxocardia
113	作	make	-poie(a)	sarcopoietic
114	動	move	kin(o/e)-/kinesi(o)-/-kinesis/-kinetic	kineplasty
115	腐	putrify	septi-/-septic	septicaemia
116	止	stop	stasi-/-stasis/-stasia	galactostasia
117	凝血	blood clot	thromb(o)-	thrombosis
118	芽細胞	primitive stage[10]	blast(o)-/-blast	blastoderm
119	癌	cancer[11]	carcin(o)-	carcinogenic
120	疾病	disease[12]	noso-/-nosic	nosology
121	疾病	disease[12]	path(o)-/-path(y)/-pathia/-pathic	psychopath
122	病態	diseased condition	-osis	mycosis
123	眼状	eye condition/defect	-op(s)ia/-opic	myopia
124	熱	fever[13]	pyr(o)-	pyretotherapy
125	形態	form	morph(o)-/-morph(ia/ic)	mesomorph
126	様	like/similar	-oid	adenoid
127	形成	formation	-plasis/-plasia	metaplasia
128	発生	generating	-gen(ic)	pathogenic
129	炎症	inflammation	-itis	hepatitis
130	形質	mould	plasm(o)-/-plasm(a)	cytoplasm
131	無感覚	numbness/torpor	narc(o)-[14]	narcolepsy
132	痛	pain[15]	alge-/-algia	neuralgia

No	Kanji	*Kun'yomi*	*On'yomi*	Example
133	痛	pain[15]	odyn(o)-/-odynia	mastodynia
134	麻痺	paralysis/stroke	pleg-/-plegia	paraplegia
135	発作	seizure[16]	-lepsy/-leptic	epilepsy
136	発作	seizure[16]	-agra	podagra
137	腫瘍	tumour	-oma	neuroma
138	腫瘍	tumour/swelling	onc(h)(o)-/-oncus[17]	oncology
		PREPOSITIONS		
139	内	inside	en-/em-/end(o)-/ent(o)-[18]	encephalitis
140	外	outside	ect(o)-	ectoscopy
141	上	above/over	ep(i)-	epidermis
142	上/超	above/excessive	hyper-	hypercholia
143	下	under	cat(a)-/kat(a)-[19]	catatonia
144	下/不全	under/deficient	hyp(o)-	hypodermic
145	中	middle	mes(o)-/mesi(o)-	mesogastric
146	前	before	pro-	prognosis
147	通過	through	di(a)-	diascopy
148	抗/対	against	ant(i)-	antibiotic
149	周囲/副/錯	next to/like/abnormal	par(a)-[20]	paraphobia
150	周	around	peri-	perirectal
151	無/不	not/lack	a(n)-[21]	anesthesia
152	端	extremity	acro-	acrodynia
153	両	both (sides)	amph(i)-/ampho-	amphicyte
154	共	together/association	syn-/sym-/syl-/sy-[22]	symbiosis
155	結合	same	home(o)-/hom(o)-/homoi(o)-	homeopathy
156	等	equal	iso-	isogamety
157	異常	different/other	all(o)-	allopathy
158	異常	abnormal	dys-	dysgraphia
		TREATMENTS		
159	化学	chemical	chem(o)-/chemi-/chemic(o)-/-chemical	chemotherapy
160	切	cut	tom(o)-/-tomy	omphalotomy
161	切除	cut out	-ectomy	mastectomy
162	薬	medicine	pharmaco-	pharmacology
163	形成外科	plastic surgery	plast(o)-/-plasty	theleplasty
164	療	treatment	therap-/-therapy	physiotherapy
		TECHNOLOGY		
165	測	measure	metr(o)-[23]/-metry/-meter	dermometer
166	学/論	science/theory[24]	log(o)-/-logy/-logic(al)	laryngology
167	観	view/see	scop(o)-/-scope/-scopy/-scopic	stethoscope
168	記器[25]	record, copy	-graph(y)/-graphic(al)	pneumograph
169	録	written record	-gram	podogram

No	Kanji	*Kun'yomi*	*On'yomi*	Example
			PSYCHOLOGY	
170	怖	fear	phobo-/-phobia/-phobe/-phobic	arachnophobia
171	愛	love	-philia/-phile/-philic	paedophilia
172	狂	madness	mani-/-mania(c)	kleptomaniac
173	精神	mind/soul	psych(o)-	psychology
			GENERAL	
174	人/男	(hu)man	anthrop(o)-	anthropopathy
175	女	woman	gyn(a)ec(o)-/gyn(o/e)-/-gynous/-gyny	gynaecology
176	子	child	p(a)ed(o)-/-p(a)edic/-p(a)edia	pediatric
177	産	childbirth	toco-/toko-/-toky	tocology
178	自	self	aut(o)-	autotherapy
179	命	life	bi-/-bio(s/t)-/-biosis	biology
180	死	death	thanat(o)-	thanatosis
181	死体	corpse	necr(o)-	necrophilia
182	食物	food	troph(o)-/-trophic/-trophy	dystrophy
183	食	eat	phag(o)-/-phagic/-phage	phagomania
184	知	know	gnot(o)-/-gnosis	diagnosis
185	感	feel	esthesi(o)-/-esthesia	esthesiology
186	眠	sleep	hypn(o)-	hypnosis
187	話	speak	-phasia	aphasia
188	片言/言語	babble, language	lalo-/-lalia	coprolalia
189	息	breath(e)	pneo-/pneum(a)-/pneumat(a)-/-pnea	pneoscope
190	自然	nature/natural	physi(o)-	physiognomy
191	空気	air	aer(o)-	aerobic
192	水	water	hydr(o)-	hydrophobia
193	石	stone	lith(o)-/-lith(ic)	lithotomy
194	明	light	phot(o)-	photogastroscope
195	菌	fungus	myc(o)-/mycet(o)-	mycosis
196	月	month	men(o)-/-menia	menorrhagia
197	始	beginning	arch(i)-/arch(a)e(o)-	archiblast
198	部	part(ial)	mer(o)-/-mere/-meric[26]	meromelia
199	毒	poison	tox(i/o)-/toxic(o)-/-toxy	urotoxy
200	音	sound	phon(o)-/-phonia/-phonic	phonocardiograph

Appendix B — Notes For Teachers on Appendix A

1. Students need to be advised of the two meanings of *breast*: (i) the mammary gland, and (ii) the upper part of the chest, and that here the word refers to the former.
2. The original Greek means *hollow vessel.*
3. 臍 (*heso*) is the *navel*, whilst 臍帯 (*seitai*) is the *umbilical cord.*
4. Whilst the anatomical similarity between the *neck* and the *cervix* is clear, use of the prefix *trachel(o)-* is often ambiguous as to which it refers to, e.g. *trachelodynia* is a 'pain in the neck', whilst *tracheloplasty* is 'plastic surgery to the cervix'. Caution is therefore necessary in its interpretation.
5. A combination of [15] *oo-* and [109] *phor(o)-*.
6. Both *hyster(o)-* and *metr(o)-* are equally common, although the former can also refer to *hysteria* rather than the *uterus* in psychological terminology. For *metr(o)-* see also 23.
7. The kanji 熱 (*netsu*) is the same as that used for [124] *fever.*
8. *Macro-* can also mean *long* and is different from [70] *mega-* etc. in that it contains the nuance of 'abnormally large'.
9. *Chlor(o)-* can also serve as an abbreviation of *chlorine* as in *chlorometry.*
10. A difficult word to define in English, but very common as a suffix. Essentially means the primitive or embryonic stage of a cell, the original Greek meaning *germ* or *shoot.*
11. The original Greek means *crab* and gained the meaning of *cancer* through association with its zodiacal symbol.
12. *Path(o)-* is the more common of the two.
13. The original Greek means *fire*, as indeed the Japanese kanji can also mean *heat.*
14. The prefix *narc(o)-* can also be used an abbreviation of 'narcotics', which has a different meaning but of course comes ultimately from the same root.
15. *Odyn(o)-/-dynia* has the nuance of 'painful condition', whilst *-algia* refers simply to *pain.*
16. In differentiating between *-lepsy/-leptic* and *-agria*, the latter has the added nuance of a 'seizure involving acute pain'.
17. The root *onc(o)-* can, from a separate etymology, also mean *hook* or *barb*, as in *oncosphere.*
18. *Em-* before labials ('b', 'p', 'ph', 'm').
19. *Cat(a)-/kat(a)-* has numerous minor meanings, including *against, along with* and *very.*
20. *Para-* is an extremely difficult prefix to define succinctly, as, in Greek, it can mean *beyond, apart from* or *an accessory to*, as well as the three definitions given here (*next to, like* and *abnormal*), which are the most common.
21. *A-* before consonants, *an-* before vowels.
22. *Sym-* before labials ('b', 'p', 'ph', 'm'), *syl-* before 'l', *sy-* before 's'.
23. The prefix *metr(o)-* is extremely uncommon but does have a homophone: [58] *uterus.*
24. The original Greek means *word* or *reason* and, indeed, as a rather uncommon (in medical terminology) prefix, *log(o)-* can only mean 'word' (e.g. *logopathy, logorrhea*).
25. The kanji compound 記器 does not actually exist. Since the suffices *-graph* or *-graphy* are variously translated in Japanese as 描写器 (*byoushaki*), 描記器 (*byoukiki*) and 記録器 (*kirokuki*) amongst others, 記器 has been chosen simply as the best 'fit', i.e. the most likely

to summon to a Japanese student's mind the likely real translation. The original Greek root means *write* and, as a prefix, *graph(o)-* refers to writing rather than recording or copying (e.g. *graphomotor, graphospasm*).

26. The prefix *mer(o)-* can, from a separate etymology, also mean *thigh*, as in *merocoxalgia*.