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# Characterization by Optical Mapping of Three Archetypal Chromosomes of *Escherichia coli* O157:H7 Involved in Three 2006 Outbreaks of *E. coli* associated with Fresh Produce

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### Results:

High resolution optical maps from 12 isolates, including the two reference sequenced *E. coli* O157:H7 strains Sakai and EDL933, were used to generate a data set of chromosomal variations (Table 1).

Eight isolates (strains 13-20) from the three 2006 outbreaks were optically mapped (Table 2). Five S1 isolates included a clinical (EC4042), spinach (EC4045), bovine-associated (EC4206), and two S1 clinical variants (EC4076 and EC4115). Strains EC4401 and EC4501 from the L1 and L2 outbreaks, respectively, were mapped. An additional outlier strain, EC4422, from the L1 outbreak was also mapped.

Thirty one variable chromosomal sites have been optically mapped in *E. coli* O157:H7 isolates (Table 1). Many of these sites, such as the Mu-like phage insertion at site 28 found in Sakai, were uninformative for the outbreak strains examined here. Therefore, these sites were not included in the comparison of outbreak strains. For comparison of the three outbreak strains, 10 of these sites (A-J) were selected and scored (Table 2).

For the 10 selected sites, markers highlighted in blue showed similarities, while markers highlighted in white showed differences relative to the S1 outbreak isolate EC4045. Most (8/10) of the chromosomal markers found in the S1 strain were the same in the L1 outbreak strain; three were the same in the L2 outbreak strain. The optical map of an outlier strain from the L2 outbreak shared none of the 10 S1 chromosomal markers (Table 2).

DNA sequencing showed that the S1 strain contains novel prophages carrying *stx2* at the *argW* chromosomal locus, *stx2c* at the *sbcB* locus, and a prophage lacking *stx1* at *yeiV*. Shiga toxin prophage profiles of the S1 strain are indistinguishable from the L1 strain and this profile is distinct from the L2 strain (*stx1+*, *sbc2+*, *stx2c-*).

### Background:

Three outbreaks of *E. coli* O157:H7 in 2006 associated with fresh produce offered an opportunity to examine the specificity and variability of a human pathogen during the course of an outbreak. Preliminary microarray analysis of gene content allowed the designation of a type strain for each outbreak. The outbreaks encompassed 199 cases linked to the nationwide fresh spinach (S1) outbreak (Sept-Oct 2006), 71 cases linked to fresh lettuce (L1) restaurants set 1 (Nov-Dec 2006), and 77 cases linked to fresh lettuce (L2) restaurants set 2 (Dec 2006). The gene content data indicated that the S1 outbreak isolates were very similar to each other and to the L1 isolates, but the L2 isolates were distinct.

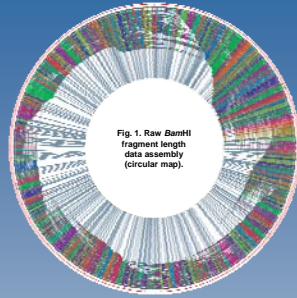
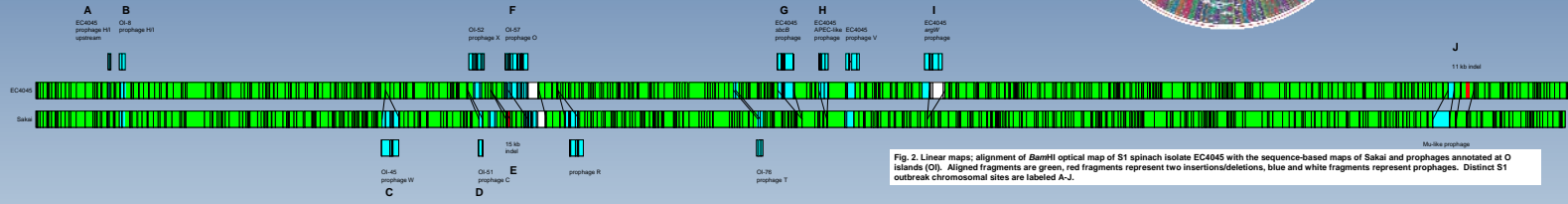


Fig. 2. Linear maps; alignment of BamHI optical map of S1 spinach isolate EC4045 with the sequence-based maps of Sakai and prophages annotated at O islands (OI). Aligned fragments are green, red fragments represent two insertions/deletions, blue and white fragments represent prophages. Distinct S1 outbreak chromosomal sites are labeled A-J.

Numbers in tables represent kb of DNA at each site relative to Sakai as a reference.

Table 1. Chromosomal polymorphisms optically mapped in *E. coli* O157:H7

Site Number	Map position (kb) EC4045																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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1	0.259	0.310	0.363	0.413	0.463	0.513	0.563	0.613	0.663	0.713	0.763	0.813	0.863	0.913	0.963	1.013	1.063	1.113	1.163	1.213	1.263	1.313	1.363	1.413	1.463	1.513	1.563	1.613	1.663	1.713	1.763	1.813	1.863	1.913	1.963	2.013	2.063	2.113	2.163	2.213	2.263	2.313	2.363	2.413	2.463	2.513	2.563	2.613	2.663	2.713	2.763	2.813	2.863	2.913	2.963	3.013	3.063	3.113	3.163	3.213	3.263	3.313	3.363	3.413	3.463	3.513	3.563	3.613	3.663	3.713	3.763	3.813	3.863	3.913	3.963	4.013	4.063	4.113	4.163	4.213	4.263	4.313	4.363	4.413	4.463	4.513	4.563	4.613	4.663	4.713	4.763	4.813	4.863	4.913	4.963	5.013	5.063	5.113	5.163	5.213	5.263	5.313	5.363	5.413	5.463	5.513	5.563	5.613	5.663	5.713	5.763	5.813	5.863	5.913	5.963	6.013	6.063	6.113	6.163	6.213	6.263	6.313	6.363	6.413	6.463	6.513	6.563	6.613	6.663	6.713	6.763	6.813	6.863	6.913	6.963	7.013	7.063	7.113	7.163	7.213	7.263	7.313	7.363	7.413	7.463	7.513	7.563	7.613	7.663	7.713	7.763	7.813	7.863	7.913	7.963	8.013	8.063	8.113	8.163	8.213	8.263	8.313	8.363	8.413	8.463	8.513	8.563	8.613	8.663	8.713	8.763	8.813	8.863	8.913	8.963	9.013	9.063	9.113	9.163	9.213	9.263	9.313	9.363	9.413	9.463	9.513	9.563	9.613	9.663	9.713	9.763	9.813	9.863	9.913	9.963	10.013	10.063	10.113	10.163	10.213	10.263	10.313	10.363	10.413	10.463	10.513	10.563	10.613	10.663	10.713	10.763	10.813	10.863	10.913	10.963	11.013	11.063	11.113	11.163	11.213	11.263	11.313	11.363	11.413	11.463	11.513	11.563	11.613	11.663	11.713	11.763	11.813	11.863	11.913	11.963	12.013	12.063	12.113	12.163	12.213	12.263	12.313	12.363	12.413	12.463	12.513	12.563	12.613	12.663	12.713	12.763	12.813	12.863	12.913	12.963	13.013	13.063	13.113	13.163	13.213	13.263	13.313	13.363	13.413	13.463	13.513	13.563	13.613	13.663	13.713	13.763	13.813	13.863	13.913	13.963	14.013	14.063	14.113	14.163	14.213	14.263	14.313	14.363	14.413	14.463	14.513	14.563	14.613	14.663	14.713	14.763	14.813	14.863	14.913	14.963	15.013	15.063	15.113	15.163	15.213	15.263	15.313	15.363	15.413	15.463	15.513	15.563	15.613	15.663	15.713	15.763	15.813	15.863	15.913	15.963	16.013	16.063	16.113	16.163	16.213	16.263	16.313	16.363	16.413	16.463	16.513	16.563	16.613	16.663	16.713	16.763	16.813	16.863	16.913	16.963	17.013	17.063	17.113	17.163	17.213	17.263	17.313	17.363	17.413	17.463	17.513	17.563	17.613	17.663	17.713	17.763	17.813	17.863	17.913	17.963	18.013	18.063	18.113	18.163	18.213	18.263	18.313	18.363	18.413	18.463	18.513	18.563	18.613	18.663	18.713	18.763	18.813	18.863	18.913	18.963	19.013	19.063	19.113	19.163	19.213	19.263	19.313	19.363	19.413	19.463	19.513	19.563	19.613	19.663	19.713	19.763	19.813	19.863	19.913	19.963	20.013	20.063	20.113	20.163	20.213	20.263	20.313	20.363	20.413	20.463	20.513	20.563	20.613	20.663	20.713	20.763	20.813	20.863	20.913	20.963	21.013	21.063	21.113	21.163	21.213	21.263	21.313	21.363	21.413	21.463	21.513	21.563	21.613	21.663	21.713	21.763	21.813	21.863	21.913	21.963	22.013	22.063	22.113	22.163	22.213	22.263	22.313	22.363	22.413	22.463	22.513	22.563	22.613	22.663	22.713	22.763	22.813	22.863	22.913	22.963	23.013	23.063	23.113	23.163	23.213	23.263	23.313	23.363	23.413	23.463	23.513	23.563	23.613	23.663	23.713	23.763	23.813	23.863	23.913	23.963	24.013	24.063	24.113	24.163	24.213	24.263	24.313	24.363	24.413	24.463	24.513	24.563	24.613	24.663	24.713	24.763	24.813	24.863	24.913	24.963	25.013	25.063	25.113	25.163	25.213	25.263	25.313	25.363	25.413	25.463	25.513	25.563	25.613	25.663	25.713	25.763	25.813	25.863	25.913	25.963	26.013	26.063	26.113	26.163	26.213	26.263	26.313	26.363	26.413	26.463	26.513	26.563	26.613	26.663	26.713	26.763	26.813	26.863	26.913	26.963	27.013	27.063	27.113	27.163	27.213	27.263	27.313	27.363	27.413	27.463	27.513	27.563	27.613	27.663	27.713	27.763	27.813	27.863	27.913	27.963	28.013	28.063	28.113	28.163	28.213	28.263	28.313	28.363	28.413	28.463	28.513	28.563	28.613	28.663	28.713	28.763	28.813	28.863	28.913	28.963	29.013	29.063	29.113	29.163	29.213	29.263	29.313	29.363	29.413	29.463	29.513	29.563	29.613	29.663	29.713	29.763	29.813	29.863	29.913	29.963	30.013	30.063	30.113	30.163	30.213	30.263	30.313	30.363	30.413	30.463	30.513	30.563	30.613	30.663	30.713	30.763	30.813	30.863	30.913	30.963	31.013	31.063	31.113	31.163	31.213	31.263	31.313	31.363	31.413	31.463	31.513	31.563	31.613	31.663	31.713	31.763	31.813	31.863	31.913	31.963	32.013	32.063	32.113	32.163	32.213	32.263	32.313	32.363	32.413	32.463	32.513	32.563	32.613	32.663	32.713	32.763	32.813	32.863	32.913	32.963	33.013	33.063	33.113	33.163	33.213	33.263	33.313	33.363	33.413	33.463	33.513	33.563	33.613	33.663	33.713	33.763	33.813	33.863	33.913	33.963	34.013	34.063	34.113	34.163	34.213	34.263	34.313	34.363	34.413	34.463	34.513	34.563	34.613	34.663	34.713	34.763	34.813	34.863	34.913	34.963	35.013	35.063	35.113	35.163	35.213	35.263	35.313	35.363	35.413	35.463	35.513	35.563	35.613	35.663	35.713	35.763	35.813	35.863	35.913	35.963	36.013	36.063	36.113	36.163	36.213	36.263	36.313	36.363	36.413	36.463	36.513	36.563	36.613	36.663	36.713	36.763	36.813	36.863	36.913	36.963	37.013	37.063	37.113	37.163	37.213	37.263	37.313	37.363	37.413	37.463	37.513	37.563	37.613	37.663	37.713	37.763	37.813	37.863	37.913	37.963	38.013	38.063	38.113	38.163	38.213	38.263	38.313	38.363	38.413	38.463	38.513	38.563	38.613	38.663	38.713	38.763	38.813	38.863	38.913	38.963	39.013	39.063	39.113	39.163	39.213	39.263	39.313	39.363	39.413	39.463	39.513	39.563	39.613	39.663	39.713	39.763	39.813	39.863	39.913	39.963	40.013	40.063	40.113	40.163	40.213	40.263	40.313	40.363	40.413	40.463	40.513	40.563	40.613	40.663	40.713	40.763	40.813	40.863	40.913	40.963	41.013	41.063	41.113	41.163	41.213	41.263	41.313	41.363	41.413	41.463	41.513	41.563	41.613	41.663	41.713	41.763	41.813	41.863	41.913	41.963	42.013	42.063	42.113	42.163	42.213	42.263	42.313	42.363	42.413	42.463	42.513	42.563	42.613	42.663	42.713	42.763	42.813	42.863	42.913	42.963	43.013	43.063	43.113	43.163	43.213	43.263	43.313	43.363	43.413	43.463	43.513	43.563	43.613	43.663	43.713	43.763	43.813	43.863	43.913	43.963	44.013	44.063	44.113	44.163	44.213	44.263	44.313	44.363	44.413	44.463	44.513	44.563	44.613	44.663	44.713	44.763	44.813	44.863	44.913	44.963	45.013	45.063	45.113	45.163	45.213	45.263	45.313	45.363	45.413	45.463	45.513	45.563	45.613	45.663	45.713	45.763	45.813	45.863	45.913	45.963	46.013	46.063	46.113	46.163	46.213	46.263	46.313	46.363	46.413	46.463	46.513	46.563	46.613	46.663	46.713	46.763	46.813	46.863	46.913	46.963	47.013	47.063	47.113	47.163	47.213	47.263	47.313	47.363	47.413	47.463	47.513	47.563	47.613	47.663	47.713	47.763	47.813	47.863	47.913