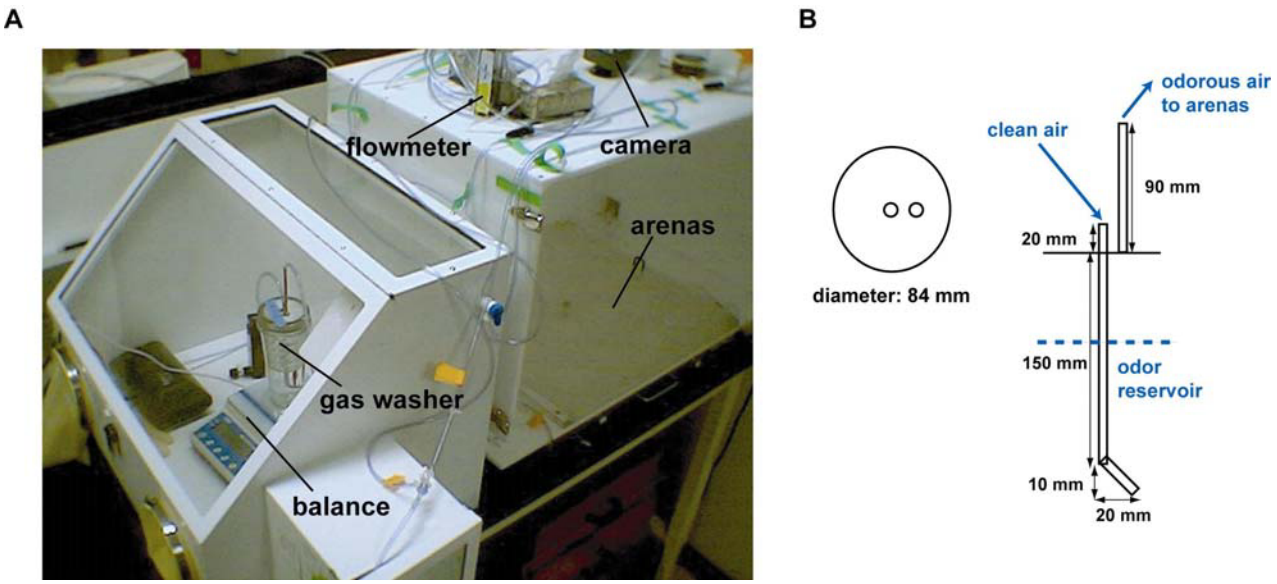

Fig. S1. Odor flow assay. (*A*) A vacuum was generated by a pump (Economical Vacuum/Pressure Pumps Coated with PTFE; Cole-Parmer; Vernon Hills, IL). The air was bubbled through a 270 ml Fisher-Milligan Gas Washer (Fisher Scientific Research; Pittsburgh, PA) with a custom made metal cap (*B*) that contained the odor. Odorous air was mixed with pure air. The airflow was controlled by a combination of flow meters. Flies were placed into each of 16 circular arenas [10 cm diameter, 1 cm high, tilted walls (45 deg)]. The arenas were covered with a transparent Plexiglas lid that contained the holes through which odorous air entered and left the arenas (in 1 mm diameter tubes). The arenas were in a custom-built box made out of white opaque plastic (860 mm x 525 mm; 545 mm high) built by Vadim Sherman in the Rockefeller University High Energy Physics Machine Shop. The arenas were illuminated from below by a light box (Porta-Trace, Model 2436; Gagne Inc. Johnson City, NJ). Flies were videotaped with a Panasonic Color CCTV Camera (WV-CP470). (*B*) Dimensions of the custom-build gas washer cap. On the left is a horizontal view of the cap. On the right is a cross-sectional view of the cap that was custom-made to fit a 270 ml Fisher-Milligan Gas Washer.

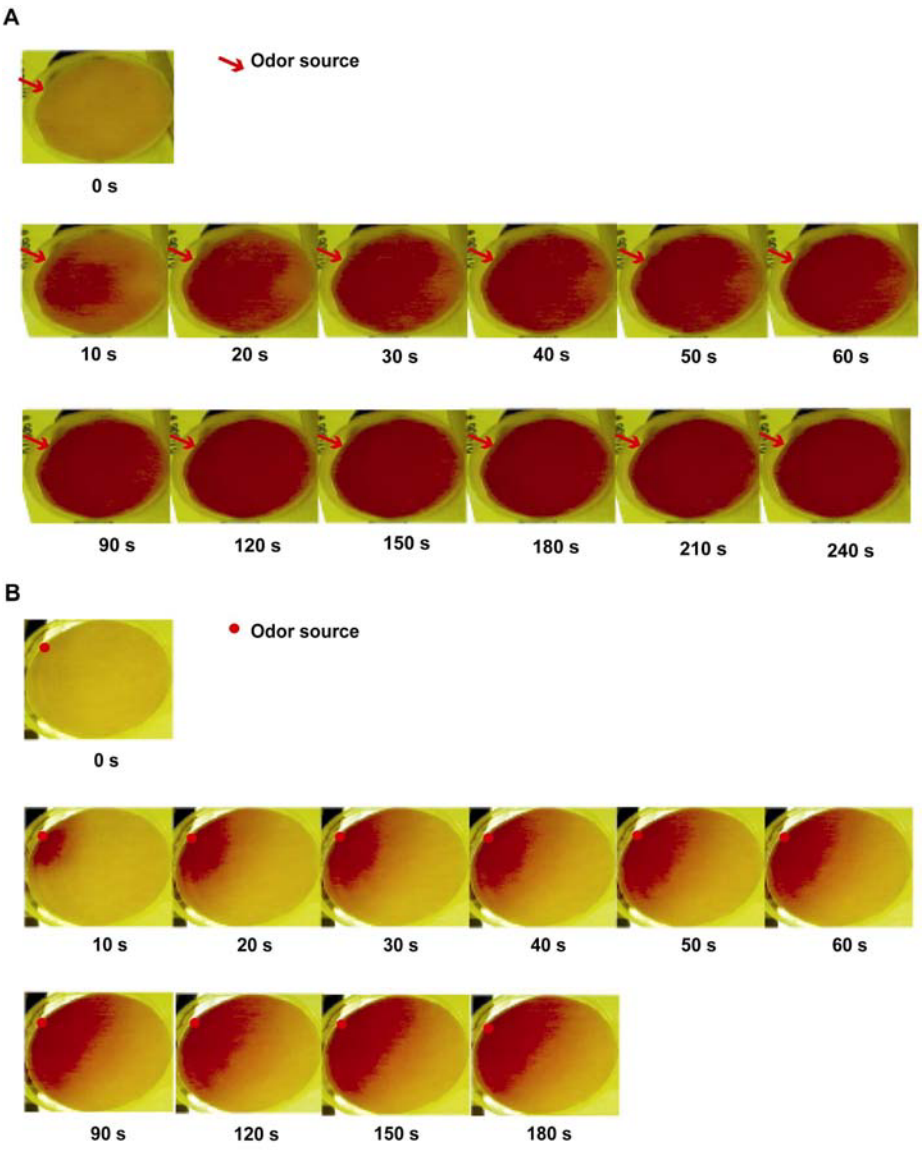

Fig. S2. Odor distribution in the olfactory assays. (*A*-*B*) An aqueous solution of hydrogen chloride (HCl) gas (Fisher Scientific) and pH-sensitive paper pHydrion Brilliant 0.0-6.0 (Micros Essential Laboratory, Brooklyn, NY) were used to visualize the odor distribution in the odor flow assay (*A*) and the stationary odor source assay (*B*). Images are captured with the same camera used for measuring fly behavior. Frames are shown before the start of the experiment and then every 10 sec for the first minute and every 30 sec thereafter. The odor builds a steep gradient in the stationary odor assay (*B*), whereas the arena is uniformly filled with odor in the odor flow assay. In (*A*), the apparatus was rebuilt with disposable parts to avoid damage from HCl gas but the diameter of the tubes, the airflow, and the arena diameter are the same as those used for the experiments.

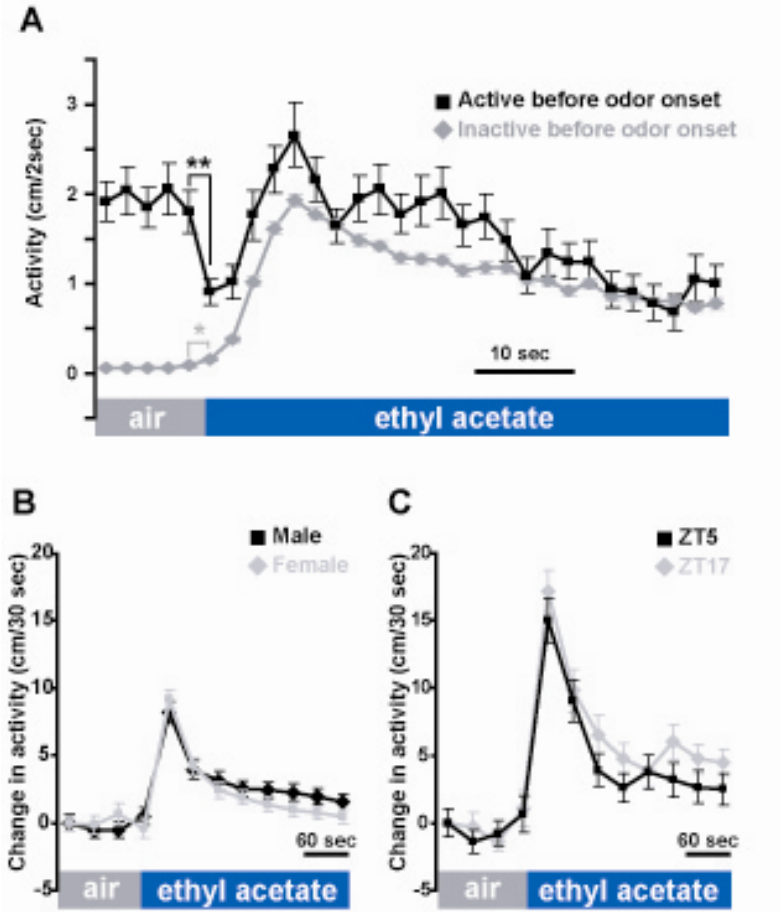

Fig. S3. Response to ethyl acetate in the odor flow assay. In this Figure the data from Figure 1*C* is analyzed further. The 484 flies that were tested are parsed in three ways. In (*A*) flies that were inactive (<5cm/10 sec; n=454; gray diamonds) or active (>5cm/10 sec; n=30; black squares) during the 10 sec before odor onset are compared and odor-induced changes in activity are seen two seconds after odor onset (**p<0.01 or *p<0.05; unpaired t-test). In (*B*) ethyl acetate-induced responses in males and females (n=242 each) are compared. Behavioral responses to ethyl acetate did not differ between male and female flies. The change in activity compared to the start of the experiment is shown. In (*C*) a subset of the data from Figure 1*C* in which animals were tested in parallel at different times of the day [ZT (Zeitgeber Time) 5; black square; n=53 and ZT17; gray diamond; n=55] is shown. Behavioral responses to ethyl acetate did not differ between flies tested at subjective day or night. Thus the circadian rhythm in neural responses to ethyl acetate in the antenna (1) does not influence this ethyl acetate-induced behavior. The flies in (*C*) were entrained in two incubators set 12 hours out of phase and were tested during a two hour period comprising ZT (Zeitgeber Time) 4-6 (“ZT5”) and ZT16-18 (“ZT17”). Flies were tested in normal fluorescent room light, such that those in the subjective night were exposed to light for 0-2 hours before testing. The reported circadian rhythm in EAG amplitude persists for 24 hours in constant light, so flies were unlikely to have been reset by this brief ambient light exposure before testing (1).

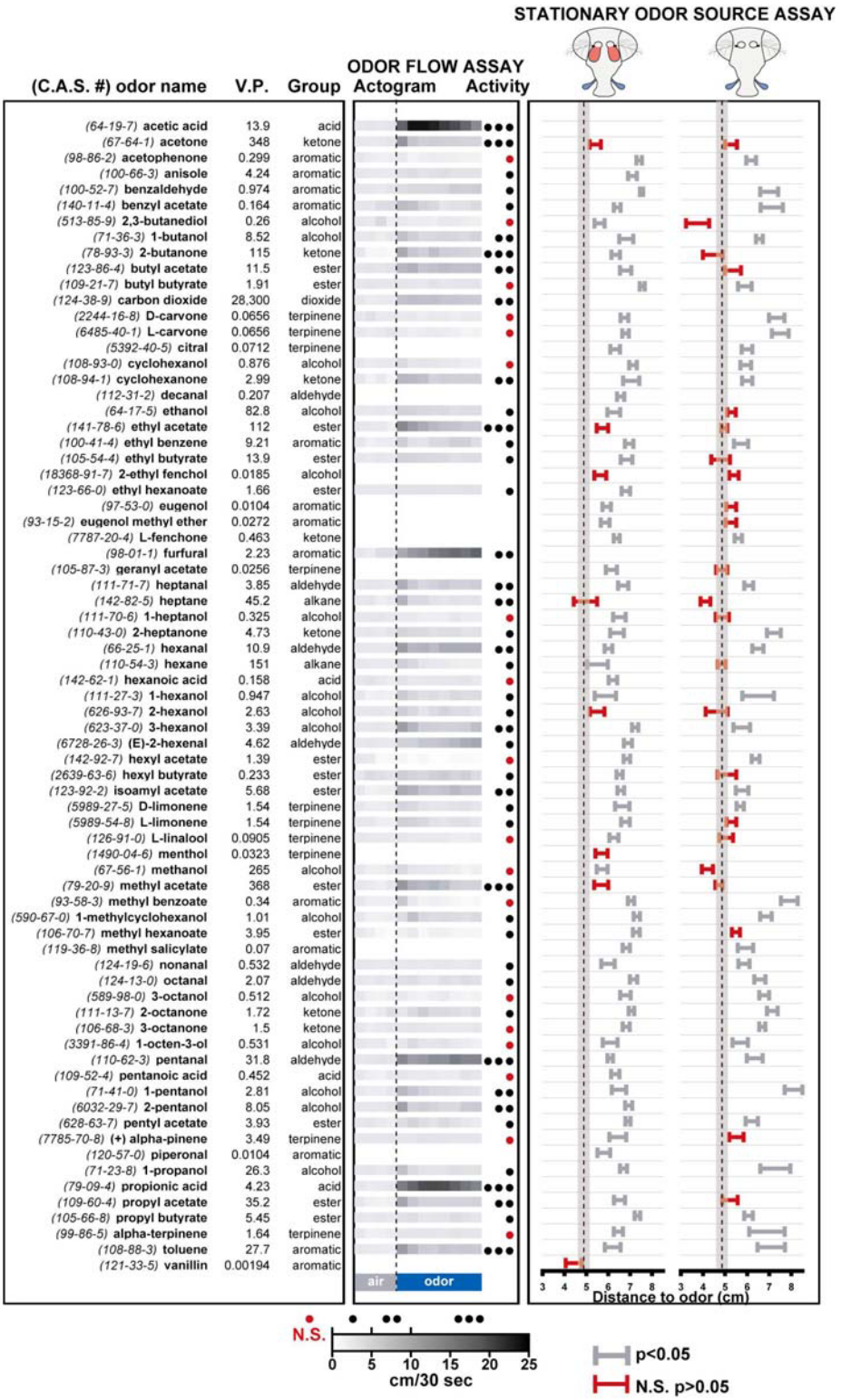

Fig. S4. Receptive range of *Drosophila*. Same data as in Fig. 3 but sorted alphabetically by odor.

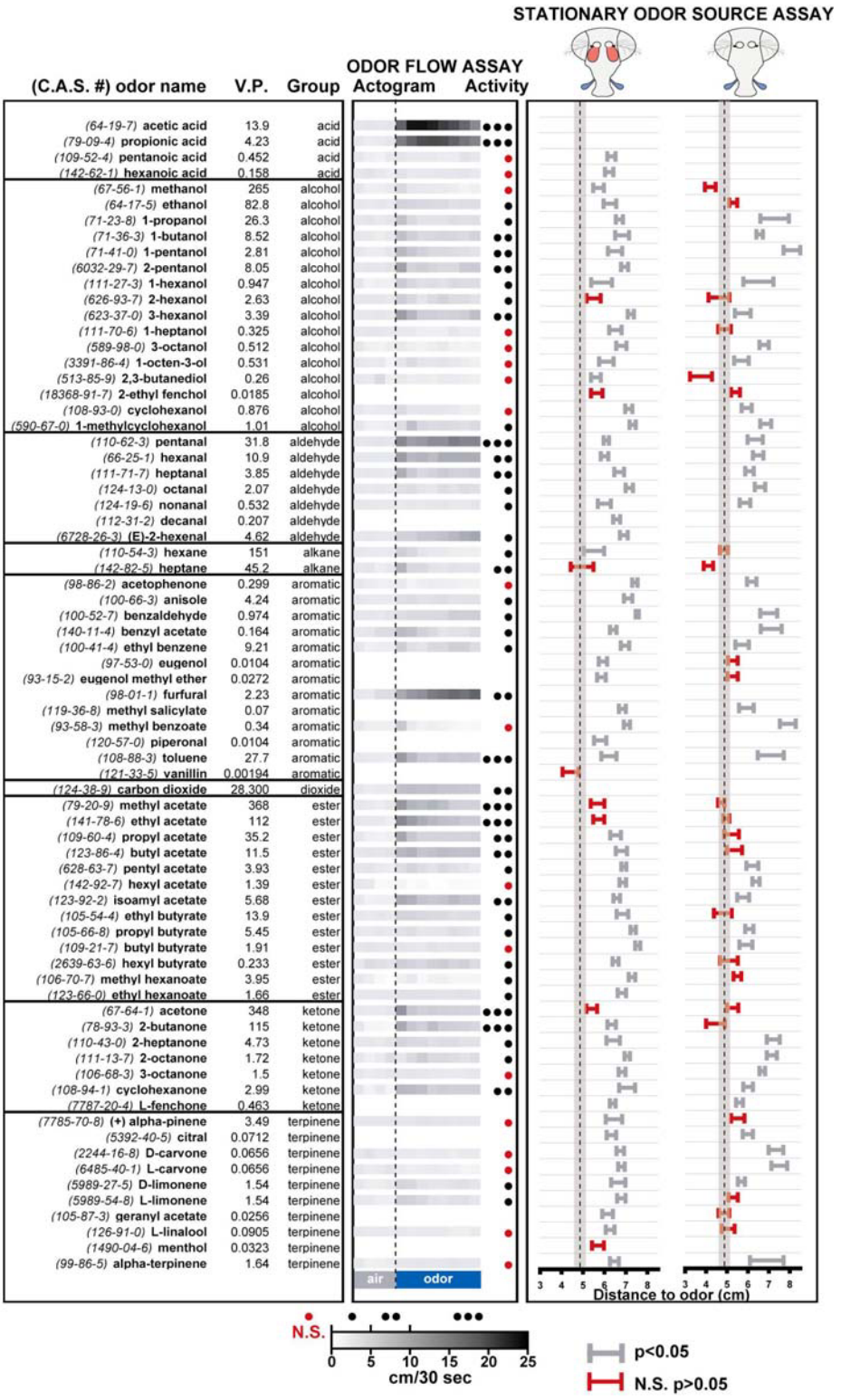

Fig. S5. Receptive range of *Drosophila*. Same data as in Fig. 3 but sorted by functional group and carbon chain length.

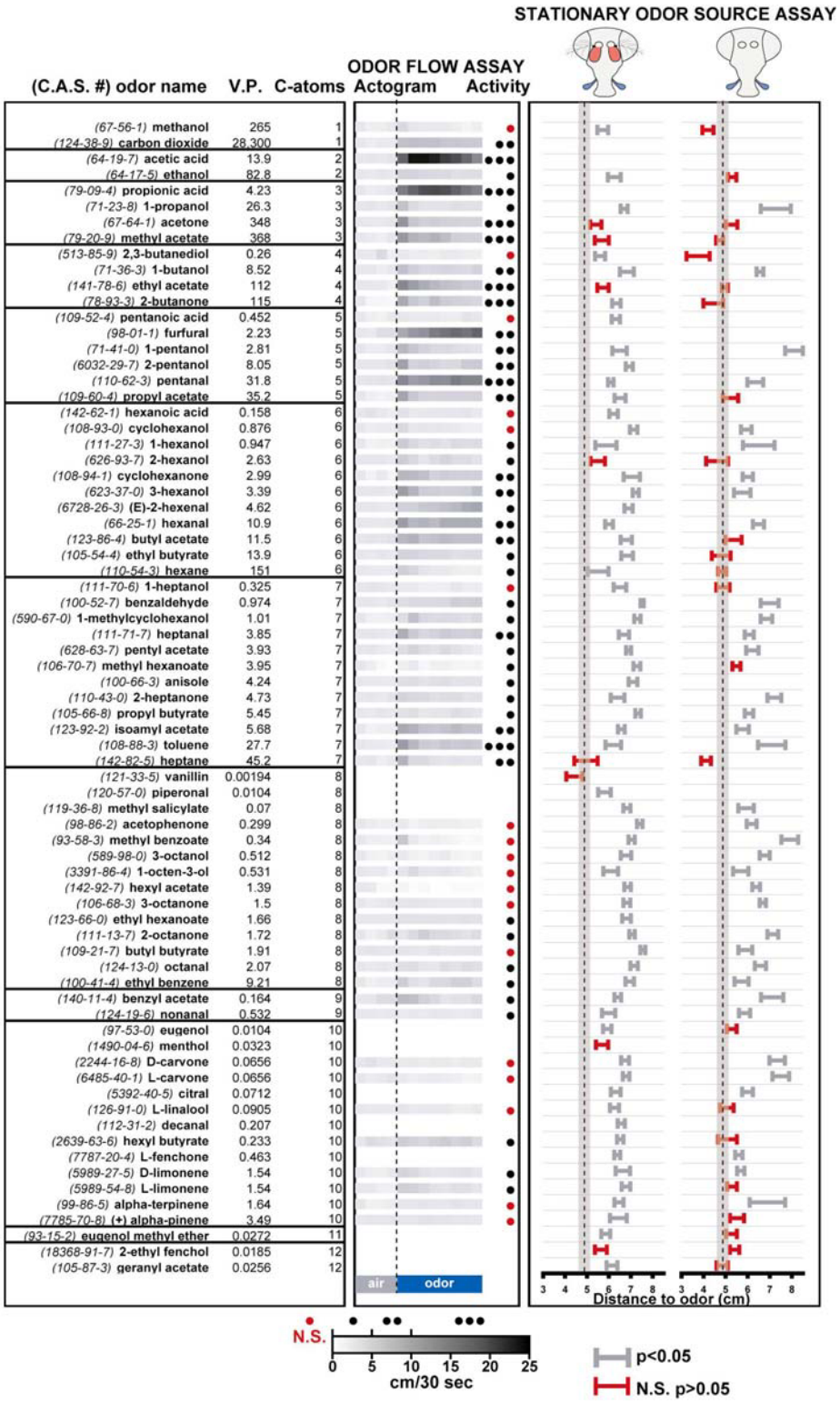

Fig. S6. Receptive range of *Drosophila*. Same data as in Fig. 3 but sorted by carbon chain length and vapor pressure.

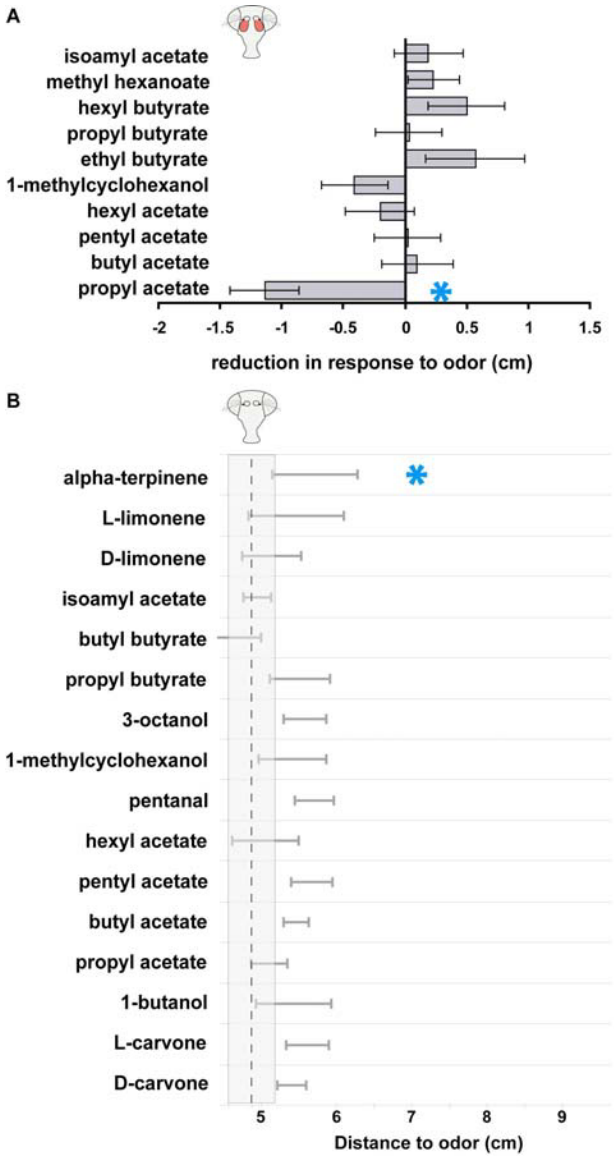

Fig. S7. Contribution of different adult olfactory organs to odor-evoked behavior. Data measured in the stationary odor source assay is shown. (*A*) Odor-evoked behavior of *Drosophila* surgically manipulated to remove only the maxillary palps (10 odors). Data are expressed as change in response (distance to odor in cm) relative to mock-treated controls. The asterisk shows a statistically significant difference between the two groups ($p<0.05$). (*B*) Odor-evoked behavior of *Drosophila* surgically manipulated to remove both antennae and maxillary palps (16 odors). Data are expressed as distance to odor. The asterisk shows a statistically significant response in comparison to the behavior with no odor ($p<0.05$).

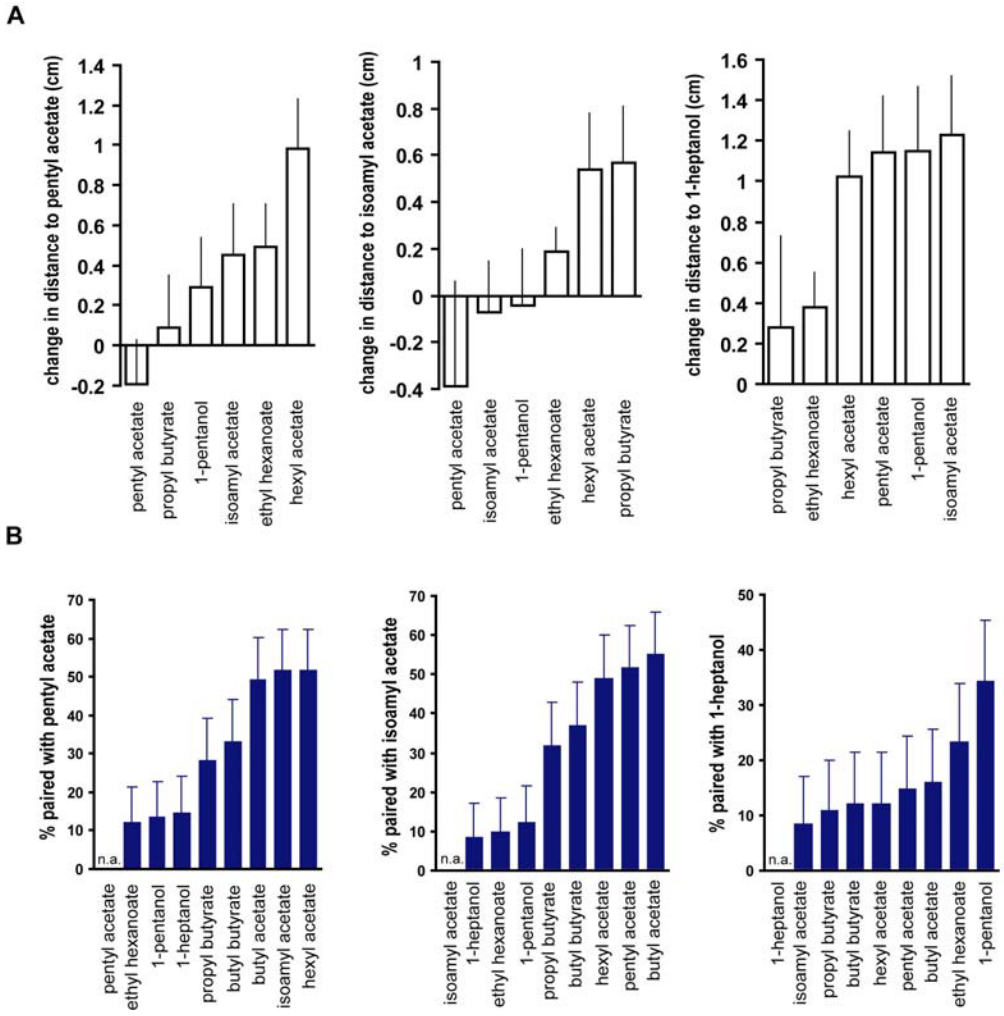

Fig. S8. Comparative odor similarity judgments in humans and flies. (*A*) Representative data used to construct the fly odor similarity tree in Fig. 6 *D*. Avoidance (measured as the change in the distance to the odor source compared to behavior measured in the absence of odor) of the panel of six odors after pre-exposure to pentyl acetate (left), isoamyl acetate (middle), and 1-heptanol (right) is shown (mean+S.E.M.). The similarity tree in Fig. 6 *D* is constructed from measuring the avoidance of all nine odors to this panel of six odors. (*B*) Representative data used to generate the human odor similarity tree in Fig. 6 *E*. Bar graphs show the frequencies (and 95% confidence intervals) with which odors are placed in the same group as pentyl acetate (left), isoamyl acetate (middle), and 1-heptanol (right). The data from experiments replicated at three concentrations are pooled. The odor similarity tree in Fig. 6 *E* is constructed from the frequencies of all 36 possible pairings.

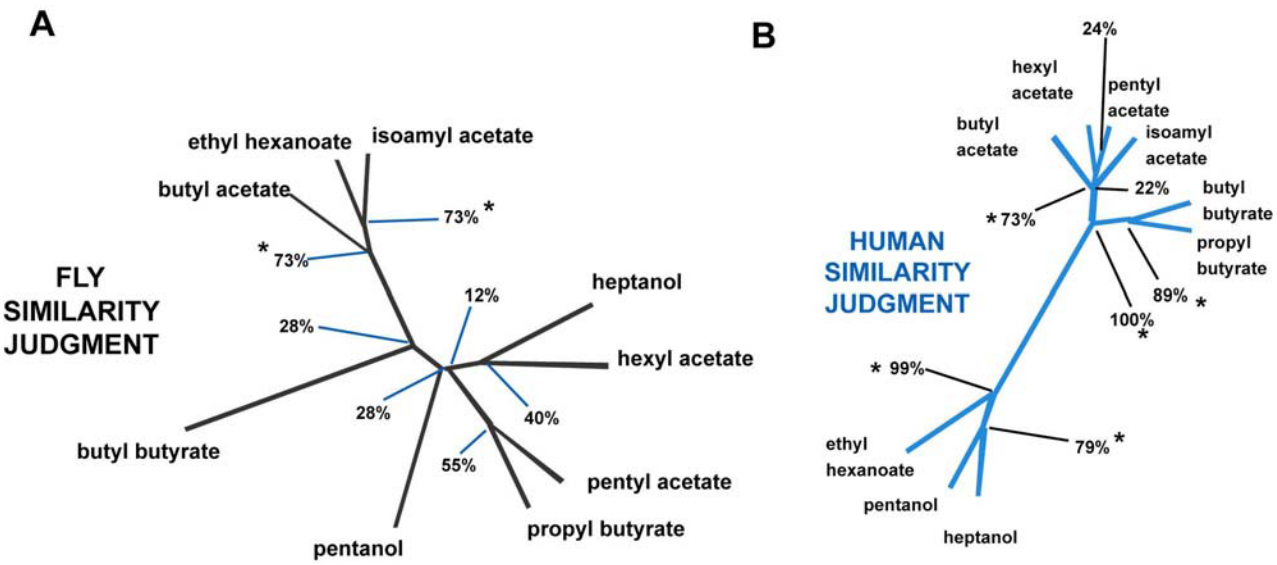

Fig. S9. Stability of odor category trees. (*A*) In the fly odor similarity tree (Fig. 6 *D*) only the nodes connecting ethyl hexanoate, butyl acetate, and isoamyl acetate are more stable than the 95th percentile of the node stability of randomized data and can be considered to be statistically significant. (*B*) In the human odor similarity tree (Fig. 6 *E*) all the nodes except those connecting isoamyl acetate, pentyl acetate, and hexyl acetate have statistically significant stability. Nodes with statistically significant stability are marked with an asterisk. The trees are constructed using unweighted Arithmetic Average of the Canberra Distance. Stability analysis (1,000,000 runs; new data generated by Bootstrap) was used to measure how many of the newly generated trees had an equivalent interior node for each of the nodes. Average stability of the nodes in the fly odor similarity tree is 44%, for the human odor similarity tree it is 69%, showing that the fly data - based on cross-adaptation - is less clear than the human data based on forming odor categories. Ten random permutations of the data resulted in trees with an average node stability of 37% (flies) and 36% (humans). The 95th percentile of the node stability of the randomized data was 69% (flies) and 67% (humans).

Movie S1. Odor-evoked behavior of four flies in odor flow assay in response to ethyl acetate (18% SV). Fly responses to two minutes air followed by 4 minutes of odor are played back at 20X real time.

Movie S2. Odor-evoked behavior of four flies in stationary odor source assay in response to paraffin oil (5 µl). Three minutes of behavior are played back at 20X real time.

Movie S3. Odor-evoked behavior of four flies in stationary odor source assay in response to L-carvone (5 µl, undiluted). Three minutes of behavior are played back at 20X real time.

SUPPLEMENTARY METHODS

Drosophila Stocks

The following genotypes and sources of fly stocks were used in this study: Wild type Berlin (M. Heisenberg); *delta halo Or22a/b*$^{-/-}$ (M. Welte) (2, 3); *delta halo* control stocks [*Df(2L)frtz14* and *Df(2L)frtz25*] (M. Welte) (3); *Or43b*^{1}, *Or43b*^{2}, and isogenic *w*^{1118} control flies (D. Smith) (4).

Odors

Odors were obtained from Sigma-Aldrich. Odors used in the stationary odor source assay were diluted (v:v) in paraffin oil, except for vanillin, piperonal, and menthol, which were diluted in dipropylene glycol. For the odor flow assay, undiluted odorants were used, and stimulus dilution was achieved by mixing odorous air with pure air. Odors for the human psychophysics experiments were diluted v:v in paraffin oil.

Odor Flow Assay

The X-Y position of the fly was tracked at 6 Hz using Ethovision (Noldus) and the activity (distance walked/unit time) was calculated. Odors with a vapor pressure <0.5 Torr were not measured in this assay due to practical constraints in handling the volume of odor needed to generate 18% SV. The odor concentration in ppm to which the animals were exposed was calculated by running the odor delivery system for an extended period of time and measuring the cumulative mass loss of the odor in the gas washer. This was converted to odor mass loss/minute and subsequently to ppm by considering the volume of the air flowing through the setup in one minute as measured by the flow meter.

Stationary Odor Source Assay

Over the course of the experiment a steep odor gradient that changed over time was established (Fig. S2 *B*). For each set of experiments the control response to paraffin oil was measured and set to zero for comparison. Recording started 30-60 seconds after flies were introduced into the arenas.

For each individual comparison in Fig. 5, the Type I error rate is 1:20. In Fig. 5, we compared the mutant to control genotypes independently to rule out non-specific genetic effects. If we pool both control genotypes or both mutant strains in (Fig. 5 *B*), the difference between control and mutant in the three cases marked with an asterisk is highly significant [p=0.0091 in (Fig. 5 *A*) and p=0.0060 and p=0.0022 in (Fig. 5 *B*)].

Odor Cross-Adaptation

Flies were transferred from the pre-exposure Petri dish to the stationary odor source assay arena containing 5 µl of undiluted test odor. Immediately thereafter the position of the fly was recorded for 3 minutes and the distance to the odor source was calculated. 54 such cross-adaptation experiments are included in the analysis (see also Fig. S8 *A*).

Human Olfactory Psychophysics

All subjects gave informed consent to participate in this study and were tested in a well-ventilated room of the Rockefeller University Hospital Outpatient Unit. Subjects were allowed as much time as desired to make both the intensity and similarity judgments. Most subjects completed both tasks within 30 minutes. Vials contained 1 ml of the respective odor. Subjects were unaware of the contents of the vials and the purpose of the study. Subjects were given minimal instructions prior to the experiments. For odor intensity judgments: "Please put these vials in order according to their intensity, with the

weakest odor on the left and the strongest odor on the right." For odor similarity judgments: "Please place the vials in groups on the table so that each group contains odors that are similar. Form as many groups as you feel necessary. Groups can be of any size." Each subject worked through the experiments in the same sequence (intensity rating before similarity grouping and lower concentrations first). Subjects were allowed to assess the same odor vials repeatedly to compare them with new vials. Each of the rankings and groupings is therefore the result of multiple pairwise-comparisons and transitivity assumptions. The purpose of allowing the repeated assessments is to minimize the influence of odor memory.

For intensity rating, the subjects separately rated the perceived intensity of homologous series of aldehydes, acetates, and alcohols. Each group of odors was tested at three concentrations (undiluted; 1/100; 1/1000). The average rank across these three concentrations is shown in Fig. 6 *A*-*C*. For similarity rating, testing was repeated at three concentrations (undiluted; 1/100; 1/1000), and results were pooled as there was no systematic effect of concentration on the results.

Quantifying Structural Similarities

The Tanimoto distances of fingerprint descriptors were calculated by Sybyl7.0 (Tripos, Inc) with equal weights of 2D fingerprints and atom pair distances. Molecular clustering was carried out by Dr. Lei Shi of the Institute for Computational Biomedicine, Weill Medical College of Cornell University. Trees of behavioral and structural similarities were constructed with Clustering Calculator (http://www2.biology.ualberta.ca/jbrzusto/cluster.php) and TreeToy (http://www2.biology.ualberta.ca/jbrzusto/TreeToy.php).

peak-plateau			
1-hexanol	D-limonene	L-limonene	ethyl hexanoate
2-hexanol	1-pentanol	cyclohexanone	3-hexanol
heptanal	2-heptanone	propyl butyrate	isoamyl acetate
2-pentanol	1-butanol	ethylbenzene	hexanal
ethyl butyrate	1-propanol	toluene	propyl acetate
ethyl acetate	2-butanone	acetone	methyl acetate
peak			
benzyl acetate	heptane	1-ethanol	hexane
plateau			
hexyl butyrate	nonanal	1-methylcyclohexanol	2-octanone
octanal	pentyl acetate	methyl hexanoate	propionic acid
anisole	butyl acetate	acetic acid	carbon dioxide
constant increase			
benzaldehyde	furfural	(E)-2-hexenal	pentanal

Table S1. Temporal dynamics in the odor flow assay. Responses to the 44 odors eliciting a response in the odor flow assay can be grouped into four response types (peak-plateau: highest activity 0-30 sec after odor onset, no return to baseline; peak: highest activity 0-30 sec, return to baseline; plateau: highest activity 30-150 sec; constant increase: highest activity after 150 sec).

odor molecule	inhibits % of ORs	activates % of ORs	found in % of fruits	odor quality
acetic acid	4	0	70	Pungent, stinging sour odor, unpleasant when concentrated, less repulsive when diluted below 15% in water (5). pungent, stingingly sour (6).
acetone	21	4	45	Light ethereal-nauseating and powerful odor of very poor tenacity. Irritant at high concentration, rather pleasant in dilution (5). light ethereal, nauseating (6).
acetophenone	17	21	42	Pungent-sweet odor, in dilution resembling that of hawthorn or a harsh orange-blossom type (5). aromatic, fragrant, almond (7). sweet, floral, wallflower-like (6).
anisole	nd	nd	0	Powerful and harsh, yet very sweet odor, rather chemical and not reminiscent of any natural material, except perhaps remotely of Anise. Its odor is often classified as "anisic", but the author finds that this term would not be used by perfumers (5). chemical, gasoline (solvent), paint (7).
benzaldehyde	17	25	79	Powerful sweet odor, reminiscent of freshly crushed bitter Almonds (5). almond, aromatic, fragrant (7). almond-, wood bark-like (6).
benzyl acetate	nd	nd	39	Powerful but "thin", sweet floral, fresh and light, fruity odor reminiscent of Jasmin, Gardenia, Muguet, Lily and other flowers. Poor tenacity (5). floral, jasmin-, lily-like (6).
2,3-butanediol	17	13	3	chemical, heavy, sickening (7).
1-butanol	8	29	73	Mild "fusel"-like odor, more volatile and more choking than fusel oil itself. Although somewhat winey in character, its odor is really nondescript, rather "chemical" (5). sweet, sickly (6).
2-butanone	8	17	33	Ethereal, slightly nauseating odor, not exactly pleasant (5). ethereal (6).
butyl acetate	13	46	61	Very diffusive, etheral-fruity, pungent odor, reminiscent of many kinds of (ripe and over-ripe) fruit. Very poor tenacity. The odor is often described as resembling that of Pear, Banana, Strawberry, etc. but it may be closer to Pear than to any other single fruit (5). ethereal, fruity, pear-like (6).
butyl butyrate	nd	nd	33	Fresh and sweet-fruity, powerful and rather diffusive odor, reminiscent of Banana (over-ripe) and Pineapple (5). fresh, sweet, fruity (6).
carbon dioxide	nd	nd	0 *	* although carbon dioxide is not a component of fruit odors it is released by all fruits during decomposition
D-carvone	nd	nd	24	Warm-herbaceous, breadlike, spicy and slightly floral odor, reminiscent of Caraway seed or Dill seed (5). (carvone:) minty (peppermint), fragrant, cool (cooling) (7). herbaceous, bread-, dill seed-like (6).

odor molecule	inhibits % of ORs	activates % of ORs	found in % of fruits	odor quality
L-carvone	nd	nd	24	Warm-herbaceous, breadlike, penetrating and diffusive odor, somewhat spicy, in extreme dilution also floral, overall reminiscent of Spearmint oil (rectified) (5). (carvone:) minty (peppermint), fragrant, cool (cooling) (7). herbaceous, bread-, dill seed-like (6).
citral	nd	nd	21	Widely used as a powerful Lemon-fragrance chemical…(5). (geranial:) lemon, fruity (citrus), fragrant (7). intensely lemon-like (6).
cyclohexanol	nd	nd	0	Warm- camphoraceous odor (5). medicinal, etherish (anaesthetic), disinfectant (carbolic) (7).
cyclohexanone	nd	nd	6	Powerful, minty-camphoraceous, "cool" and "solvent-like" odor, generally described as "unpleasant" (by non-professionals) (5). camphoraceous, mint-like (6).
decanal	nd	nd	39	Penetrating and very powerful, sweet-waxy, Orange-peel-like odor. In extreme dilution refreshing, Citrus-peel-like (5). sweet, waxy, orange peel-like (6).
ethanol	0	4	76	The odor is sweet-ethereal, mild (in view of its low boiling point which tempt us to expect a very diffusive odor) and it is perceptible in aqueous solutions down to about 12% alcohol and room temperature (5). sickly, sweet, ethereal (6).
ethyl acetate	0	21	97	Pleasant, ethereal-fruity, Brandy-like odor, somewhat nauseating in high concentration (5). ethereal, fruity, banana-like (6).
ethyl benzene	nd	nd	21	Sweet, but somewhat "gassy" odor. If at all reminiscent of any natural material, it would be a Hyacinth-type of gassy sweetness (5). sweet, gassy (6).
ethyl butyrate	0	46	64	Powerful, ethereal-fruity odor suggestive of Banana and Pineapple, and very diffusive (5). fruity (other than citrus), sweet, fragrant (7). ethereal, fruity, banana-like (6).
2-ethyl fenchol	nd	nd	0	
ethyl hexanoate	25	21	58	Powerful, diffusive, fruity-winey odor, suggestive of Apple, Banana, Pineapple, with a slightly floral undertone (5). fruity, floral, wine-like (6).
eugenol	21	8	39	Powerful, warm-spicy, rather dry and almost sharp odor, drier and harder than that of Clove bud oil, less peppery-woody than that of Clove leaf oil (5). clove, spicy, fragrant (7). warm, spicy, burning (6).
eugenol methyl ether	nd	nd	3	Peculiar musty-tealike, warm and mildly spicy, slightly earthy, tenacious odor. The warm notes are mostly herbaceous, the spicy notes very subdued, and there is an overall resemblance to notes of Ginger and Tea (5).
L-fenchone	nd	nd	6	Warm-camphoraceous, powerful and diffusive, basically sweet odor (5).

odor molecule	inhibits % of ORs	activates % of ORs	found in % of fruits	odor quality
furfural	8	25	55	Pungent, but sweet, bread-like, caramellic, Cinnamon-Almond-like odor of poor tenacity (5). sweet, fragrant, woody (resinous) (7). cold meat, gravy-, coconut-like (6).
geranyl acetate	8	8	6	Sweet, fruity-floral, rosy, somewhat green and remotely Lavender-like odor of moderate tenacity (5).
heptanal	nd	nd	33	Very powerful and diffusive oily-fatty, "rancid" odor. Penetrating and pungent at high concentration, almost fruity, "fermented-fruit"-like in extreme dilution (5). oily (fatty), woody (resinous), sickening (7). powerful diffusive, oily, fatty (6).
heptane	nd	nd	6	Sweet-ethereal, diffusive odor of poor tenacity (5).
1-heptanol	nd	nd	42	Fresh and light, green fatty, winey and sap-like odor of poor tenacity (5). fragrant, aromatic, heavy (7). fresh, light green, nutty (6).
2-heptanone	0	38	52	Penetrating, fruity-spicy light and volatile odor with resemblance to the fresher notes in Cinnamon bark. However, it is generally classified as a rather "chemical" odor, and only in extreme dilution it displays the more attractive spicy fragrance (5). ethereal, fruity, pungent (6).
hexanal	4	17	76	Very powerful, penetrating, fatty green, grassy odor. In extreme dilution more reminiscent of freshly cut grass und unripe fruits (Apple and Plum). The acrid note of the concentrated material resembles that of rancid Butter (5). herbal (green, cut grass), woody (resinous), oily (fatty) (7). fatty green, green grass-like (6).
hexane	nd	nd	9	ethereal, kerosene-like (6)
hexanoic acid	8	4	64	Heavy, acrid-acid, fatty-rancid odor, often described as "sweat-like". (5). sour (vinegar), sickening, sweaty (7). fatty, rancid, sweat-like (6).
1-hexanol	4	67	91	Somewhat "chemical"-winey, slightly fatty and fruity odor, weaker than Amyl alcohol, but resembling that material, except that Hexanol seems fattier and fruitier (5). aromatic, fragrant, woody (resinous) (7). fatty, fruity, wine-like (6).
2-hexanol	nd	nd	15	
3-hexanol	nd	nd	12	alcoholic, etherish (anaesthetic), medicinal (7).
(E)-2-hexenal	4	25	67	Powerful green-fruity, pungent, vegetable-like odor, pungent in high concentrations, almost acrylic-sharp, but pleasant fruity and fresh-green in dilutions below 0.1% (5). sweet, fragrant, almond (7). green, fruity, pungent, vegetable-like (6).
hexyl acetate	17	25	58	Sweet fruity Berry-and-Pear-like odor, milder than Amyl acetate, less natural, slightly floral and green (5). sweet, fruity, berry-, pear-like (6).

odor molecule	inhibits % of ORs	activates % of ORs	found in % of fruits	odor quality
hexyl butyrate	0	13	30	Powerful, fruity, heavy odor, reminiscent not of one particular fruit, but of a "melange" of unripe fruits (5). powerful-fruity (6).
isoamyl acetate	13	42	45	Pronounced fruity-fresh odor, sweet but slightly nauseating. In dilution reminiscent of Pear, Banana, Apple. Very volatile (5). fresh, pear, banana-like (6).
D-limonene	nd	nd	64	Fresh, light and sweet citrusy odor with strong resemblance to Orange peel oil (5). (limonene:) fruity (citrus), lemon, orange (7). sweet citrusy, lemon-like (6).
L-limonene	nd	nd	64	… refreshing, light, very clean odor, not reminiscent of Citrus fruits in particular, and not recalling any specific Pine or Mint (5). (limonene:) fruity (citrus), lemon, orange (7). sweet citrusy, lemon-like (6).
L-linalool	nd	nd	76	Light and refreshing, floral-woody odor with a faintly citrusy note (5). fragrant, light, aromatic (7). refreshing, floral, woody (6).
menthol	nd	nd	3	Odor very similar to that of (L-)Menthol, but somewhat more woody, not quite as sweet, and the cooling sensation is not perceptible at the same low concentration as it is in (L-)Menthol. (L-Menthol: Refreshing, light, diffusive odor with a sweet pungency. Characteristic resemblance to main odor of Peppermint, and a cooling effect upon the mucous membrane...) (5). (menthol:) cool (cooling), minty (peppermint), medicinal (7).
methanol	4	4	39	Very pure Methyl alcohol has only a mild odor, but commercial grade Methyl alcohol will usually display a somewhat pungent-gassy topnote followed by a sweeter ethereal odor of very poor tenacity (5). pungent, ethereal (6).
methyl acetate	13	8	30	Sweet, and extremely diffusive, ethereal-fruity odor of very poor tenacity. In fact, one must hurry to smell it from a perfume blotter before it is completely evaporated (5). sweet, ethereal, diffusive (6).
methyl benzoate	13	13	48	Pungent, heavy-sweet, deep-floral odor of moderate to poor tenacity. Its fruity undertones resemble Prunes and Blackcurrant, while the heavy floral tones recall notes of Tuberose and Longoza (5). pungent, heavy-sweet, floral (6).
1-methylcyclohexanol	nd	nd	0	
methyl hexanoate	21	25	45	Powerful ethereal and diffusive, sweet odor of Pineapple-Apricot type. Poor tenacity (5). pineapple-, apricot-like (6).
methyl salicylate	8	4	39	Pungent-sweet, fruity-rooty odor with burning sensation at high concentration… the ester will obviously have very different odor/flavor descriptions in different countries (5). minty (peppermint), fragrant, aromatic (7). pungent, sweet, fruity (6).
nonanal	nd	nd	48	Very powerful and diffusive fatty-floral, waxy odor of moderate tenacity. In proper dilution, the fatty notes become more pleasant, floral-waxy, more rosy and sweet, fresh as Neroli (5).
octanal	nd	nd	30	Powerful, and in undiluted state harsh-fatty, penetrating odor. In extreme dilution sweet, Orange-like, slightly fatty, Honey-like and of moderate to poor tenacity (5).

odor molecule	inhibits % of ORs	activates % of ORs	found in % of fruits	odor quality
3-octanol	nd	nd	9	Sweet and powerfully herbaceous, oily-nutty and warm odor. Milder and not as harsh as that of 2-Octanol, much warmer than 1-Octanol. Moderate to poor tenacity (5).
2-octanone	nd	nd	21	Description range from "harsh-gassy-metallic" to floral-green-fruity. The author prefers to give a general description of a good commercial grade of the ketone, suitable for perfumery. Pleasant, floral, but bitter-green, slightly musty-herbaceous and "unripe-Apple"-fruity odor of moderate to poor tenacity (5). floral, bitter, green (7).
3-octanone	nd	nd	15	Pungent, herbaceous-fruity, warm odor, somewhat spicy-buttery with distinct resemblance to the topnotes in Lavender oil (5). spicy, butter-, lavender oil-like (6).
1-octen-3-ol	13	38	39	Very powerful, sweet-earthy, almost buttery and fungus- or fermentation-like odor with a strong herbaceous note, suggestive of Lavender-Lavandin-Rose and Hay. Somewhat acrid-chemical undertone which is hardly perceptible at proper (high) dilution (5). musty (earthy, moldy), mushroom, woody (resinous) (7). sweet, ethereal (6).
pentanal	17	17	30	Very powerful and diffusive, penetrating, acrid-pungent odor, in the concentrated form repulsively choking, cough-provoking. In extreme dilution dry-fruity, musty, Nut-like (5). powerful diffusive, choking, penetrating (6).
pentanoic acid	4	4	39	Very powerful and penetrating, diffusive, acid odor, pungent when undiluted, but more unpleasant when diluted. In fact it becomes more animal- and perspiration-like in dilution. Only in extreme dilution the odor becomes again more pleasant, fruity, warm (5). sickening, putrid (foul, decayed), rancid (7). animal persipiration-like (6).
1-pentanol	4	67	82	Somewhat harsh, chemical odor, reminiscent of Fusel oil, but not as heavy, however, more penetrating, nauseating, cough-provoking (5). harsh, fusel oil-like (6).
2-pentanol	4	54	45	Winey-ethereal, rather choking odor, somewhat drier than that of commercial "Amyl alcohol" (5). ethereal, wine-like (6).
pentyl acetate	4	42	39	
(+) alpha-pinene	nd	nd	45	Its odor is warm-resinous, refreshing Pine-like… (5). (pinene:) woody (resinous), light, turpentine (pine oil) (7). floral, resinous, pine-, cedar wood-like (6).
piperonal	nd	nd	3	Very sweet floral, warm slightly spicy and tenacious odor, sometimes described as "Cherry-like" (American type Cherry) (5).
1-propanol	8	17	45	Highly purified Propyl alcohol has only a very faint odor… (5). alcoholic, nauseating (6).
propionic acid	0	0	30	Pungent sour odor reminiscent of sour Milk, Cheese or sour Butter (5). pungent, sour milk-like (6).

odor molecule	inhibits % of ORs	activates % of ORs	found in % of fruits	odor quality
propyl acetate	8	46	30	Diffusive and fresh, ethereal-fruity, Pear-like odor of poor tenacity (5). diffusive, ethereal, pear, raspberry-like (6).
propyl butyrate	nd	nd	18	Heavy-fruity, Pineapple-like ethereal-pungent odor of poor tenacity (5). sour (vinegar), sickening, rancid (7). sweet, fruity, pineapple-like (6).
alpha-terpinene	nd	nd	18	Refreshing, lemony-citrusy odor of poor tenacity (5). refreshing, lemon-, citrus-like (6).
toluene	nd	nd	39	Pure toluene has a sweet-gassy odor, milder than that of Benzene (5). low: light, chemical, woody (resinous); high: light, fragrant, aromatic (7). ethereal (6).
vanillin	nd	nd	33	Intensely sweet and very tenacious creamy Vanilla-like odor… A common remark from laymen, smelling highly diluted Vanillin is "Chocolate"…(5). vanilla, sweet, chocolate (7). intensely sweet, vanilla-like (6).

Table S2. Odor characteristics. The percentage of *Drosophila* ORs (from a set of 24 ORs) inhibited or activated by each odor is shown in columns two and three (8). Column four shows in what percentage of fruits (from a set of 33 fruits; see **Table S3**) each odor was found (9). The description of odor quality from three different sources is cited in column 5 (5-7). Only the three most frequently used descriptors out of 146 from the work of Dravnieks are listed here (7).

	apple	apricot	arctic bramble	beli fruit	bilberry
acetic acid					
propionic acid					
pentanoic acid					
hexanoic acid					
methanol					
ethanol					
1-propanol					
1-butanol					
1-pentanol					
2-pentanol					
1-hexanol					
2-hexanol					
3-hexanol					
1-heptanol					
3-octanol					
1-octen-3-ol					
2,3-butanediol					
2-ethyl fenchol					
cyclohexanol					
1-methylcyclohexanol					
pentanal					
hexanal					
heptanal					
octanal					
nonanal					
decanal					
(E)-2-hexenal					
hexane					
heptane					
acetophenone					
anisole					
benzaldehyde					
benzyl acetate					
ethyl benzene					
eugenol					
eugenol methyl ether					
furfural					
methyl salicylate					
methyl benzoate					
piperonal					
toluene					
vanillin					
carbon dioxide					
methyl acetate					
ethyl acetate					
propyl acetate					
butyl acetate					
pentyl acetate					
hexyl acetate					
isoamyl acetate					
ethyl butyrate					
propyl butyrate					
butyl butyrate					
hexyl butyrate					
methyl hexanoate					
ethyl hexanoate					
acetone					
2-butanone					
2-heptanone					
2-octanone					
3-octanone					
cyclohexanone					
L-fenchone					
(+) alpha-pinene					
citral					
D-carvone					
L-carvone					
D-limonene					
L-limonene					
geranyl acetate					
L-linalool					
menthol					
alpha-terpinene					

	blueberry	blackberry	blackcurrant	carambola	cashew apples
acetic acid	■	■			
propionic acid					
pentanoic acid	■				
hexanoic acid	■	■			
methanol			■		
ethanol	■	■	■		
1-propanol			■		
1-butanol	■		■		
1-pentanol	■	■		■	
2-pentanol			■		
1-hexanol	■	■	■	■	
2-hexanol			■		
3-hexanol					
1-heptanol	■	■			
3-octanol					
1-octen-3-ol	■	■	■		
2,3-butanediol					
2-ethyl fenchol					
cyclohexanol					
1-methylcyclohexanol					
pentanal		■	■		
hexanal	■	■	■	■	■
heptanal		■		■	
octanal		■		■	
nonanal		■	■	■	■
decanal		■	■		
(E)-2-hexenal		■	■		■
hexane					
heptane					
acetophenone		■		■	■
anisole					
benzaldehyde	■	■	■	■	■
benzyl acetate					
ethyl benzene					
eugenol	■	■			
eugenol methyl ether					
furfural			■		
methyl salicylate			■	■	
methyl benzoate		■	■	■	■
piperonal	■				
toluene	■	■			■
vanillin	■	■			
carbon dioxide					
methyl acetate			■		
ethyl acetate	■	■	■	■	■
propyl acetate					
butyl acetate		■	■		
pentyl acetate		■	■		■
hexyl acetate	■	■	■		
isoamyl acetate		■	■		
ethyl butyrate			■	■	■
propyl butyrate					
butyl butyrate		■			
hexyl butyrate					
methyl hexanoate		■		■	■
ethyl hexanoate		■		■	■
acetone			■		
2-butanone		■	■		
2-heptanone		■			
2-octanone					
3-octanone		■	■		
cyclohexanone					
L-fenchone					
(+) alpha-pinene					
citral					
D-carvone					
L-carvone					
D-limonene					
L-limonene					
geranyl acetate					
L-linalool					
menthol					
alpha-terpinene			■		■

	cherimoya fruit	cherry	cloudberry	cowberry	cranberry
acetic acid					
propionic acid					
pentanoic acid					
hexanoic acid					
methanol					
ethanol					
1-propanol					
1-butanol					
1-pentanol					
2-pentanol					
1-hexanol					
2-hexanol					
3-hexanol					
1-heptanol					
3-octanol					
1-octen-3-ol					
2,3-butanediol					
2-ethyl fenchol					
cyclohexanol					
1-methylcyclohexanol					
pentanal					
hexanal					
heptanal					
octanal					
nonanal					
decanal					
(E)-2-hexenal					
hexane					
heptane					
acetophenone					
anisole					
benzaldehyde					
benzyl acetate					
ethyl benzene					
eugenol					
eugenol methyl ether					
furfural					
methyl salicylate					
methyl benzoate					
piperonal					
toluene					
vanillin					
carbon dioxide					
methyl acetate					
ethyl acetate					
propyl acetate					
butyl acetate					
pentyl acetate					
hexyl acetate					
isoamyl acetate					
ethyl butyrate					
propyl butyrate					
butyl butyrate					
hexyl butyrate					
methyl hexanoate					
ethyl hexanoate					
acetone					
2-butanone					
2-heptanone					
2-octanone					
3-octanone					
cyclohexanone					
L-fenchone					
(+) alpha-pinene					
citral					
D-carvone					
L-carvone					
D-limonene					
L-limonene					
geranyl acetate					
L-linalool					
menthol					
alpha-terpinene					




	dalieb	feijoa	guava	kiwifruit	mango
acetic acid	■		■		■
propionic acid	■				
pentanoic acid	■		■		■
hexanoic acid	■		■		■
methanol	■		■		
ethanol	■		■	■	■
1-propanol	■				
1-butanol	■		■		■
1-pentanol	■		■	■	■
2-pentanol			■		■
1-hexanol		■	■	■	■
2-hexanol					
3-hexanol					
1-heptanol			■	■	
3-octanol		■			
1-octen-3-ol			■		
2,3-butanediol					
2-ethyl fenchol					
cyclohexanol					
1-methylcyclohexanol					
pentanal			■	■	
hexanal			■	■	■
heptanal			■		
octanal					
nonanal					
decanal			■		
(E)-2-hexenal		■	■		■
hexane			■		
heptane					
acetophenone					■
anisole					
benzaldehyde			■	■	■
benzyl acetate			■		
ethyl benzene			■	■	
eugenol			■		
eugenol methyl ether					
furfural		■	■	■	■
methyl salicylate		■		■	
methyl benzoate		■	■	■	
piperonal					
toluene			■	■	■
vanillin		■	■		
carbon dioxide					
methyl acetate			■	■	
ethyl acetate	■	■	■	■	■
propyl acetate			■		
butyl acetate	■		■		■
pentyl acetate					
hexyl acetate			■		■
isoamyl acetate		■	■		■
ethyl butyrate	■	■	■	■	■
propyl butyrate				■	
butyl butyrate	■				■
hexyl butyrate					
methyl hexanoate			■	■	
ethyl hexanoate		■	■	■	■
acetone			■		■
2-butanone			■		
2-heptanone		■			■
2-octanone					
3-octanone		■	■		
cyclohexanone					
L-fenchone					
(+) alpha-pinene			■	■	■
citral			■		
D-carvone			■	■	
L-carvone			■	■	
D-limonene			■	■	■
L-limonene			■	■	■
geranyl acetate					
L-linalool		■	■	■	■
menthol					
alpha-terpinene					




	mountain papaya	papaya	passion fruit	peach	pear
acetic acid	■	■	■	■	
propionic acid		■			
pentanoic acid		■	■	■	
hexanoic acid	■	■	■	■	
methanol		■	■	■	■
ethanol	■	■	■	■	■
1-propanol		■	■	■	■
1-butanol	■	■	■	■	■
1-pentanol	■	■	■	■	■
2-pentanol	■	■	■		
1-hexanol	■	■	■	■	■
2-hexanol		■			
3-hexanol		■			
1-heptanol		■	■		■
3-octanol					
1-octen-3-ol	■	■	■		
2,3-butanediol			■		
2-ethyl fenchol					
cyclohexanol					
1-methylcyclohexanol					
pentanal					
hexanal			■	■	■
heptanal				■	
octanal					
nonanal				■	
decanal	■	■			
(E)-2-hexenal				■	■
hexane		■			
heptane		■			
acetophenone	■	■			
anisole					
benzaldehyde	■	■	■	■	
benzyl acetate	■	■	■		
ethyl benzene	■	■			
eugenol		■			
eugenol methyl ether					
furfural	■	■	■	■	
methyl salicylate			■	■	
methyl benzoate	■				
piperonal					
toluene		■	■		
vanillin			■		
carbon dioxide					
methyl acetate			■	■	■
ethyl acetate	■	■	■	■	■
propyl acetate	■			■	■
butyl acetate	■	■	■	■	■
pentyl acetate				■	■
hexyl acetate	■	■	■	■	■
isoamyl acetate	■	■			■
ethyl butyrate	■	■	■	■	■
propyl butyrate	■		■		
butyl butyrate	■	■	■		
hexyl butyrate	■	■	■		
methyl hexanoate	■	■	■		
ethyl hexanoate	■	■	■	■	
acetone	■	■	■		
2-butanone		■			
2-heptanone	■	■	■	■	
2-octanone	■	■			
3-octanone					
cyclohexanone	■	■			
L-fenchone					
(+) alpha-pinene					
citral					
D-carvone					
L-carvone					
D-limonene					
L-limonene					
geranyl acetate					
L-linalool					
menthol					
alpha-terpinene					

	pepino	plum	quince	raspberry	red currants
acetic acid		■	■	■	
propionic acid				■	
pentanoic acid				■	
hexanoic acid		■		■	
methanol		■	■	■	
ethanol	■	■	■	■	
1-propanol		■	■	■	
1-butanol	■	■	■	■	■
1-pentanol		■	■	■	■
2-pentanol					■
1-hexanol	■	■	■	■	■
2-hexanol					
3-hexanol					
1-heptanol		■		■	
3-octanol					
1-octen-3-ol		■			■
2,3-butanediol					
2-ethyl fenchol					
cyclohexanol					
1-methylcyclohexanol					
pentanal					■
hexanal	■	■	■	■	■
heptanal		■	■		
octanal		■	■		■
nonanal	■	■	■		■
decanal		■			■
(E)-2-hexenal	■	■	■	■	■
hexane					
heptane					
acetophenone		■		■	
anisole					
benzaldehyde		■	■	■	■
benzyl acetate		■			
ethyl benzene		■			
eugenol			■		
eugenol methyl ether					
furfural		■	■	■	
methyl salicylate		■			
methyl benzoate				■	
piperonal					
toluene			■		■
vanillin					
carbon dioxide					
methyl acetate				■	
ethyl acetate	■	■	■	■	
propyl acetate	■	■	■		
butyl acetate	■	■	■	■	
pentyl acetate	■	■		■	
hexyl acetate	■	■	■	■	
isoamyl acetate	■	■	■	■	
ethyl butyrate		■	■		
propyl butyrate		■			
butyl butyrate		■	■		
hexyl butyrate		■	■		
methyl hexanoate		■	■		
ethyl hexanoate		■		■	
acetone			■	■	
2-butanone	■	■	■		
2-heptanone			■	■	
2-octanone			■		
3-octanone		■			
cyclohexanone					
L-fenchone					
(+) alpha-pinene		▒			
citral		▒	▒	▒	
D-carvone		▒			
L-carvone		▒			
D-limonene		▒	▒		▒
L-limonene		▒	▒		▒
geranyl acetate					
L-linalool		▒	▒	▒	
menthol				■	
alpha-terpinene	■				

	strawberry	wild raspberry	wild strawberry
acetic acid	■	■	■
propionic acid	■	■	■
pentanoic acid	■		
hexanoic acid	■	■	■
methanol	■		
ethanol	■	■	■
1-propanol	■		
1-butanol	■		
1-pentanol	■	■	■
2-pentanol	■		
1-hexanol	■	■	■
2-hexanol	■		
3-hexanol	■		
1-heptanol	■		■
3-octanol	■		
1-octen-3-ol	■		
2,3-butanediol			
2-ethyl fenchol			
cyclohexanol			
1-methylcyclohexanol			
pentanal			
hexanal	■	■	■
heptanal	■		
octanal			
nonanal	■		
decanal	■		
(E)-2-hexenal	■	■	
hexane			
heptane			
acetophenone	■		
anisole			
benzaldehyde	■	■	■
benzyl acetate	■	■	■
ethyl benzene			
eugenol	■	■	■
eugenol methyl ether			
furfural	■		
methyl salicylate	■		■
methyl benzoate			■
piperonal			
toluene			
vanillin		■	■
carbon dioxide			
methyl acetate	■		
ethyl acetate	■	■	■
propyl acetate	■		
butyl acetate	■		■
pentyl acetate	■		
hexyl acetate	■		■
isoamyl acetate	■		
ethyl butyrate	■		■
propyl butyrate	■		
butyl butyrate	■		
hexyl butyrate	■		■
methyl hexanoate	■		■
ethyl hexanoate	■		■
acetone			
2-butanone	■		
2-heptanone	■		■
2-octanone	■		
3-octanone			
cyclohexanone			
L-fenchone			
(+) alpha-pinene	▒	▒	
citral			
D-carvone			
L-carvone			
D-limonene	▒	▒	
L-limonene	▒	▒	
geranyl acetate			
L-linalool	▒	▒	▒
menthol			
alpha-terpinene			

Table S3. Volatile chemicals in fruits. The table entries are shaded to indicate whether compounds are found in fruit (9) using the following scheme: dark orange: chemical found in the fruit; light orange: chemical found in the fruit but enantiomer not specified; white: chemical not found in fruit. Images are from http://commons.wikimedia.org and are either in the Public Domain or are free content under the GNU Free Documentation License or the GNU General Public License.

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