In [4]:

```
import mglearn
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
import sklearn

from sklearn.datasets import load_breast_cancer
from sklearn.model_selection import train_test_split
from sklearn.neighbors import KNeighborsClassifier
```

```
C:₩Anaconda₩lib₩site-packages₩sklearn₩externals₩six.py:31: DeprecationWarning: The
module is deprecated in version 0.21 and will be removed in version 0.23 since w
e've dropped support for Python 2.7. Please rely on the official version of six (h
ttps://pypi.org/project/six/).
  "(https://pypi.org/project/six/).", DeprecationWarning)
C:₩Anaconda₩lib₩site-packages₩sklearn₩externals₩joblib₩__init__.py:15: Deprecation
Warning: sklearn.externals.joblib is deprecated in 0.21 and will be removed in 0.2
3. Please import this functionality directly from joblib, which can be installed w
ith: pip install joblib. If this warning is raised when loading pickled models, yo
u may need to re-serialize those models with scikit-learn 0.21+.
  warnings.warn(msg, category=DeprecationWarning)
```

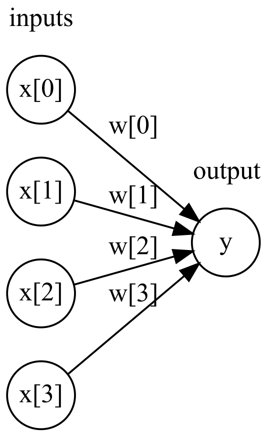
In [5]:

```
from matplotlib import font_manager, rc

plt.rcParams['axes.unicode_minus'] = False
font_name = font_manager.FontProperties(fname="C:/Windows/Fonts/malgun.ttf").get_name()
rc('font', family=font_name)

plt.rcParams['axes.unicode_minus'] = False
```

In [8]:

```
mglearn.plots.plot_logistic_regression_graph()
```

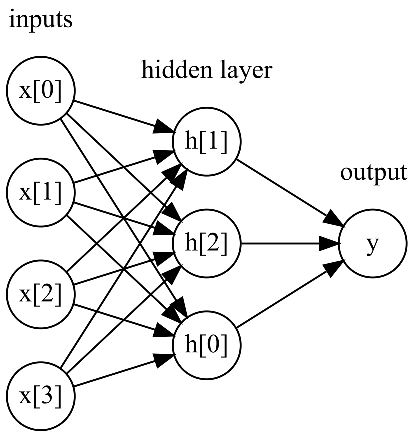
Out[8]:



In [9]:

```
mglearn.plots.plot_single_hidden_layer_graph()
```

Out[9]:

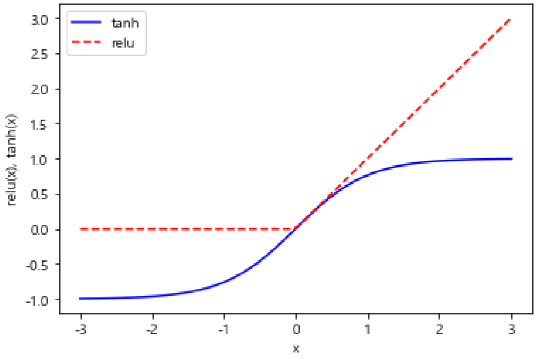


In [11]:

```
line = np.linspace(-3, 3, 100)
plt.plot(line, np.tanh(line), label="tanh", color="blue")
plt.plot(line, np.maximum(line, 0), linestyle='--', label="relu", color="red")
plt.legend(loc="best")
plt.xlabel("x")
plt.ylabel("relu(x), tanh(x)")
```

Out[11]:

```
Text(0, 0.5, 'relu(x), tanh(x)')
```



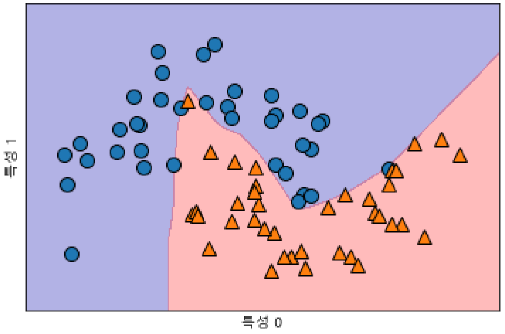
신경망 튜닝

In [12]:

```
from sklearn.neural_network import MLPClassifier
from sklearn.datasets import make_moons

X, y = make_moons(n_samples=100, noise=0.25, random_state=3)

X_train, X_test, y_train, y_test = train_test_split(X, y, stratify=y,
                                                    random_state=42)

mlp = MLPClassifier(solver='lbfgs', random_state=0).fit(X_train, y_train)
mglearn.plots.plot_2d_separator(mlp, X_train, fill=True, alpha=.3)
mglearn.discrete_scatter(X_train[:, 0], X_train[:, 1], y_train)
plt.xlabel("특성 0")
plt.ylabel("특성 1")
```

Out[12]:

```
Text(0, 0.5, '특성 1')
```

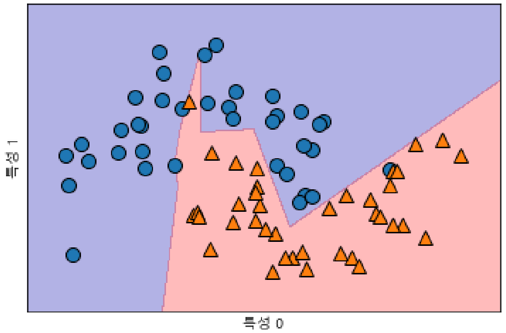


In [13]:

```
mlp = MLPClassifier(solver='lbfgs', random_state=0, hidden_layer_sizes=[10])
mlp.fit(X_train, y_train)
mglearn.plots.plot_2d_separator(mlp, X_train, fill=True, alpha=.3)
mglearn.discrete_scatter(X_train[:, 0], X_train[:, 1], y_train)
plt.xlabel("특성 0")
plt.ylabel("특성 1")
```

Out[13]:

```
Text(0, 0.5, '특성 1')
```

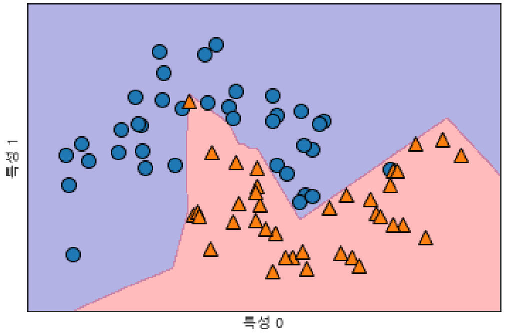


In [14]:

```
mlp = MLPClassifier(solver='lbfgs', random_state=0, hidden_layer_sizes=[10, 10])
mlp.fit(X_train, y_train)
mglearn.plots.plot_2d_separator(mlp, X_train, fill=True, alpha=.3)
mglearn.discrete_scatter(X_train[:, 0], X_train[:, 1], y_train)
plt.xlabel("특성 0")
plt.ylabel("특성 1")
```

Out[14]:

```
Text(0, 0.5, '특성 1')
```

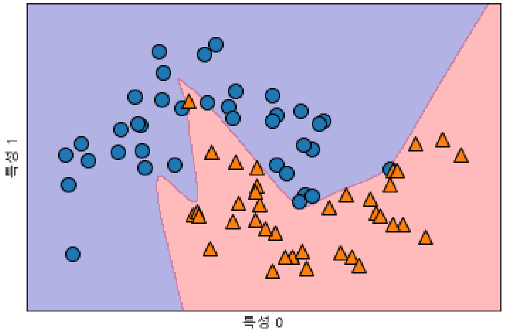


In [15]:

```
mlp = MLPClassifier(solver='lbfgs', activation='tanh',
                    random_state=0, hidden_layer_sizes=[10, 10])
mlp.fit(X_train, y_train)
mglearn.plots.plot_2d_separator(mlp, X_train, fill=True, alpha=.3)
mglearn.discrete_scatter(X_train[:, 0], X_train[:, 1], y_train)
plt.xlabel("특성 0")
plt.ylabel("특성 1")
```

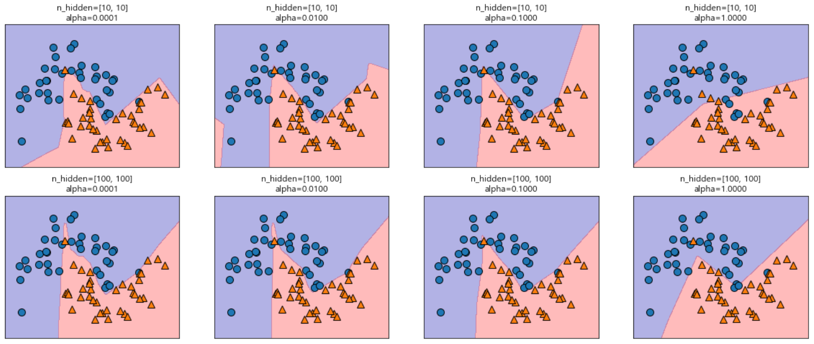
Out[15]:

```
Text(0, 0.5, '특성 1')
```



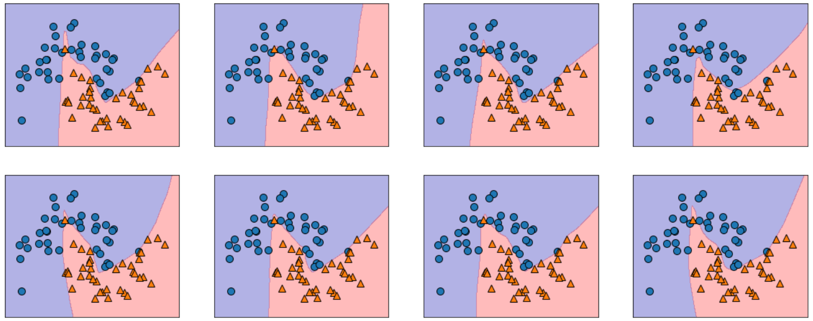
In [16]:

```
fig, axes = plt.subplots(2, 4, figsize=(20, 8))
for axx, n_hidden_nodes in zip(axes, [10, 100]):
    for ax, alpha in zip(axx, [0.0001, 0.01, 0.1, 1]):
        mlp = MLPClassifier(solver='lbfgs', random_state=0,
                            hidden_layer_sizes=[n_hidden_nodes, n_hidden_nodes],
                            alpha=alpha)
        mlp.fit(X_train, y_train)
        mglearn.plots.plot_2d_separator(mlp, X_train, fill=True, alpha=.3, ax=ax)
        mglearn.discrete_scatter(X_train[:, 0], X_train[:, 1], y_train, ax=ax)
        ax.set_title("n_hidden=[{}, {}]₩nalpha={:.4f}".format(
                      n_hidden_nodes, n_hidden_nodes, alpha))
```



In [17]:

```
fig, axes = plt.subplots(2, 4, figsize=(20, 8))
for i, ax in enumerate(axes.ravel()):
    mlp = MLPClassifier(solver='lbfgs', random_state=i,
                        hidden_layer_sizes=[100, 100])
    mlp.fit(X_train, y_train)
    mglearn.plots.plot_2d_separator(mlp, X_train, fill=True, alpha=.3, ax=ax)
    mglearn.discrete_scatter(X_train[:, 0], X_train[:, 1], y_train, ax=ax)
```



In [19]:

```
cancer = load_breast_cancer()
```

In [20]:

```
print("유방암 데이터의 특성별 최대값:₩n{}".format(cancer.data.max(axis=0)))
```

```
유방암 데이터의 특성별 최대값:
[2.811e+01 3.928e+01 1.885e+02 2.501e+03 1.634e-01 3.454e-01 4.268e-01
 2.012e-01 3.040e-01 9.744e-02 2.873e+00 4.885e+00 2.198e+01 5.422e+02
 3.113e-02 1.354e-01 3.960e-01 5.279e-02 7.895e-02 2.984e-02 3.604e+01
 4.954e+01 2.512e+02 4.254e+03 2.226e-01 1.058e+00 1.252e+00 2.910e-01
 6.638e-01 2.075e-01]
```

In [21]:

```
X_train, X_test, y_train, y_test = train_test_split(
    cancer.data, cancer.target, random_state=0)

mlp = MLPClassifier(random_state=42)
mlp.fit(X_train, y_train)

print("훈련 세트 정확도: {:.2f}".format(mlp.score(X_train, y_train)))
print("테스트 세트 정확도: {:.2f}".format(mlp.score(X_test, y_test)))
```

```
훈련 세트 정확도: 0.94
테스트 세트 정확도: 0.92
```

In [22]:

```
mean_on_train = X_train.mean(axis=0)
std_on_train = X_train.std(axis=0)

X_train_scaled = (X_train - mean_on_train) / std_on_train
X_test_scaled = (X_test - mean_on_train) / std_on_train

mlp = MLPClassifier(random_state=0)
mlp.fit(X_train_scaled, y_train)

print("훈련 세트 정확도: {:.3f}".format(mlp.score(X_train_scaled, y_train)))
print("테스트 세트 정확도: {:.3f}".format(mlp.score(X_test_scaled, y_test)))
```

```
훈련 세트 정확도: 0.991
테스트 세트 정확도: 0.965

C:₩Anaconda₩lib₩site-packages₩sklearn₩neural_network₩multilayer_perceptron.py:566:
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (200) reached and the
optimization hasn't converged yet.
  % self.max_iter, ConvergenceWarning)
```

In [23]:

```
mlp = MLPClassifier(max_iter=1000, alpha=1, random_state=0)
mlp.fit(X_train_scaled, y_train)

print("훈련 세트 정확도: {:.3f}".format(mlp.score(X_train_scaled, y_train)))
print("훈련 세트 정확도: {:.3f}".format(mlp.score(X_test_scaled, y_test)))
```

```
훈련 세트 정확도: 0.988
훈련 세트 정확도: 0.972
```

In [24]:

```
mlp.coefs_[0].std(axis=1), mlp.coefs_[0].var(axis=1)
```

Out[24]:

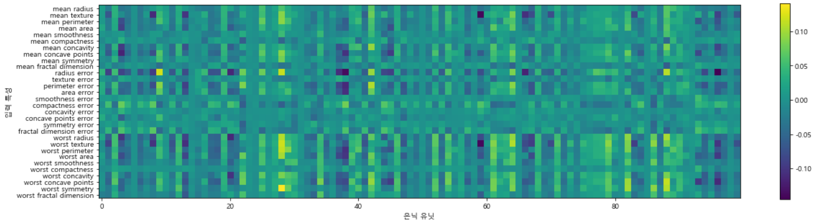
```
(array([0.02559193, 0.04066835, 0.03308025, 0.03081333, 0.01669964,
        0.01838658, 0.03626209, 0.04066151, 0.02432519, 0.01737967,
        0.05508384, 0.01659837, 0.04014836, 0.036805  , 0.0131538 ,
        0.03408178, 0.01182728, 0.015795  , 0.01424585, 0.02966082,
        0.04854174, 0.05185808, 0.04186009, 0.04332929, 0.03185674,
        0.01475534, 0.04066124, 0.04863656, 0.03751535, 0.0262638 ]),
 array([0.00065495, 0.00165391, 0.0010943 , 0.00094946, 0.00027888,
        0.00033807, 0.00131494, 0.00165336, 0.00059171, 0.00030205,
        0.00303423, 0.00027551, 0.00161189, 0.00135461, 0.00017302,
        0.00116157, 0.00013988, 0.00024948, 0.00020294, 0.00087976,
        0.0023563 , 0.00268926, 0.00175227, 0.00187743, 0.00101485,
        0.00021772, 0.00165334, 0.00236552, 0.0014074 , 0.00068979]))
```

In [25]:

```
plt.figure(figsize=(20, 5))
plt.imshow(mlp.coefs_[0], interpolation='none', cmap='viridis')
plt.yticks(range(30), cancer.feature_names)
plt.xlabel("은닉 유닛")
plt.ylabel("입력 특성")
plt.colorbar()
```

Out[25]:

```
<matplotlib.colorbar.Colorbar at 0x20b801d9978>
```



분류 예측의 불확실성 추정

In [26]:

```
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.datasets import make_circles

X, y = make_circles(noise=0.25, factor=0.5, random_state=1)

y_named = np.array(["blue", "red"])[y]

X_train, X_test, y_train_named, y_test_named, y_train, y_test = ₩
    train_test_split(X, y_named, y, random_state=0)

gbrt = GradientBoostingClassifier(random_state=0)
gbrt.fit(X_train, y_train_named)
```

Out[26]:

```
GradientBoostingClassifier(criterion='friedman_mse', init=None,
                           learning_rate=0.1, loss='deviance', max_depth=3,
                           max_features=None, max_leaf_nodes=None,
                           min_impurity_decrease=0.0, min_impurity_split=None,
                           min_samples_leaf=1, min_samples_split=2,
                           min_weight_fraction_leaf=0.0, n_estimators=100,
                           n_iter_no_change=None, presort='auto',
                           random_state=0, subsample=1.0, tol=0.0001,
                           validation_fraction=0.1, verbose=0,
                           warm_start=False)
```

결정 함수

In [27]:

```
print("X_test.shape: {}".format(X_test.shape))
print("결정 함수 결과 형태: {}".format(gbrt.decision_function(X_test).shape))
```

```
X_test.shape: (25, 2)
결정 함수 결과 형태: (25,)
```

In [28]:

```
print("결정 함수:₩n{}".format(gbrt.decision_function(X_test)[:6]))
```

```
결정 함수:
[ 4.13592629 -1.7016989  -3.95106099 -3.62599351  4.28986668  3.66166106]
```

In [29]:

```
print("임계치와 결정 함수 결과 비교:₩n{}".format(
      gbrt.decision_function(X_test) > 0))
print("예측:₩n{}".format(gbrt.predict(X_test)))
```

```
임계치와 결정 함수 결과 비교:
[ True False False False  True  True False  True  True  True False  True
  True False  True False False False  True  True  True  True  True False
 False]
예측:
['red' 'blue' 'blue' 'blue' 'red' 'red' 'blue' 'red' 'red' 'red' 'blue'
 'red' 'red' 'blue' 'red' 'blue' 'blue' 'blue' 'red' 'red' 'red' 'red'
 'red' 'blue' 'blue']
```

In [30]:

```
greater_zero = (gbrt.decision_function(X_test) > 0).astype(int)
pred = gbrt.classes_[greater_zero]

print("pred 는 예측 결과와 같다: {}".format(np.all(pred == gbrt.predict(X_test))))
```

```
pred 는 예측 결과와 같다: True
```

In [31]:

```
decision_function = gbrt.decision_function(X_test)
print("결정 함수 최소값: {:.2f} 최대값: {:.2f}".format(
      np.min(decision_function), np.max(decision_function)))
```

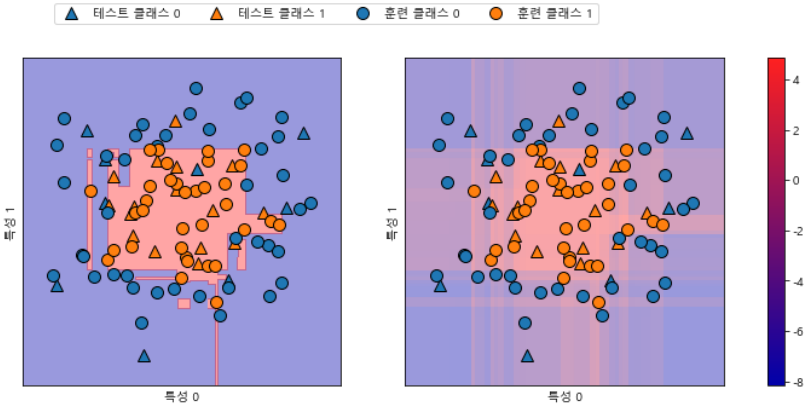
```
결정 함수 최소값: -7.69 최대값: 4.29
```

In [37]:

```
fig, axes = plt.subplots(1, 2, figsize=(13, 5))

mglearn.tools.plot_2d_separator(gbrt, X, ax=axes[0], alpha=.4,
                                fill=True, cm=mglearn.cm2)
scores_image = mglearn.tools.plot_2d_scores(gbrt, X, ax=axes[1],
                                            alpha=.4, cm=mglearn.ReBl)

for ax in axes:
    mglearn.discrete_scatter(X_test[:, 0], X_test[:, 1], y_test,
                             markers='^', ax=ax)
    mglearn.discrete_scatter(X_train[:, 0], X_train[:, 1], y_train,
                             markers='o', ax=ax)
    ax.set_xlabel("특성 0")
    ax.set_ylabel("특성 1")

cbar = plt.colorbar(scores_image, ax=axes.tolist())
cbar.set_alpha(1)
cbar.draw_all()
axes[0].legend(["테스트 클래스 0", "테스트 클래스 1", "훈련 클래스 0",
                "훈련 클래스 1"], ncol=4, loc=(.1, 1.1))
```

Out[37]:

```
<matplotlib.legend.Legend at 0x20bf1c534e0>
```



In [33]:

```
print("확률 값의 형태: {}".format(gbrt.predict_proba(X_test).shape))
```

```
확률 값의 형태: (25, 2)
```

In [38]:

```
print("Predicted probabilities:₩n{}".format(
      gbrt.predict_proba(X_test[:6])))
```

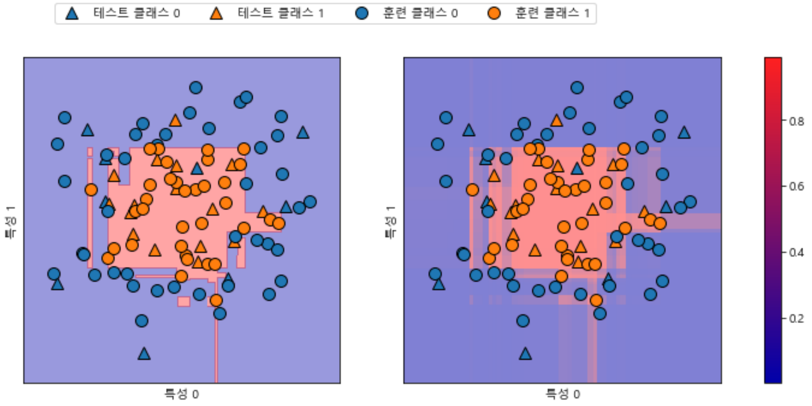
```
Predicted probabilities:
[[0.01573626 0.98426374]
 [0.84575649 0.15424351]
 [0.98112869 0.01887131]
 [0.97406775 0.02593225]
 [0.01352142 0.98647858]
 [0.02504637 0.97495363]]
```

In [39]:

```
fig, axes = plt.subplots(1, 2, figsize=(13, 5))

mglearn.tools.plot_2d_separator(
    gbrt, X, ax=axes[0], alpha=.4, fill=True, cm=mglearn.cm2)
scores_image = mglearn.tools.plot_2d_scores(
    gbrt, X, ax=axes[1], alpha=.5, cm=mglearn.ReBl, function='predict_proba')

for ax in axes:
    mglearn.discrete_scatter(X_test[:, 0], X_test[:, 1], y_test,
                             markers='^', ax=ax)
    mglearn.discrete_scatter(X_train[:, 0], X_train[:, 1], y_train,
                             markers='o', ax=ax)
    ax.set_xlabel("특성 0")
    ax.set_ylabel("특성 1")

cbar = plt.colorbar(scores_image, ax=axes.tolist())
cbar.set_alpha(1)
cbar.draw_all()
axes[0].legend(["테스트 클래스 0", "테스트 클래스 1", "훈련 클래스 0",
                "훈련 클래스 1"], ncol=4, loc=(.1, 1.1))
```

Out[39]:

```
<matplotlib.legend.Legend at 0x20b80602278>
```



In [40]:

```
from sklearn.datasets import load_iris

iris = load_iris()
X_train, X_test, y_train, y_test = train_test_split(iris.data, iris.target, random_state=42)

gbrt = GradientBoostingClassifier(learning_rate=0.01, random_state=0)
gbrt.fit(X_train, y_train)
```

Out[40]:

```
GradientBoostingClassifier(criterion='friedman_mse', init=None,
                           learning_rate=0.01, loss='deviance', max_depth=3,
                           max_features=None, max_leaf_nodes=None,
                           min_impurity_decrease=0.0, min_impurity_split=None,
                           min_samples_leaf=1, min_samples_split=2,
                           min_weight_fraction_leaf=0.0, n_estimators=100,
                           n_iter_no_change=None, presort='auto',
                           random_state=0, subsample=1.0, tol=0.0001,
                           validation_fraction=0.1, verbose=0,
                           warm_start=False)
```

In [41]:

```
print("결정 함수의 결과 형태: {}".format(gbrt.decision_function(X_test).shape))
print("결정 함수 결과:₩n{}".format(gbrt.decision_function(X_test)[:6, :]))
```

```
결정 함수의 결과 형태: (38, 3)
결정 함수 결과:
[[-1.9957153   0.04758118 -1.92721297]
 [ 0.0614655  -1.90755689 -1.92793177]
 [-1.99058105 -1.87637856  0.09686741]
 [-1.9957153   0.04758118 -1.92721297]
 [-1.99730166 -0.13469231 -1.20341532]
 [ 0.0614655  -1.90755689 -1.92793177]]
```

In [42]:

```
print("가장 큰 결정 함수의 인덱스:₩n{}".format(np.argmax(gbrt.decision_function(X_test), axis=1
)))
print("예측:₩n{}".format(gbrt.predict(X_test)))
```

```
가장 큰 결정 함수의 인덱스:
[1 0 2 1 1 0 1 2 1 1 2 0 0 0 0 1 2 1 1 2 0 2 0 2 2 2 2 2 0 0 0 0 1 0 0 2 1
 0]
예측:
[1 0 2 1 1 0 1 2 1 1 2 0 0 0 0 1 2 1 1 2 0 2 0 2 2 2 2 2 0 0 0 0 1 0 0 2 1
 0]
```

In [43]:

```
print("예측 확률:₩n{}".format(gbrt.predict_proba(X_test)[:6]))
print("합: {}".format(gbrt.predict_proba(X_test)[:6].sum(axis=1)))
```

```
예측 확률:
[[0.10217734 0.78840063 0.10942203]
 [0.7834712  0.1093673  0.1071615 ]
 [0.09818079 0.11005862 0.79176059]
 [0.10217734 0.78840063 0.10942203]
 [0.10360014 0.66723882 0.22916105]
 [0.7834712  0.1093673  0.1071615 ]]
합: [1. 1. 1. 1. 1. 1.]
```

In [44]:

```
print("가장 큰 예측 확률의 인덱스:₩n{}".format(np.argmax(gbrt.predict_proba(X_test), axis=1)))
print("예측:₩n{}".format(gbrt.predict(X_test)))
```

```
가장 큰 예측 확률의 인덱스:
[1 0 2 1 1 0 1 2 1 1 2 0 0 0 0 1 2 1 1 2 0 2 0 2 2 2 2 2 0 0 0 0 1 0 0 2 1
 0]
예측:
[1 0 2 1 1 0 1 2 1 1 2 0 0 0 0 1 2 1 1 2 0 2 0 2 2 2 2 2 0 0 0 0 1 0 0 2 1
 0]
```

In [47]:

```
from sklearn.linear_model import LogisticRegression

logreg = LogisticRegression()

named_target = iris.target_names[y_train]
logreg.fit(X_train, named_target)
print("훈련 데이터에 있는 클래스 종류: {}".format(logreg.classes_))
print("예측: {}".format(logreg.predict(X_test)[:10]))
argmax_dec_func = np.argmax(logreg.decision_function(X_test), axis=1)
print("가장 큰 결정 함수의 인덱스: {}".format(argmax_dec_func[:10]))
print("인덱스를 classses_에 연결: {}".format(
      logreg.classes_[argmax_dec_func][:10]))
```

```
훈련 데이터에 있는 클래스 종류: ['setosa' 'versicolor' 'virginica']
예측: ['versicolor' 'setosa' 'virginica' 'versicolor' 'versicolor' 'setosa'
 'versicolor' 'virginica' 'versicolor' 'versicolor']
가장 큰 결정 함수의 인덱스: [1 0 2 1 1 0 1 2 1 1]
인덱스를 classses_에 연결: ['versicolor' 'setosa' 'virginica' 'versicolor' 'versic
olor' 'setosa'
 'versicolor' 'virginica' 'versicolor' 'versicolor']

C:₩Anaconda₩lib₩site-packages₩sklearn₩linear_model₩logistic.py:432: FutureWarning:
Default solver will be changed to 'lbfgs' in 0.22. Specify a solver to silence thi
s warning.
  FutureWarning)
C:₩Anaconda₩lib₩site-packages₩sklearn₩linear_model₩logistic.py:469: FutureWarning:
Default multi_class will be changed to 'auto' in 0.22. Specify the multi_class opt
ion to silence this warning.
  "this warning.", FutureWarning)
```

In [ ]:

```
```